STUDY

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Opportunities of Artificial Intelligence

Policy Department for Economic, Scientific and Quality of Life Policies
Directorate-General for Internal Policies
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Opportunities of Artificial Intelligence

Abstract

This study focuses on presenting the technological, impact and regulatory state of play in the EU, as compared to key competitor countries. This study also highlights industrial areas in which AI will bring significant socioeconomic benefits, before presenting a methodology for scrutinising the fitness of the EU policy and regulatory framework in the context of AI.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AI HLEG	High-Level Expert Group on Artificial Intelligence
AI-SAFE	Automated Intelligent System for Assuring Safe Working Environments
AR	Augmented Reality
B2B	Business-to-Business
B2C	Business-to-Consumer
BAU	Business as Usual
CAGR	Compound Annual Growth Rate
CCPA	California Consumer Privacy Act
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
ECSEL JU	Joint Undertaking on Electronic Components and Systems for European Leadership
EESC	European Economic and Social Committee
EMPL	European Parliament Committee on Employment and Social Affairs
ENI	Experiential Networked Intelligence
ESO	European Standards Organisations
ETSI	European Telecommunications Standards Institute
EU-OSHA	EU Agency for Safety and Health at Work
FP7	7th Framework Programme
GDP	Gross Domestic Product
GDPR	EU General Data Protection Regulation
GVC	Global Value Chains

HMI	Human Machine Interface
HR	Human Resources
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
IES	Intelligent Energy Storage
IoT	Internet of Things
ISG	Industry Specification Groups
ISO	International Organisation for Standardisation
IT	Information Technology
ITI	Information Technology Industry Council
KET	Key Enabling Technologies
ML	Machine Learning
NGO	Non-Governmental Organisation
NLP	Natural Language Processing
OCD	Obsessive-compulsive disorder
OEE	Overall Equipment Effectiveness
OT	Operational Technology
P&L	Profit and Loss
PPE	Personal Protective Equipment
PPP	Public-Private Partnership
RoI	Return on Investment
SAI	Securing Artificial Intelligence
SDG	UN Sustainable Development Goals
SIIA	Software and Information Industry Association

TB	Terabyte
TRAN	Committee on Transport and Tourism
R&D	Research and Development
VR	Virtual Reality
ZSM	Zero touch network and Service Management

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EXECUTIVE SUMMARY

This study on 'Opportunities of Artificial Intelligence' aims to assess the state of play of Artificial Intelligence (AI) adoption in European industry from a technological, impact and regulatory perspective, before presenting a methodology to scrutinise the EU policy and regulatory framework in the context of AI.

AI technology and impacts: State of play

A vast range of AI applications are being implemented by European industry, which can be broadly grouped into two categories: i) applications that enhance the performance and efficiency of processes through mechanisms such as intelligent monitoring, optimisation and control; and ii) applications that enhance human-machine collaboration.

At present, such applications are being implemented across a broad range of European industrial sectors. However, some sectors (e.g. automotive, telecommunications, healthcare) are more advanced in AI deployment than others (e.g. paper and pulp, pumps, chemicals). The types of AI applications implemented also differ across industries. In less digitally mature sectors, clear barriers to adoption have been identified, including both internal (e.g. cultural resistance, lack of skills, financial considerations) and external (e.g. lack of venture capital) barriers. For the most part, and especially for SMEs, barriers to the adoption of AI are similar to those hindering digitalisation.

The adoption of such AI applications is anticipated to deliver a wide range of positive impacts, for individual firms, across value chains, as well as at the societal and macroeconomic levels. AI applications can bring efficiency, environmental and economic benefits related to increased production output and quality, reduced maintenance costs, improved energy efficiency, better use of raw materials and reduced waste. In addition, AI applications can add value through product personalisation, improve customer service and contribute to the development of new product classes, business models and even sectors. Workforce benefits (e.g. improved workplace safety) are also being delivered by AI applications.

Alongside these firm-level benefits and opportunities, significant positive societal and economy-wide impacts are envisaged. More specifically, substantial increases in productivity, innovation, growth and job creation have been forecasted. For example, one estimate anticipates labour productivity increases of 11-37% by 2035. In addition, AI is expected to positively contribute to the UN Sustainable Development Goals and the capabilities of AI and machine learning to address major health challenges, such as the current COVID-19 health pandemic, are also noteworthy. For instance, AI systems have the potential to accelerate the lead times for the development of vaccines and drugs.

However, AI adoption brings a range of challenges. Although certain workforce benefits are anticipated, it is clear that AI will result in the elimination or adaptation of a large number of jobs. Although this will allow humans to focus on higher-skilled roles, the adaptation of the workforce in terms of education and retraining is of vital importance as those displaced will typically not have the skills to profit from AI-driven job creation. Furthermore, SMEs face particular challenges with regard to AI adoption and large firms are better placed to take advantage of the opportunities of AI. This could lead to overconcentration in the market of large firms. In addition, key ethical and legal challenges

exist, including related to: security of AI systems; privacy and data protection; transparency and accountability; discrimination; explainability; and liability.

Given the opportunities, there is fierce competition on AI between global governments, driven by geopolitical as well as economic and technological factors. Considering the US and China, each has a particular balance of strengths. For example, the EU and US are relatively equal, and ahead of China, with regard to AI talent and research capabilities, whereas Europe has a disadvantage when considering venture capital funding, practical adoption and development of hardware. However, the EU has longstanding competitive strengths in a range of key industries, such as automotive, healthcare, energy and agriculture, and is well placed to capitalise on new waves of industrial (big) data. This will be crucial to foster the full potential of the European data economy.

AI policy and regulatory approaches: State of play

Globally, the policy focus to date has been on fostering adoption of AI through investment, adaptation of training and education and development of key AI enablers. In the EU, this is primarily guided by the EU's first AI strategy (AI for Europe) and the Coordinated Plan on AI. The EU is also engaging extensively with the ethical and legal challenges, primarily through the work of the High-Level Expert Group on AI and the Expert Group on Liability and New Technologies.

In February 2020, the Commission published the White Paper on AI and the European strategy for data, which present the possible future regulatory direction for AI and data. The White Paper presents a vision for developing ecosystems of excellence and trust in AI, including the possibility of a new horizontal AI legislation. The European data strategy presents a vision for a single European data space and data-agile economy.

Existing EU legislation also interacts with AI. For instance, the development of a European data economy will require supportive framework conditions, including legislation flexible enough to accommodate new market developments. In this respect, recent assessments of industrial product legislation have incorporated the need to analyse the impact of new technologies.

Scrutinising EU regulation in the context of AI

The Commission's REFIT programme, as well as the Better Regulation guidelines, advise on assessing the impacts of proposed new legislation. However, such frameworks need customisation to meet the specific challenges in optimising the potential benefits of AI for Europe's industrial competitiveness, whilst mitigating the potential adverse consequences. Moreover, there is a need to strengthen attention to managing the potential risks posed by new technologies, including unintended consequences, through these means.

The European Parliament has a crucial role to play in scrutinising the regulatory fitness of proposed new EU legislation in the area of AI and in ensuring that assessments conducted by the Commission: strike the right balance between respecting European values and capitalising on the opportunities of AI; and ensure that such assessments use a risk-based approach to analysing AI that considers different types of risks.

On the basis of the above, this study has developed a checklist that could support scrutiny of EU legislation in the context of AI. Utilising elements of the Better Regulation approach, this checklist covers issues related to suitability of regulatory objectives, assessment of legal considerations, assessment of trade-offs between opportunities and challenges, assessment of unintended consequences, coherence with existing legislation and the extent to which risk levels have been considered.

Recommendations

The main recommendations can be grouped as follows:

- **Recommendations on fostering the use of AI in industry**. Sufficient funding and investment is considered to be of significant importance, particularly considering the strength and focus of global competitors in the area. This could include supporting the effectiveness of specific SME focused activities and ensuring investment in AI, for example to ensure industry has the ability to demonstrate AI applications, highly skilled expertise is retained, and investment is protected in light of the COVID-19 crisis and recovery plans; and
- **Recommendations regarding scrutiny of EU legislation in the context of AI**. A focus could be placed on: encouraging greater focus on assessing the impacts of new technologies on all stakeholders as an explicit consideration in the context of the Better Regulation approach and REFIT programme; ensuring a risk-based assessment approach is taken for AI-related regulation; ensuring the best expertise from all stakeholder groups is used for regulatory scrutiny; and encouraging the development of a holistic approach to AI across the Parliament. Moreover, the Parliament could encourage the Commission to put in place enabling framework conditions, including through reviews of existing legislation to ensure that the legislation is future-proofed to accommodate developments in AI. A specific area of further research relates to the complex interplay between AI and the GDPR, as clear communication of the legal and practical issues could strengthen industry.

1. INTRODUCTION

This study on the **'Opportunities of Artificial Intelligence'** was conducted by the Centre for Strategy and Evaluation Services (CSES), in combination with external experts Professor João Mendes Moreira (Institute for Systems and Computer Engineering, Technology and Science – INESC TEC) and Dr. Anastasios Drosou (Centre for Research and Technology, Hellas – CERTH), has been commissioned by the European Parliament's committee on Industry, Research and Energy (ITRE committee).

This section presents the objectives and scope of the study, before briefly detailing the methodological approach to the research.

1.1. Study context and objectives

The overall aim of the research is to assist the ITRE committee by providing insights into the general debate surrounding the emergence of Artificial Intelligence (AI) as a general-purpose technology and the associated opportunities and challenges for the EU in terms of industrial policy (including the small and medium-sized enterprises (SMEs) dimension), competitiveness and innovation.

To achieve these aims, the study has three objectives:

Objective 1. Review the state of play of AI in the EU from a technological, economic, policy and regulatory perspective, covering the following elements:

- **Technology assessment**: Provide an understanding of AI in the context of industry and examine the nature and scale of existing AI implementations across EU industry, the challenges facing the adoption of AI by EU industry and the EU's standing with regard to key competitor countries;
- **Impact assessment**: Examine the nature and scale of the positive and negative impacts of AI adoption by industry, while assessing who is impacted and the EU's standing with regard to key competitor countries; and
- **Policy and regulatory assessment:** Examine the EU policy and legislative framework on AI, the challenges in this regard and the EU's standing with regard to key competitor countries.

Objective 2. Identify industrial areas in which the integration of AI will bring increased socioeconomic benefits.

Objective 3. Develop a methodology to scrutinise the fitness of the EU policy and regulatory framework in the context of AI.

As regards the context, the study also aims to assist the ITRE Committee in understanding how to scrutinise the new EU policy and potential future regulatory framework on AI in the context of the Commission's new EU Digital Agenda and the White Paper on Artificial Intelligence (AI).[1] In the White Paper, the Commission supports a regulatory and investment-oriented approach with the twin objective of promoting the uptake of AI, whilst addressing the risks associated with certain uses of this new technology. There is also an emphasis on exploiting the benefits of AI, whilst respecting European values, in particular ensuring ethical use of AI, including in industrial applications.

[1] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

1.2. Scope of the study

Considering the **geographical scope** of the study, the primary focus is on the **EU-27 as a whole**. However, with regard to Objective 1, the study examines developments in a selection of **third countries** considered to be key competitors of the EU in the field of AI. For the most part, this relates to the US and China, although references to other countries, such as Japan, are included, where relevant.

Concerning the **scope of the economic sectors** covered by the study, as detailed in the Annex VI, section IX of the Rules of Procedure of the European Parliament, the ITRE committee has responsibility for the following areas:

- Industrial policy and related measures, and the application of new technologies, including measures related to SMEs;
- Research and innovation policy;
- Space policy;
- Energy policy, including security of energy supply, promotion of energy efficiency and energy saving and renewable energy, and the interconnection of energy networks and energy efficiency;
- Euratom Treaty and Supply Agency, including nuclear safety, decommissioning and waste disposal; and
- Information society, information technology and communications networks and services.

The research focuses most prominently on industrial applications, but also incorporates insights related to other key areas under the ITRE committee's remit, such as energy, space and research and innovation.

1.3. Methodological approach

In order to collect the data necessary to achieve the study objectives, a combination of the following research methods was employed:

- **Scoping activities**: Following a kick-off meeting with representatives from the research function which supports the ITRE committee, all members of the study team met to refine the methodology, facilitate a shared understanding of the study context, objectives and work plan and map relevant literature and stakeholders. In addition, familiarisation interviews were conducted with key stakeholders representing industry and consumers;
- **Desk research**: On the basis of the refined methodological approach, a desk research exercise was conducted to collect qualitative and quantitative data across all study objectives. As illustrated in the study bibliography (see References), a wide variety of sources have been identified and reviewed as part of this desk research exercise. In particular, literature was identified through targeted searches of relevant academic journals, as well as the websites of international, EU and inter-governmental authorities and statistical bodies; industry, AI and consumer associations; research institutes; and management consultancies;
- **Interview programme**: To add to the literature reviewed through the desk research exercise, a wide-ranging interview programme was conducted. Interviews were conducted with 34 representatives of the following stakeholder groups: private companies, EU bodies, industry associations, intergovernmental organisations, national authorities, consumer associations,

academia and other research and innovation stakeholders. A further four written responses to the interview questionnaire were provided by research and innovation stakeholders. A list of organisations interviewed is presented in Annex 1; and

- **Case studies**: To illustrate AI applications currently in use in EU industry, three case studies have been conducted. These aim to ensure balanced representation in terms of: i) covering AI applications across a range of different Member States; ii) covering a range of different types of AI applications; and iii) covering AI applications in a range of different industry sectors. The case studies, which are presented throughout the report in vignettes, present details on AI implementation, as well as the impacts of the application.

The data collected through these means was analysed in accordance with the study objectives and related research questions. To test and ensure the **validity and veracity of the study findings**, the research has been reviewed and quality-assured by the study team's external expert advisors Professor João Mendes Moreira (INESC TEC) and Dr. Anastasios Drosou (CERTH).

2. ARTIFICIAL INTELLIGENCE IN INDUSTRY: STATE OF PLAY IN THE EU

KEY FINDINGS

A **wide range of different types of AI application can be distinguished**. These applications broadly fit into two categories encompassing enhancing the performance and efficiency of industrial processes and human-machine collaboration.

AI applications are currently being implemented across a range of European industries. Prominent amongst these are areas where Europe already has competitive strengths, such as automotive, healthcare, energy, financial services, media, and the tech sector. However, the types of AI applications implemented differ across industries, and some sectors, particularly more traditional sectors, are less mature with regard to deployment of AI applications.

Key **barriers to adoption** include internal factors (e.g. cultural resistance, lack of clear leadership on AI, lack of knowledge and talent and financial considerations) and external factors (e.g. lack of venture capital funding, lack of data availability).

With this said, take-up of AI technologies in Europe is concentrated in sectors with high value-added that are best positioned to capitalise on the operational efficiencies that AI is able to generate (e.g. automotive, sectors strongly dependent on transport and logistics, and those with complex Global Value Chains, which potentially have the greatest savings to make).

A **challenge is in fostering adoption by a wider range of sectors and by SMEs**, who find it harder to implement AI applications as compared with large firms. However, as the costs of deploying Industry 4.0 technologies, AI and automation reduce over time, this should serve as a stimulus for more SMEs to invest in digitisation and use of AI technologies.

Considering **global competitiveness**, Europe has strong capabilities globally in terms of AI research; however, it lags behind the US and China with regard to the practical application and adoption of AI solutions. As such, in order to maintain a strong competitive position in AI, Europe needs to accelerate the pace of adoption of digital technologies and AI, building on its longstanding technological and industrial strengths.

2.1. Understanding Artificial Intelligence

In 1956, the scientist John McCarthy coined AI (Artificial Intelligence) as "*the science and engineering of making intelligent machines*".[2] AI (Artificial Intelligence) is a term referring to computer systems that can sense their environment, think, possibly learn and take action in response to what they are sensing or their objectives.[3] It refers to computer systems capable of performing tasks requiring some intelligence for humans.[4] These tasks can either be specific, often called 'weak' or 'narrow' AI (e.g. optimising electricity usage on a smart grid)[5] or 'general' (e.g. an advanced chatbot).

AI processes vast amounts of data, which may originate from diverse sources, including human language, sensors or text, through software that allows it to draw conclusions, adjust its parameters and produce outputs. The combination of high precision and low computation time makes AI a cutting-

[2] McCarthy, J. (2007). What is Artificial Intelligence?

[3] PwC. (2018). The macroeconomic impact of artificial intelligence.

[4] Intellectual Property Office. (2019). Artificial Intelligence, A worldwide overview of AI patents and patenting by the UK AI sector.

[5] DigitalEurope. (2018). Recommendations on AI Policy Towards a sustainable & innovation friendly approach Brussels.

edge technology. Some of the new technological processes that have taken root in AI in recent years are described in Table 1.

AI often relies on the use of algorithms. An algorithm is composed by a set of instructions and operations, ranging from very simple to a very long and complex set of lines of programming software code. These operations in turn process the data that is supplied to the algorithms.

In 1959, Arthur Samuel defined machine learning as the field of study that gives computers the ability to learn "*without being explicitly programmed*".[6] With the advent of big data and machine learning, algorithms have seen significant growth and development. Machine learning has grown, receiving inputs not only from AI but also from the statistics and the databases communities. Machine learning with the advent of big data, has seen significant growth leading to the development of new algorithms.

Whilst technological developments in AI and machine learning, as well as wider developments in robotics and automation linked to Industry 4.0 (defined in Box 1, below), have made particular strides in the past five years, there is a misperception that AI and related developments are entirely new.[7] On the contrary, industry stakeholders point to the integration of a degree of automation and use of robotics over a period of several decades in aspects of manufacturing processes.[8] Indeed, Turing's important research on computing machinery and intelligence[9] dates back to 1950.

What has changed, however, is that high-speed internet, and the advent of the industrial internet of things, along with advances in computational power and use of big data have accelerated the process of adoption of AI technologies, which have themselves rapidly developed.

Box 1: Key concepts

Defining Industry 4.0

The fourth industrial revolution (or Industry 4.0), as explained by the OECD in 2017, refers to "*the use in industrial production of recent, and often interconnected, digital technologies that enable new and more efficient processes, and which in some cases yield new goods and services. The associated technologies are many, from developments in machine learning and data science, which permit increasingly autonomous and intelligent systems, to low-cost sensors which underpin the IoT, to new control devices that make second-generation industrial robotics possible*".

Source: OECD. (2017). The Next Production Revolution, Implications for Governments and Business.

The concepts and definitions relating to AI technologies shown in Table 1 will help to frame the present study. In the remainder of this section, the state of play in relation to technological developments in artificial intelligence are considered. In particular, the degree of adoption by major industry sectors in the EU is considered, and the extent to which this depends on the degree of innovation in the industry, the nature of value chains, and the degree to which particular sectors can benefit from AI, which varies. For example, some sectors can benefit from operational efficiencies more than others.

6 Samuel, A. L. (1959). Some Studies in Machine Learning Using the Game of Checkers, IBM Journal of Research and Development 44:1.2 (1959): 210–229.

7 TWI. (n.d.). INDUSTRY 4.0.

8 For example: Orgalim. (2020). Orgalim Manifesto: a European Agenda on Industrial AI, Brussels, 15 January 2020.

9 Turing, A. M. (1950). Computing Machinery and Intelligence.

Examples of AI processes are provided in the following table:

Table 1: Examples of AI processes

AI technological Process	Description
Robotic process automation	Application of specific technology and methodologies which are based on software and algorithms aiming to automate repetitive human tasks.[10]
Computer vision	Computer vision aims to build autonomous systems which can perform tasks humans can perform, or even surpass human vision tasks.[11]
Machine learning	Ability of computer programmes to extract knowledge from data. Machine learning relies on the application of statistical models to data.[12]
Natural language text understanding	Natural Language Processing (NLP) analyses text through digital means. NLP gathers knowledge based on how humans understand or use language.[13]
Virtual agents or conversational interfaces	Conversational interfaces are defined as interfaces relying on dialogue between humans and digital agents, through speech or text.[14]
Physical robotics	Refers to the 'embodiment' or physical existence of a body in the field of robotics.[15]

Source: CSES secondary research (2020).

2.2. Industrial applications of Artificial Intelligence

As AI technologies advance, there is an increasing array of different areas in which their increased adoption will have an impact. These range from economic production, through to increased integration into industrial processes, to energy efficiency. These may in turn bring environmental benefits and strengthened sustainability.

This section presents the range of different AI applications that organisations can leverage, and identifies which are the main characteristics necessary to implement AI, and the extent to which European industry as a whole, and particular industry sectors, are already doing so. This section also presents the different challenges to increased AI adoption and provides an overview of the EU's position as regards how technological developments in AI and their rolling out in industrial applications might be supported, for instance, by putting in place an enabling policy and regulatory framework, as outlined in the European Commission's White Paper on AI.

[10] Ivancic, L. et al. (2019). Robotic Process Automation: Systematic Literature Review.
[11] Huang T. S. (1996). Computer Vision: Evolution and Promise.
[12] Panch et al. (2018). Artificial intelligence, machine learning and health systems.
[13] Kaniwa et al. (2016). Natural Language Processing: A Review.
[14] Pinhanez, C. and Candello, H. (2016). Tutorial. XV Simpósio Sobre Fatores Humanos em Sistemas Computacionais.
[15] Duffy, B. and Joue, G. (2000). Intelligent Robots: The Question of Embodiment.

2.2.1. Taxonomy of industrial AI applications

Following the most recent developments in AI, manufacturing businesses have been working to identify ways in which different forms of AI can be applied in industrial applications.[16] AI has increasingly been integrated in the shop-floor of many manufacturing plants, where they work alongside humans in fulfilling several operations of varying complexity. Beyond manufacturing, AI has been increasingly integrated in different economic sectors such as telecommunications and strategic sectors such as energy production and distribution, where AI has the potential to rationalise the production and distribution of energy derived from renewable energy sources, such as wind. Indeed, in this study's interview programme, energy sector stakeholders noted that AI can play a leading role in enabling delivery of the EU's new Green Deal.

For the purposes of this study, industrial AI applications shall be defined as any AI application being used to enhance the performance and efficiency of a business' physical operations. Industrial AI therefore affects business processes, such as the managing of warehouses and supply chains and assembly lines. Given the physical characteristics of industrial production, AI must take into account the risks that are carried by machine malfunction, flawed product design, health and safety concerns and a comprehensive body of product regulation, which require significant reporting actions and the ability to read complex sensor data. These features contribute to making AI industrial applications more complicated than in other digital business solution applications.[17]

A framework for categorising the industrial applications of AI, at a high level of abstraction, can be based on two broad categories: i) enhancing the performance and efficiency of industrial processes; and ii) improving human-machines collaboration. The first related to enhancing the performance and efficiency or industrial processes through intelligent monitoring applications, as well as optimisation or control applications with the capability to automatically make decisions in relation to industrial processes. This categorisation is based on the degree of automation that is involved for each of the AI industrial applications, with 'monitoring' requiring the least and 'control' assuming the most.

Monitoring: In industrial scenarios, there is a need to monitor the performance of systems and processes to identify or predict faults. Using machine learning, it is possible to predict systems' future performance and conditions based on a set of data. Monitoring can also be key to quality control, as AI may be able to visually inspect items on assembly lines directly, ensuring that products have fewer defects. AI can also implement predictive maintenance, whereby faults and failures are isolated before they affect the production line based on data inputs from the production processes. Predictive maintenance can also result in a reduction in maintenance operations, since maintenance is only conducted when it is predicted instead of being conducted at fixed intervals.

Optimisation: Beyond monitoring the performance of existing industrial processes to ensure they operate as expected, an additional path would be to enable AI to allow for enhanced business processes based on a plan and the fulfilment of business criteria. A field in which AI may facilitate this type of optimisation in industrial application is product design; designers may be able to input the constraints within a product, allowing the AI system to produce design alternatives by leveraging machine learning algorithms. Thus, AI can help determine whether a designers' product is manufacturable, preventing the need to test its production and saving testing time in the process. Moreover, based on product deficiency data, optimisation processes may be able to suggest alternative designs for existing products.

[16] Yuan, Y. (2019). Artificial Intelligent Diagnosis and Monitoring in Manufacturing.
[17] Charrington, S. (2017). Artificial Intelligence for Industrial Applications.

Control: Control systems are needed in order to realise the full benefits of automation. Some of the objectives of control applications of AI relate to the need to be able to respond to changes to the environment within an industrial process, while aiming to increase production and productivity, lower labour costs and reduce waste.[18] There are a few examples of industrial applications that benefit from AI-based control systems; for instance, autonomous mobile robots in factories may support material transport and inventory management in warehouses. AI in these cases allows robots to perform tasks more effectively than humans while also ensuring human safety. AI can further be used to automate heating, ventilation and air conditioning systems, as well as power smart grids to save energy.

Beyond the above-mentioned forms of industrial AI applications, which primarily aim to enhance or replace a production system based on human labour, AI can also be used to enhance human-machine collaboration. For instance: i) AI can be used to improve the processing, analysis and presentation of machine, system or factory data to human controllers via an interface or dashboard; ii) AI systems can support automated personnel management and other enterprise tasks, such as customer support, sales, marketing; and iii) augmented reality (AR) and virtual reality (VR) technologies with AI capabilities can support the workforce, for example through more interactive training.

The following sections in this study examine: i) the types of organisations implementing AI; and ii) the extent to which AI is being applied and adopted in EU industry.

2.2.2. Key sectors implementing AI

The European Commission has described advanced technologies as a *"fusion of digital and key enabling technologies (KETs), and the integration of physical and digital systems. Such technologies are instrumental in modernising Europe's industrial base"*.[19] AI is particularly relevant to sectors falling within advanced manufacturing technologies and KETs, as they are high-value, high-productivity sectors, with a high level of technological embeddedness and digitisation.

Examples of industries that are currently identified as implementing AI include the following: 1) High-tech; 2) Automotive and Assembly; 3) Financial Services; 4) Telecom; 5) Retail; 6) Consumer packaged goods; 7) Travel, transport, logistics; 8) Electric power and natural gas; 9) Infrastructure; 10) Pharmaceuticals and medical products; 11) Healthcare systems and services[20] and 12) parts of the engineering sector characterised by advanced manufacturing technologies and Key Enabling Technologies (KETs).

Some of the leading economic sectors in terms of AI adoption are financial services, automotive & assembly and High tech & telecommunications, with around 30% of firms having adopted one or more AI technologies. Conversely, less digitised sectors include travel and tourism, which stands at around 12%.[21] Certain capabilities derived from use of AI, such as technologies for gathering big-data and advanced-analytics capabilities are likely to be relevant to many different sectors.

The potential of AI can already be seen in successful real-world implementations by specific organisations with clear recorded benefits across various industries. A 2017 McKinsey Institute report[22] showcases a series of examples of real-world AI applications by companies and their effects in different industries, as illustrated in Table 2.

[18] Charrington, S. (2017). Artificial Intelligence for Industrial Applications.

[19] European Commission. (n.d.). Internal Market, Industry, Entrepreneurship and SMEs, Advanced technologies.

[20] McKinsey. (2019). Driving impact at scale from automation and AI.

[21] McKinsey. (2019). Driving impact at scale from automation and AI.

[22] Bughin, J. et al. (2017). Artificial Intelligence the Next Digital Frontier? McKinsey Global Institute.

Table 2: Company Use Cases of AI application

Industry	Use cases
Retail	The Germany-based e-commerce merchant Otto[23] was able to cut stock by 20% and reduce product return through deep-learning, which helped it analyse billions of transactions to predict customer behaviour with 90% accuracy.
	Online supermarkets, such as Ocado in the UK, use machine learning algorithms to steer products over conveyor belts and deliver them to customers.[24] Robots prepare bags for delivery vans whose drivers are then guided through an AI application to find the best route.
Electric Utilities	DeepMind, which was purchased by Google, has worked with the national grid in the UK to predict electricity demand by using weather related variables and smart meters to optimise consumption.[25]
	Google company Nest's Wi-Fi thermostat can create a heating schedule by monitoring a user's habits with motion sensors, detecting when homes are empty and optimising energy use.[26]
Manufacturing	At Siemens' Electronic Works Amberg, production is controlled through programmable logic circuits in a virtual factory replicating the factory floor. Bar codes help products communicate with machines to manufacture parts and detect defects. Approximately 75% of production is fully automated.[27]
	Intel deployed data scientists to speed up data integration in its R&D department. The company achieved 10% higher yield for integrated-circuit products.
Education	Civitas Learning and Salesforce have collaborated on services for universities that identify and engage with students at risk of dropping-out. Salesforce tools use machine learning to recommend engagement strategies facilitating retention.[28]
	Coursera provides online classes that use machine learning to alert teachers when students make recurrent mistakes in given assignments, denoting potential gaps in the course materials.[29]

Source: McKinsey Global Institute. (2017). Artificial Intelligence: The Next Digital Frontier?

International organisations, such as the EU, have undertaken steps to help the development of AI applications by providing funding to diverse AI projects. For example, in the EU, investments in AI under the Horizon 2020 programme will increase by 70% to EUR 1.5 bn in the period 2018-2020, as compared with 2014-2017 (discussed further in section 3.1.2). Within the framework of Horizon 2020, the EU has funded a wide range of projects, including projects that explore the development and application of AI technologies. Examples of such projects are presented in Table 3.

[23] The Economist. (2017). How Germany's Otto uses artificial intelligence.

[24] NewScientist. (2016). Robo Shop.

[25] Kreutzer, R. and Sirrenberg, M. (2019). Understanding Artificial Intelligence: Fundamentals, Use Cases and Methods.

[26] Bughin, J. et al. (2017). Artificial Intelligence the Next Digital Frontier? McKinsey Global Institute.

[27] Bughin, J. et al. (2017). Artificial Intelligence the Next Digital Frontier? McKinsey Global Institute.

[28] Robotic Biz. (2020). AI can personalize learning and optimize teaching.

[29] Robotic Biz. (2020). AI can personalize learning and optimize teaching.

Table 3: AI projects funded by Horizon 2020

EU Project	Description
UNEXMIN[30]	Funded through Horizon 2020, the UNEXMIN project seeks to develop a robotic system exploring and mapping Europe's flooded mines. Its platform is made-up of three robots – UX-1a, UX-1b and UX-1c, which use 3D mine mapping to gather geological, mineralogical and spatial information helping to decide whether mines can be re-opened, without major additional costs through actualised data. UNEXMIN is made possible through the development of mine explorer service robots.
ECSEL	The ECSEL is an autonomous European community body, focused on Electronic Components and Systems and part of the Horizon 2020 program. ECSEL projects focus on areas where AI can be applied through tasks and work packages focused on practical AI problems. More specifically, a few AI areas of interest for ECSEL include: 1) AI on the edge (Distributed AI); 2) (Deep) machine learning; 3) Smart sensors; 4) Data analytics; and 5) Assisted decision making.
AI4EU	The AI4EU consortium was established in January 2019 to develop the European Artificial Intelligence On-Demand Platform and Ecosystem. This project aims to facilitate collaboration between all European stakeholder groups (from research to industry) with a focus on real-world applications.[31] In practice, the consortium's activities include funding the development of prototype AI products and financing of AI scale-ups.[32]

Source: CSES secondary research (2020).

In addition, the EU has been heavily involved in investing in AI and robotics projects across the EU, such as SIMBAD, ConCreTe, COINVENT to name a few.[33] It is the goal that initiatives like AI4EU will help bridge the gap between research and commercial applications and lead to the development of new products and their use in Europe as well as contributing to research capabilities.[34] The European Union will continue to support development of artificial intelligence in the years to come through the 2021-2027 Horizon Europe programme and the Digital Europe Programme in AI.[35]

2.2.3. Scale of adoption

The adoption of AI is continuously increasing, with AI applications surfacing in a wide array of different fields and processes across industry. AI adoption has been facilitated by the shift to cloud computing and the increasing availability of plug-and-play AI services along with a growing presence of AI-led software suppliers.[36] The increasing relevance of AI adoption can further be appreciated in the exponential growth of new AI-related patents, the last decade has seen a 400% increase in the number of published AI patent applications.[37] In terms of AI patent applications, as per filing under the Patent Cooperation Treaty (PCT), from 1960 to 2018 there have been 1,863 filings in the US, 1,085 in China and

30 UNEXMIN. (n.d.). Developing science and technology.

31 AI4EU. (2020). AI4EU Website: About the Project.

32 Business Finland. (2020). AI Business Program: AI Calls in H2020 (08/2020), 5 February 2020.

33 European Commission. (n.d.). EU-funded FET projects on AI & Cognition.

34 European Commission. (2019). Artificial intelligence: 79 partners from 21 countries to develop an AI-demand-platform with €20 million EU funding.

35 European Commission. (2018). Artificial intelligence.

36 Kelnar, D. and Kostadinov, A. (2019). The State of AI 2019 Divergence.

37 UK Intellectual Property Office. (2019). Artificial Intelligence, A worldwide overview of AI patents and patenting by the UK AI sector.

1,074 in the EU, with US firms leading in filing patents for 12 out 20 fields of Application for AI such as education, cartography, business and agriculture.[38]

As regards further drivers of take-up of AI technologies, these include the ease-of-use of technologies, which has improved considerably in recent years. *"The rise of software-as-a-service (SaaS) management platforms and subscription-based pricing models led to increased adoption rates, and now, manufacturing software is growing easier for employees to use. Companies have the ability to access real-time information, as explained by PwC, and intelligent systems are built with AI in mind".*[39]

The costs of AI and machine learning software, and of wider Industry 4.0 technologies such as automation software has become more reasonable over time, such that this could serve as a driver to encourage SMEs to use AI technologies that were previously mainly accessible to large firms due to the need for high levels of investment.[40] In addition, SMEs can now benefit from less costly AI solutions which are cloud-based and are made increasingly available by service, thus making AI more accessible and allowing SMEs to derive some of the benefits that, to date, have been mainly enjoyed by larger organisations.[41] The proliferation of digital AI solutions can therefore be an opportunity for EU SMEs to start adopting AI and incorporating them in their processes, which usually tended to rely on large R&D and access to talent which was out of the reach of many SMEs. However, it takes time and human resource investment for businesses across different sectors to develop a good understanding of the potential benefits and suitable metrics for assessing their Return on Investment (RoI) from AI.[42]

Furthermore, the increasing adoption of AI was reported to being growing, with just 4% of enterprises having adopted AI solutions at the beginning of 2018, the number was 14% in early 2019.[43] According to a 2019 report, in the following 24 nearly two thirds of large companies will have adopted AI strategies.[44] A McKinsey Global Survey, which consulted 2360 business executive respondents from different organisations, also showed that the adoption of AI applications is increasing fast, with an estimated 25% growth in AI applications in standard business processes around the world, with many organisations increasingly using AI in more than one of the areas of their business.[45]

Increasing numbers of new start-ups have also been adopting AI as a core value proposition from 1 in 50 in 2013 to 1 in 12 in 2019.[46] Indeed, in major tech hubs such as Paris, Berlin, London, etc. there are clusters of AI start-ups. It is unclear how the growth of dedicated AI specialist firms in Europe will be impacted by the economic slowdown and / or possible recession linked to COVID-19, but such start-ups have grown considerably in number in the past 3-5 years. While an initial fear would have been that the COVID-19 crisis would have delayed EU funding for artificial intelligence, recent developments seem to indicate that the European Commission is seeking to provide funding to the EU's healthcare manufacturing sectors in order to apply AI to better enable them to withstand and tackle the crisis, and therefore it might be possible to combine Pandemic emergency funding with AI development.[47,48] Moreover, it is not to be underestimated how the COVID-19 crisis might act as a catalyst for further

[38] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.

[39] Robinson A. (2018). The Future is Now: Why these 5 Advanced Manufacturing Technologies Trends will Dominate 2018.

[40] Azati. (2019). How much does artificial intelligence (AI) cost in 2019?

[41] Royal Bank of Scotland. (2018). Artificial intelligence for SMEs.

[42] Schacklett, M. (2018). The true costs and ROI of implementing AI in the enterprise.

[43] Goasduff, L. (2019). Top Trends on the Gartner Hype Cycle for Artificial Intelligence.

[44] Kelnar, D. and Kostadinov, A. (2019). The State of AI 2019 Divergence.

[45] Cam, A. (2020). Global AI Survey: AI proves its worth, but few scale impact. McKinsey.

[46] Kelnar, D. and Kostadinov, A. (2019). The State of AI 2019 Divergence.

[47] Espinoza, J. (2020). Coronavirus prompts delays and overhaul of EU digital strategy.

[48] Naujokaitytė, G. (2020). Commission launches new €122M coronavirus research funding call.

digital transformation, as more and more business executives are evaluating their automation and digital transformation strategies in light of the current crisis.[49]

The same report further identified that there are nine different examples of AI applications that organisations could use in their processes: 1) Robotic Process Automation; 2) Computer Vision; 3) Machine Learning; 4) Natural language text understanding; 5) Virtual agents or conversational interfaces; 6) Physical robotics; 7) Natural language speech understanding; 8) Natural language generation; and 9) Autonomous vehicles. The percentage of respondents stating they have implemented any of these AI applications, by industry, is reported in Table 4. The same survey found that 58% of respondents reported embedding at least one of the AI applications in 2019, up from 47% in the previous year, further illustrating the growth of AI in industry. Moreover, companies are increasingly shown to use more than one AI technology; the number of organisations applying two technologies or more grew from 21% in 2018 survey to 30% in the 2019 survey.

[49] Ernst & Young. (2020). Global Capital Confidence Barometer.

Table 4: Proportion of respondents by industry stating to have used a given AI Technology

Industry	Robotic process automation	Computer vision	Machine learning	Natural language text understanding	Virtual agents or conversational interfaces	Physical robotics	Natural language speech understanding	Natural language generation	Autonomous vehicles
High-Tech	35%	33%	54%	38%	35%	9%	24%	22%	4%
Automotive Assembly	46%	42%	31%	28%	17%	44%	19%	18%	25%
Telecom	30%	36%	45%	38%	45%	20%	23%	26%	3%
Travel, transport, logistics	33%	26%	19%	24%	29%	10%	12%	12%	7%
Financial services	36%	24%	25%	28%	32%	7%	19%	16%	6%
Retail	21%	24%	23%	24%	27%	25%	18%	16%	9%
Packaged consumer goods	17%	14%	12%	13%	11%	47%	7%	7%	15%
Electric power and natural gas	26%	31%	30%	9%	22%	22%	8%	6%	4%
Healthcare systems and services	23%	32%	23%	30%	20%	14%	22%	16%	4%
Pharma and medical products	21%	19%	15%	10%	6%	31%	7%	8%	5%
Infrastructure	20%	17%	15%	10%	4%	14%	5%	5%	2%
Professional services	17%	20%	22%	22%	17%	7%	12%	13%	6%

Source: McKinsey. (2019). Global AI Survey.[50]

[50] Cam, A. (2020). Global AI Survey: AI proves its worth, but few scale impact. McKinsey.

From Table 4, it can be inferred that the adoption of specific AI technologies varies by industry. It is more likely, for example, that AI technologies adopted in automotive industries consist of physical robotics applications. In the case of telecoms, however, the applications in use are more likely to be virtual agents for customer interactions. Overall, the data in the table suggests that autonomous vehicles and natural language generation/speech understanding are the least widespread forms of adopted AI. In some sectors more than others, it appears that the most innovative sectors, such as High-tech, Automotive assembly and Telecom lean towards robotic process automation, computer vision, machine learning, physical robotics and virtual conversation agents. The trend towards the expansion of AI technologies is due to increase in the foreseeable future, as 74% of respondents having implemented an AI application suggest they will increase their investment in AI technologies. Half of these respondents expect that they will increase investment by 10% or more, with those organisations that have more heavily invested in AI technology (high performers) stating that they will increase investments by 50% or more.[51]

The difference in invested amounts might contribute to a divergence between players in the developing AI landscape, as some move away from others in the extent to which they apply and onboard AI applications. This can be seen already with the widening gap between the so-called high adopters which comprise those organisations that have advanced the most in the adoption of AI, as opposed to the rest who are integrating AI applications at a slower pace. In terms of industry-wide adoption of AI, financial services and high-tech are early adopters, with retail and healthcare catching up and the public sector lagging behind.[52]

When considering the differing levels of adoption rates across different sectors, it is important to provide examples of which aspects of the value chain can potentially benefit most from the use of AI technologies; for industries that depend heavily on transportation and logistics services, AI can be used to identify bottlenecks and to improve operational efficiencies both in transport and across the value chain. In production processes, AI can be used to derive greater efficiencies by feeding big data to optimise production across different manufacturing facilities; in case an incorrect component is being used, a digital copy of the component can be made to replace it and avoid stoppages to the production. Lead times to market can be accelerated through the use of Virtual and Augmented Reality, whose adoption rates are expected to increase significantly.[53] This could also have wider implications, such as driving the reshoring of manufacturing production back to Europe, as is the case already in the US, as VR and AR may facilitate more effective supply chains by providing real-time information on manufacturing facilities, distribution centres, and warehouses and make deliveries more effective and secure, while also supporting a trend towards localisation.[54,55]

Lastly, in the patenting area, a 2019 report on AI[56] by the World Intellectual Property Organization (WIPO) found that there had been a significant increase in the number of scientific papers in the field since 2000, with a particular upsurge in patent applications between 2013 and 2016. The most often-patented sectors were: telecommunications, transport, life sciences and medical sciences, and personal devices for human–computer interaction. As regards patenting at the application level, those most commonly patented were in the fields of smart cities, agriculture, e-government, banking and finance (FinTech).

[51] Cam, A. (2020). Global AI Survey: AI proves its worth, but few scale impact. McKinsey.

[52] Kelnar, D. and Kostadinov, A. (2019). The State of AI 2019 Divergence.

[53] Filipowiak, J. (2019). How can Virtual Reality (VR) be used for business?

[54] Moser, H. (2016). Reshoring: The Trend from Globalization to Localization.

[55] Saunders, K. (2018). How far AR and VR create effective supply chains.

[56] World Intellectual Property Office (WIPO). (2019). Technology Trends 2019 – Artificial Intelligence.

It is worth noting that there is a strong concentration of AI patents among globally-leading AI companies. As regards patent's property/ownership, software giants dominate the AI ecosystem. IBM has the largest portfolio of AI patent applications for 8,290 inventions, followed by Microsoft with 5,930 of all 167,038 patent documents in 2019.[57]

They are followed by consumer electronics firms Samsung and Toshiba, both of whom have more than 5,000 patented inventions.[58] Moreover, patents in machine learning grew by an annual average of 26% between 2011 and 2016.[59] However, unlike other technological sectors where activities are dominated by a select few organisations, AI presents a much more diverse environment, which includes many smaller organisations that have recently been established.[60]

2.2.4. Challenges and barriers to wider adoption

While there is an increase in the interest of organisations in investing in, and adoption of AI solutions into their business processes, significant barriers remain at the organisational level that prevent organisations from leveraging the full potential of AI. These barriers have a direct bearing on the ability of organisations to access and utilise the enablers that permit AI. The enablers that are more relevant to the application of artificial intelligence include access to knowledge, technology, data, computing power and access to complete AI solutions.[61] The barriers to AI are described in Table 5.

Table 5: Barriers to AI implementation

Barrier	Description
Lack of clear AI strategy	In a recent report,[62] only 18% of respondents said that their companies have adopted a clear AI strategy. In the same report, only about 25% of respondents suggested that their organisation developed some of the 11 AI practices that were addressed by the study. Examples of the practices were: ''Organisation uses data (both internal and external) effectively to support goals of AI work'' and ''Employees trust AI-generated insights'', among others.
Functional silos in organisations	Functional silos are reported as a barrier to the adoption of AI in organisations. Organisational IT is often structured in silos to enable vertical top-down command. A lack of understanding of AI can prevent lagging sectors, such as agriculture, from adopting AI technology.[63]
Cultural Resistance	Cultural resistance is a source of friction in the implementation of AI. This is particularly true in those instances where the implementation of AI requires the cooperation of different groups.[64]
Lack of talent needed for AI solutions	AI raises major questions as regards companies' workforce, such as where to attract the talent needed to develop AI technologies and to what extent AI might reduce the size of the workforce. The cost and effort associated with attracting new talent or developing in-house capabilities constitute a further consideration to the development and

[57] World Intellectual Property Office (WIPO). (2019). Technology Trends 2019 – Artificial Intelligence.
[58] World Intellectual Property Office (WIPO). (2019). Technology Trends 2019 – Artificial Intelligence.
[59] World Intellectual Property Office (WIPO). (2019). Technology Trends 2019 – Artificial Intelligence.
[60] Santeli, J. and Gerdon, S. (2019). 5 challenges for government adoption of AI.
[61] Dasgupta, A. and Wendler, S. (2019). AI Adoption Strategies.
[62] McKinsey Analytics. (2018). Notes from the AI frontier: AI adoption advances, but foundational barriers remain.
[63] Dasgupta, A. and Wendler, S. (2019). AI Adoption Strategies.
[64] Dasgupta, A. and Wendler, S. (2019). AI Adoption Strategies.

Barrier	Description
	application of AI technologies. Industries leading in the development of AI capabilities tend to be focusing more on developing capabilities in-house, as is the case in high-tech or financial services.[65]
Budget constraints	Along with the lack of skills, budget constraints may also impact investment, hiring and necessary re-training of the workforce. Budget restraints further hinder the ability to access data, which is required by companies to implement AI applications.
Enterprise size (e.g. SMEs and large firms)	The deployment of AI implies considerable investment. However, many SMEs lack access to finance generally, and/ or the necessary investment capital to dedicate to investment in digitisation and AI.

Source: CSES secondary research (2020).

Table 5 indicates that the constraints to AI are mainly due to issues that are related to the internal set-up of organisations adopting AI. For example, issues related to leadership, budget or communication channels can hamper the ability of organisations to adopt AI. There are also external factors that affect their ability to invest the resources needed to kick-start the development and adoption of AI solutions, such the lack of an adequate venture capital environment for smaller businesses[66] and inadequate cost-benefit metrics to be able to demonstrate a positive ROI to more conventional bank lenders.

2.2.5. Global position of the EU in AI

The Commission's White Paper on AI notes that there is "*fierce global competition*"[67] in AI. The race towards developing significant AI capabilities is driven not only by economic and technological drivers, but also by other factors, such as defence and security-related considerations. There is therefore a **geopolitical dimension** to efforts to strengthen the competitive position of Europe and its major global competitors in AI, namely the US and China. Furthermore, whichever economies globally lead in AI will also be in a very strong competitive position to achieve leading market shares in related areas, such as Big Data, Blockchain and the Industrial and Consumer Internet of Things (IoT), as technological developments in AI are closely inter-linked. Competitiveness in these sectors will ensure that any country maintains an economic and technological edge over others, which could be applied across all sectors, including, for example, research, health, education, among others.

The US has greatly benefitted from the last wave of digital innovation, having witnessed the rise of large tech multinationals such as Google, Apple and Amazon.[68] Three players have emerged as the primary contenders in the race to lead in the field of AI: China, US and the EU. [69] China has been able to develop its own technological industry, which has become more competitive and is catching up rapidly with the US.

Recently, the new European Commission has sought to define itself as a 'Geopolitical Commission',[70] a strategy that could not be achieved without the digital dimension, which is why it should be coupled with the EU's plan on AI, having the *"ambition is for Europe to become the world-leading region for*

[65] Kelnar, D. and Kostadinov, A. (2019). The State of AI 2019 Divergence.

[66] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.

[67] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[68] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.

[69] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.

[70] European Commission. (2019). Main principles of the working methods.

developing and deploying cutting-edge, ethical and secure AI".[71] Currently, the US is still leading in most categories related to AI, while China is catching up and Europe remains third. China, in particular, is leading in key AI aspects such as the adoption of new AI technologies and in terms of data collected, while starting to challenge the US and surpassing the EU in AI chips and supercomputers.[72] The Center for Data Innovation has measured[73] the performance of these actors in the following six key areas related to AI: 1) Talent; 2) Research; 3) Development; 4) Adoption; 5) Data; and 6) Hardware. The findings are further discussed below, by area.

a. Talent

As indicated above, the extent of access to talents – and any shortages in talents e.g. in the EU as a whole or in particular countries – limits the ability of firms to deploy and adopt AI. It also increases costs, which impacts on competitiveness. Recognising the need to strengthen talents in AI, the EU, China and the US have all started initiatives to increase their AI talent pool. Table 6 provides an overview of the distribution of talent between the three competitors.

Table 6: Talent Distribution between the US, EU and China in 2017

Metric	China	EU	US
Number of AI Researchers	18,232	43,064	28,536
Number of AI Researchers per 1 Million Workers	23.2	172.9	173.1

Source: Center for Data Innovation (2019).

Overall, the EU has a large enough pool of AI researchers to compete with China and the United States. Even in terms of AI research talent (defined as being in the top 10%), some individual EU countries such as Italy, Germany and France have more researchers than China.[74] While the US has less overall AI talent than the EU in absolute terms (see Table 7), its talent tends to be more represented among the 10% AI research talent. A factor contributing to the overall availability of AI research talent in the EU is the brain-drain of European AI researchers that go to work in the US.[75]

A report by the JRC on the *Impact of Artificial Intelligence on Learning, Teaching, and Education*[76] notes that AI has had an impact on advanced digital skills demand. The report notes that the development of new AI and machine learning models requires high levels of competences, which means that AI experts are highly paid and in short supply. *"The number of neural AI experts is perhaps doubling annually, but the basic knowledge needed for state-of-the-art work in this area requires advanced levels of scientific, mathematical and technical skills that are demanding to acquire. Development of new AI methods requires good understanding of statistics, linear algebra, differential equations, as well as computer architectures and emerging chip technologies, programming approaches and tools".*

b. Research

AI still requires research for it to advance and the number of academic papers related to AI has been used as a measure of AI research development. Table 7 gives an overview of each of the competitors' contribution to expanding knowledge around AI.

[71] European Commission. (2018). Communication Coordinated Plan on Artificial Intelligence, Brussels, 7.12.2018, COM(2018) 795 final.
[72] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.
[73] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.
[74] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.
[75] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.
[76] Ilkka, T. et al. (2018). The Impact of Artificial Intelligence on Learning, Teaching, and Education.

Table 7: AI papers in US, EU and China in 2017

Metric	China	EU	US
Number of AI Papers	15,199	14,776	10,287
Number of AI Papers per 1 Million Workers	19.2	59.2	62.6

Source: Center for Data Innovation (2019).

The EU is strong as regards both the quality and output of its AI research.[77] In 2017, however, China surpassed the EU in terms of the number of AI publications.[78] While the US produces fewer AI scholarly papers than both the EU and China, it produces papers of higher quality in terms of the number of top citations. Moreover, unlike the US, the EU struggles to translate research into business applications.[79]

c. Development

The EU, China and the US have all placed a strategic focus on creating a supportive policy environment to foster the development of AI firms. To develop AI solutions, functional AI ecosystems are needed which rely on the availability of finance, expertise and market size. The number of AI firms provides an indication of an AI ecosystem's viability. Moreover, the availability of funding is a way to assess the ability to develop AI firms. These metrics are presented in the following table.

Table 8: Key indicators and investments in US, EU and China's AI ecosystems

Metric	China	EU	US
AI firms (2019)[80]	6400	5120	9000
Number of AI Start-ups (2017)[81]	383	726	1393
AI Venture Capital and Private Equity Funding (Billion USD) (2017-18)	$13.5	$2.8	$16.9
AI Venture Capital and Private Equity Funding per Worker (Billion USD) (2017-18)	$17.2	$11.2	$102.4

Source: CSES secondary research (2020).

As can be seen above, the US has received more private funding than the EU and China.[82] Moreover, on a per-worker basis, the US leads significantly over China and the EU. However, although the EU market of start-ups is diverse and dynamic; it has been found that 25% of AI start-ups are in Europe, only 10% of digital unicorns are based in Europe.[83] It is reported that these companies suffer from a lack of significant investment due to the absence of an appropriate venture capital ecosystem. Moreover, some of Europe's AI firms get purchased by non-EU firms, as illustrated by Facebook's recent purchase of UK companies Bloomsbury AI, Scape Technologies and Deeptide Ltd.[84]

77 Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.
78 Yang, Z. et al. (2018). Artificial Intelligence Related Publication Analysis Based on Citation Counting.
79 Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.
80 European Commission. (n.d.). AI Watch Dashboard.
81 Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.
82 Liu, S. (2020). Artificial intelligence (AI) funding investment in the United States from 2011 to 2019.
83 Bughin, J. et al. (2019). (n.d.), Tackling Europe's gap in digital and AI.
84 O'Hear, S. (2020). Facebook quietly acquired another UK AI startup and almost no one noticed.

As regards public funding, Europe has increased its commitment to developing Artificial Intelligence (AI) technologies. In December 2018, the European Commission released two important strategy documents on AI in Europe, and a Memorandum of Understanding (MoU) on Public-Private Partnerships (PPP) for AI collaboration was also signed. Plus, it was announced that research funding for AI in Europe will increase to EUR 20 billion from now to 2020. Prior to this, funding was provided through the Big Data Value PPP[85] and SPARC PPP, the partnership for robotics in Europe.[86] In addition, some curiosity-driven research through the ERC grants has focused on research into AI technologies. In addition, through Horizon 2020, funding for AI research projects has been supported through Future and Emerging Technologies.[87]

The US is arguably the global leader in AI. It has made significant investments to date and will continue to do so in the near future. For example, in February 2020, the Trump administration announced it planned to double spending on (civil) AI R&D funding from USD 973 million to nearly USD 2 billion by 2022 and to double spending on quantum information sciences spending to USD 860 million within two years.[88] This includes a proposed 70% increase for National Science Foundation (NSF) for AI-related grants and interdisciplinary research institutes to more than USD 850 million.

According to some estimates, the Chinese government is projected to have spent USD 70 billion on AI by 2020 in areas such as fundamental algorithm development, robotics research and smart-infrastructure development.[89] However, the real figure may be significantly lower, as other research suggests the figure on basic AI research may be circa USD 9.4 billion.[90]

d. Adoption

Firms have to adopt AI in order to remain competitive, because it permits both automation and process optimisation through more accurate insights from data. This process in turn helps organisations develop new products and services. Table 9 shows the extent to which companies in the US, EU and China are adopting or experimenting with the use of AI.

Table 9: Firms and AI in the US, EU and China (2018)

Metric	China	EU	US
Firms Adopting AI	32%	18%	22%
Firms Piloting AI	53%	26%	29%

Source: Center for Data Innovation (2019).

In terms of firms adopting AI, the EU is both behind China and the US. In order to measure the distribution of AI adoption, the EU has established an online resource called 'AI Watch'[91] that enables it to measure aspects of AI applications in the EU-28 compared to other global economic competitors such as China and the US. Unlike China, which has a strong distribution of AI firms operating in manufacturing (52%), The EU has, like the US, a greater focus on ICT firms operating in AI; 43.7% and 27.6% respectively. China's lead in AI firms operating in manufacturing is due to recent development in the manufacturing industry; China used manufacturing technologies from the West and through its

[85] Big Data Value Association (BDVA). (n.d.). Big Data Value PPP.
[86] EU-robotics. (n.d.). SPARC.
[87] European Commission. (n.d.). EU-funded FET projects on AI & Cognition.
[88] Shepardson, D. (2020). Trump administration to propose big jump in funding for AI, Quantum R&D: sources.
[89] Hao, K. (2019). Yes, China is probably outspending the US in AI—but not on defense.
[90] Acharya, A. and Arnold, Z. (2019). Chinese Public AI R&D Spending: Provisional Findings.
[91] European Commission. (2020). AI Watch.

cheap labour was able to manufacture goods at lower prices leading many U.S. and European companies to move their manufacturing to China.[92] However China's industrial base has evolved since then, such as the largest consumer of commercial robots in recent years, while the hardware equipment and factories in China tend to be newer than the EU's and are more likely to be able to engage in their digital transformation.[93] The EU's strategy could focus its strengths in research access to high quality data, such as in public health, however the modernisation of the EU's industries should not been discarded given their relative strength and at least 14 out of the top 22 countries in terms of robot density are in the EU.[94, 95]

e. Big Data

AI systems rely on big data to develop accurate models to perform a range of tasks and to recognise patterns. There are no universal metrics for such data, in the research conducted by the Center for Data innovation, access to data for China, the EU and the US has been assessed through measures related to new IoT data and New Productivity Data.

Table 10: Big data levels in US, EU and China in 2018

Metric	China	EU	US
New IoT Data Generated (TB, Millions)	152	53	69
New IoT Data Generated (TB) per 100 Workers	19.3	21.5	41.9
New Productivity Data Generated (TB, Millions)	684	583	966
New Productivity Data Generated (TB, Millions) per 100 Workers	86.9	233.9	585.9

Source: Center for Data Innovation (2019).

For the selected data metrics, the EU is placed third in three out of four metrics. It is placed second in ''New Productivity Data Generated (TB, Millions) per 100 Workers''; however, it still lags significantly behind the US in this measure. Consequently, based on these data, the EU still has a significant gap to fill with its closest competitors in terms of access to big data. However, Table 10 provides a blueprint for the EU on which to compete with both China and the US; given the EU's strengths in New IoT Data generated per 100 workers and New Productivity Data Generated per 100 Workers and its strengths in physical manufacturing, a possible focus could be investment in the manufacturing of IoT products as opposed to solutions based on consumer data where it is lagging.[96]

f. Hardware and components

As regards the manufacturing of hardware and components crucial to AI, European industry is behind compared its main competitors. However, the EU is taking steps to address this lag by having proposed its own European Processor Initiative (EPI) financed by Horizon 2020, whose aim is to implement a roadmap for low-power European processors suited to scale computing, high-performance Big-Data and to foster an High Performance Computing (HPC) ecosystem capable of developing lower HPC chips.[97] The EU retains a strong competitive position in markets such as sensors, especially in niche areas such as EV in the automotive sector. However, it is significantly lagging behind

[92] Ramanathan, S. (n.d.). China's booming AI industry: What you need to know.
[93] Gambardella, L. (2018). China, EU should join hands to work on industrial AI.
[94] Gambardella, L. (2018). China, EU should join hands to work on industrial AI.
[95] Sahin, K. (2019). What China's "Chips Endeavor" Can Teach Europe.
[96] Sahin, K. (2019). What China's "Chips Endeavor" Can Teach Europe.
[97] European Processor Initiative (EPI). (n.d.). EPI.

in other areas, such as the production of semi-conductors, where there has been a continued shift to production in Asia (e.g. China, Taiwan, Singapore) and in the US.[98] Moreover, semi-conductors were identified as being of national strategic interest in the US and China, and therefore the scale of public R&D investment to support these sectors has been very significant. In Europe, support has also been provided through Public Private Partnerships (PPP), namely the ECSEL Joint Undertaking,[99] which manages a EUR 5 billion research and innovation programme to strengthen the EU's electronic components and systems industry.

There are signs that the EU will also fall behind in the production of advanced chips for AI, which are mostly developed by organisations in China and the US (e.g. Alphabet, Facebook, and Baidu), while no EU semiconductor company figures in the top 10 firms in terms of R&D spend. The US is currently leading in both the production of traditional semiconductors and AI computer chips.

g. AI and European digital sovereignty

A final key aspect to consider when examining the EU's global position in AI relates to issues of digital sovereignty and the strategic autonomy of European industry. Strategic autonomy, as a means to achieve digital or technological sovereignty, has been defined as "*the ability, in terms of capacity and capabilities, to decide and act upon essential aspects of one's longer-term future in the economy, society and their institutions*".[100] Considering the metrics presented above, in addition to the dominance of US platforms in the deployment of business-to-consumer (B2C) AI applications, there are challenges and risks facing the EU with regard to ensuring digital or technological sovereignty.

A report by the European Parliament's ITRE committee[101] points to certain concerns regarding the use of AI by companies and entities from third countries. The report notes that these companies "*are increasingly employing AI-based predictive models to provide services and to extract the added value on EU markets, especially at local level, and to monitor and possibly influence political sentiment, thus posing potential threats to the technological sovereignty of EU citizens*".[102]

A further piece of research from October 2019 notes that "*sovereignty and strategic autonomy are felt to be at risk today, being threatened by the forces of rising international tensions, disruptive digital transformations and explosive growth of cybersecurity incidents. The combination of AI and cybersecurity is at the sharp edge of this development and raises many ethical questions and dilemmas*"[103]. Among the ethical challenges for AI and cybersecurity identified in the same article are: identifying trusted strategic partners, as: i) AI is a component to ensure the security and safety of critical infrastructures (e.g. telecoms, smart grids, industry 4.0); and ii) securing AI to enable the effective functioning of smart critical facilities (e.g. to prevent hacking of algorithms that control self-driving cars).

Achieving Europe's strategic independence in specific industrial sectors, such as space, the manufacturing of key electrical components and semi-conductors (including those required to remain globally-leading in 5G) could all have an AI dimension as a tool to ensure strategic autonomy. It is also arguable that the current COVID-19 pandemic (and associated global supply chain dislocations) has heightened awareness regarding European over-dependence on crucial components and sensors from China and the US. A similar analogy could be used in respect of AI, that Europe needs to maintain

[98] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.

[99] ECSEL Joint Undertaking. (n.d.). What we do ... and how.

[100] Timmers, P. (2019). The Ethics of AI and Cybersecurity When Sovereignty is at Stake, Minds and Machines, 29, 635-645.

[101] European Parliament. (2019). A comprehensive European industrial policy on artificial intelligence and robotics.

[102] European Parliament. (2019). A comprehensive European industrial policy on artificial intelligence and robotics.

[103] Timmers, P. (2019). The Ethics of AI and Cybersecurity When Sovereignty is at Stake, Minds and Machines, 29, 635-645.

strategic independent capabilities in these areas, given that it is behind China and the US (although still relatively well-positioned globally).

The EU's February 2020 digital strategy, including the White Paper on AI (discussed further in section 3), as well as national AI strategies in Europe, consider issues around AI and European sovereignty. For instance, considering the issue of maintaining Europe's technological sovereignty in AI by ensuring an independent capability, the White Paper makes clear that "*Harnessing the capacity of the EU to invest in next generation technologies and infrastructures, as well as in digital competences like data literacy, will increase Europe's technological sovereignty in key enabling technologies and infrastructures for the data economy. The infrastructures should support the creation of European data pools enabling trustworthy AI, e.g. AI based on European values and rules*"[104]. In other words, the full benefits of the European strategy for data will only materialise if this is supported by a suitable regulatory and policy framework to capitalise on the benefits of AI. The strategy aims at creating a single market for data that will ensure Europe's global competitiveness and data sovereignty and is discussed further in section 3.[105]

Most national AI strategies also recognise the importance of cooperation at an EU level on AI. Achieving independence in AI and in other digital arenas is expected to serve in enhancing Europe's role in building trust in the wider deployment of such technologies, including by industry. A report for the JRC from 2018 notes that in France, in 2018, the French strategy for AI (known as "Mission Villani") argued for an AI strategy structured around the goals of sovereignty and strategic autonomy.[106] In this respect, data is seen as a public good to also include a dimension of preserving data about society for future generations, and consider whether the state should exercise some degree of sovereignty over national data.[107]

Although achieving digital or technological sovereignty by ensuring that Europe has the capacity and capabilities to deploy AI solutions across industry is important, international, as well as multi-disciplinary, collaboration on the approach to AI and other emerging technologies is also considered to be vital.[108] This is particularly true regarding the ethical and legal considerations that accompany the implementation of AI applications. Arguably, the intention announced in the EU's White Paper on AI could help to strengthen Europe's digital sovereignty by reinforcing European values, and promoting the concept of trust-based and ethical AI. If Europe is either the first or among the first few global regulatory movers in this area, it is possible that other jurisdictions will adopt similar regulatory frameworks, which could help to reinforce the notion of achieving technological sovereignty but in a way that does not preclude collaboration.

h. Conclusion

Despite exhibiting many strengths in the field of AI, particularly in the fields of talent and research compared to China and the US, the EU is punching below its weights in areas such as access to and use of big data and AI technology adoption.[109] Indeed, across a series of measured AI-related dimensions identified in previous studies, such as Talent, Research, Development, Hardware and Adoption, the EU is often in second or third place behind its major global competitors, except as regards the total number of AI researchers.

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[104] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[105] Data sovereignty is the concept that data is subject to EU legislation and governance structures. This is closely linked to issues around data security, cloud computing and technological sovereignty.

[106] Mission Villani sur l'intelligence artificielle. (2018). For a meaningful artificial intelligence. Towards a French and European Strategy.

[107] Joint Research Centre, European Commission. (2018). Artificial Intelligence: A European Perspective.

[108] For example: Rasmussen, A. F. (2020). Opinion: Europe doesn't need 'digital sovereignty' – it needs to collaborate. Protocol.

[109] Castro, D. et al. (2017). Who Is Winning the AI Race: China, the EU or the United States? Centre for Data Innovation.

The EU presently has limited companies which are top players in the field of AI of sufficient critical mass to be competitive at a global level. Moreover, there is a trend towards leading tech firms in third countries, especially the US, often buying the most promising AI firms in the EU. Whilst the EU is clearly an important global player in the AI wave of digital innovation, it needs to catch up to be as competitive as the US, or increasingly China.

There are however EU policy and R&I programme funding initiatives that the European Commission has been taking to address this competitive gap. Most recently, the EU published the AI White Paper, which sets out principles that might underpin the development of a future EU policy and regulatory framework on AI, and facilitate the goal of digital sovereignty. It is evidently important that this does not place a disproportionate burden on SMEs and avoids fragmentation of the single market addressing the market fragmentation in the EU.

The research also makes clear that the industrial potential of AI (and also the growing data economy) needs to be capitalised on in a way that preserves Europe's strategic autonomy both overall, and in key sectors of the economy.

2.3. Impact of Artificial Intelligence on Industry

KEY FINDINGS

AI implementation has already delivered significant positive impacts to European industry. Increasing adoption and the emergence of different types of applications will only drive **further positive impacts in future**. In particular, for individual businesses and at the industry level, these impacts include efficiency benefits, effectiveness benefits and workforce benefits.

Furthermore, the **cumulative effect of these impacts can deliver significant society and economy wide gains**. Extensive productivity, growth, job creation and innovation benefits are envisaged in the near future, and key social impacts are also expected. Prominent amongst these social impacts are the ability of AI to contribute to the achievement of the UN's Sustainable Development Goals and the specific potential to deliver environmental and health-related benefits.

On the other hand, **AI implementation will bring certain challenges**. Most prominently this will include significant changes to the make-up of the EU workforce. In addition, the struggles faced by SMEs in AI adoption at present could lead to overconcentration of large firms and multinationals in the market.

AI applications also bring **significant ethical, trust and legal challenges**, for example, related to security, robustness and resilience of AI systems privacy and data protection; transparency and accountability of AI systems; fairness, discrimination and explainability of AI systems; and liability issues.

Building on the assessment of the technological state of play presented above, this section details the **impacts resulting from the implementation of AI solutions in European industry**. Through discussions on both the positive and negative impacts, this section highlights the nature of the identified impacts, including the stakeholders that are impacted, the scale of the impacts and any related challenges.

2.3.1. Opportunities and positive impacts

The implementation of AI in European industry has achieved a **wide range of positive impacts** already, and further different types of impacts can be expected in future as more firms across a broader range of sectors implement AI. These impacts range from improvements in the efficiency and effectiveness of existing industry practices to the development of entirely new industrial applications. Furthermore, impacts achieved at an organisational level within industry as a whole and in individual companies are expected to drive positive societal and economic changes at both the national and EU levels.

a. Efficiency benefits

At the organisational level, many key **efficiency benefits** being experienced by companies deploying AI solutions are related to business process optimisation, under which many existing applications of AI fall. For example, in an industrial manufacturing context, process improvements can arise through real-time data collection and the analysis of big data from cameras to inspect product quality, or the

collection and analysis of data from disparate locations in a complex factory using cloud-based computing (the **Factory 4.0 concept**)[110]. Digital inventories can also replace physical inventories.[111]

The creation of **'digital twins' of all components in advanced manufacturing industries** can minimise the risk of production stoppages and downtime due to accidental use of the wrong components in production processes. Forms of Industrial additive manufacturing (3D printing) have been effective in the 3D printing of both plastic and metal.[112, 113] If Global Value Chains (GVCs) suffer from dislocation,[114] as happened during the COVID-19 outbreak, and crucial components are unavailable from particular countries due to lockdowns and/ or temporary manufacturing closures, then having a digital inventory with digital twins could enable industry to source components from alternative suppliers.

There are also potential operational efficiency savings in different sectors. For example, in the **energy sector**, process improvements could result from the collection and analysis of data from sensors to provide predictive maintenance capabilities. In the area of **transportation and logistics**, there is scope to analyse bottlenecks in transportation across global value chains so as to identify potential improvements and to reduce transport costs, which could potentially benefit all sectors of the European economy, but particularly those that are heavily dependent on transport for components and/ or produce (e.g. automotive, wholesale and retail sectors).

The resulting benefits from the monitoring and analysis of operational data can include **increased production output, increased production quality and reduced maintenance costs ultimately leading to higher revenues and profits**. Furthermore, similar solutions can result in important **environmental benefits** such as improved energy efficiency, more efficient use of raw materials and reduced waste. This would in turn contribute to EU policy objectives relating to the new EU Action Plan for the Circular Economy,[115] including strengthening the sustainable supply of raw materials within the EU,[116] fostering sustainable development and contributing to the Green Deal.

Interviewees from a range of industrial sectors and stakeholder groups concurred that these were key benefits in areas of AI deployment for process optimisation. The below box illustrates the positive economic outcomes that were achieved through the specific implementation of AI solutions to optimise the production process of a company in the chemicals sector.

Box 2: Case study: Real-life AI application in the chemicals sector

Case study: Production optimisation in the chemicals sector

Context: A large multinational chemicals company was experiencing a range of process inefficiencies that were hindering quality and yield in its production of Ethylene Dichloride (EDC). According to IHS Markit research, over 98% of global EDC consumption in 2018 was in the production of vinyl chloride monomer (VCM), a key ingredient in the manufacture of polyvinyl chloride (PVC).[117] In the same year, the US was found to be the largest producer, consumer and exporter of EDC – accounting for around 30% of global capacity, production and consumption – with Northeast Asia (comprising key European competitors such as China and Japan) in second

[110] Seebo. (n.d.). How Factory 4.0 is transforming production.
[111] Woflgang, K. (2019). Handbook Of Digital Enterprise Systems: Digital Twins, Simulation And AI.
[112] Mraz, S. (2014). Hybridized 3D-Printed Part Combines Plastic and Metal.
[113] Marangell, F. (2019). Metal and plastic 3D printing: hype and the quiet revolution.
[114] Seric, A. (2020). Managing COVID-19: How the pandemic disrupts global value chains.
[115] European Commission. (n.d.). EU Circular Economy Action Plan.
[116] European Commission. (n.d.). Policy and strategy for raw materials.
[117] IHS Markit. (2019). Ethylene Dichloride: Chemicals Economics Handbook.

place and Europe third.[118] Furthermore, significant growth of more than 7-8% per year is still expected in the Chinese PVC market underlining the competitiveness challenge facing European manufacturers.[119]

Challenge: The company was facing formation of higher levels of undesired side products; 6 parts per million as opposed to a target of 2 parts per million. The manufacturer was also experiencing losses of EDC during its separation from the reaction mixture. This resulted in lower quality product and lower EDC yield.

Solution: Using data from Information Technology (IT) and Operational Technology (OT) sources, and insights from the company's process engineers, the production line was modelled and a specific process-based data schema developed. Once modelled, supervised machine learning was used on real-time data to identify five primary root causes suspected of contributing to the high formation of side products. Furthermore, it was identified that the major factors were a combination of different temperatures around the installation column and the flow rate to the distillation column. The flow rate and temperature values were not flagged previously as they were within the ranges permitted by the factory control system. Once these major factors were identified, a predictive simulation was conducted to analyse different scenarios and determine the optimal temperatures and flow rates.

Outcomes: The company reportedly achieved EUR 1.7mn per year in increased yield and quality. Approximately EUR 850k of this was driven by higher sales prices; EUR 450k per year as a result of increased yield; and EUR 400k per year due to increased throughput. It was found that the root cause identified was resulting in excessive pressure in one of the pumps. Fixing the problem also provided a reduction in maintenance on the affected pump.

Source: Seebo. (n.d.). Improving chemical production quality and yield by minimising process inefficiencies.

Considering the **possible scale of these efficiency benefits**, data has been analysed in relation to a range of sectors and industries. For instance, a 2018 survey of energy sector stakeholders anticipates significant economic benefits from AI deployment.[120] The survey data indicated that the majority of respondents (53%, N=51) believe AI will deliver a 10-30% efficiency improvement to the energy sector in the next 5 years.[121] Furthermore, the below box presents an analysis of the positive economic impacts expected through the deployment of smart factories.

Box 3: Forecasted scale of the efficiency benefits to be delivered by smart factories

Smart factories: Scale of future economic benefits[122]

Context: In 2017, Capgemini's Digital Transformation Institute conducted a survey to understand the perceptions of industry with regard to the possible economic benefits of implementing smart factories. Although smart factories comprise more than deployment of AI solutions in a factory environment, AI will play an important role and, in most deployments, will deliver greater value as part of a holistic digital transformation. As such, this analysis represents an interesting proxy for the benefits to be provided by AI. The survey received responses from more than 1,000 executives at manufacturers with a reported revenue of greater than USD 1 bn (EUR 920 mn). The survey covered

[118] IHS Markit. (2019). Ethylene Dichloride: Chemicals Economics Handbook.

[119] Mordor Intelligence. (n.d.). Polyvinyl Chloride (PVC) Market – Growth, Trends, and Forecast (2020-2025).

[120] Henzelmann, T. (2018). Artificial intelligence: A smart move for utilities.

[121] Henzelmann, T. (2018). Artificial intelligence: A smart move for utilities.

[122] Capgemini Digital Transformation Institute. (2017). Smart Factories: How can manufacturers realize the potential of digital industrial revolution.

six industries (Industrial Manufacturing, Automotive & Transportation, Energy & Utilities, Aerospace & Defense, Life Sciences & Pharmaceuticals, and Consumer Goods) and eight countries (China, France, Germany, India, Italy, Sweden, the UK and the US).

Impacts: The analysis presents significant realised and expected benefits, including:

- In 2017, it was anticipated that, in the years 2018-2023, the annual overall productivity gains from smart factories will have a rate of growth seven times higher than the average Compound Annual Growth Rate (CAGR) in the period 1990-2017. For other metrics analysed, this acceleration in the CAGR will reportedly be even greater: for example, a nine times improvement in labour cost is anticipated;
- To put that acceleration into perspective, smart factories are expected to deliver annual overall productivity gains of 5% in the years 2018-2023, and annual labour cost improvements of 4.6%;
- The combination of higher productivity and a lower cost base will have positive P&L implications for manufacturing firms. This was illustrated through a hypothetical case analysis that suggested the implementation of smart factories, in a conservative scenario, could improve operating profit by 1.44 times and operating margin by 1.36 times over the five years 2018-2023;
- The conservative estimate proposed by the analysis forecasts that the predicted productivity gains will add around USD 500 billion (EUR 463 bn) to the global economy by 2023; and
- The analysis also presents the overall productivity and quality gains already achieved as a result of smart factory deployments. All six industries examined have reportedly achieved 17-20% overall productivity gains and 15-20% quality gains, with industrial manufacturing (20% for both) and automotive (19% for both) the most advanced.

Source: Capgemini Digital Transformation Institute. (2017). Smart Factories, How can manufacturers realize the potential of digital industrial revolution.

b. Effectiveness benefits

Beyond the efficiency benefits described above, the implementation of AI solutions has been found to bring about **greater effectiveness in European industry**. In particular, industry stakeholders interviewed for this study noted the opportunity for greater product personalisation, improved customer service and a large number of opportunities for innovation, including in the development of new product classes, new business models and even fostering the emergence of new sectors.

For example, considering the development of new products, the life sciences and pharmaceutical industries (in particular, drug development) are areas already showing promise. Specific examples in this area include:

- The drug candidate DSP-1181, created for the treatment of obsessive-compulsive disorder (OCD), entered a phase 1 clinical trial in January 2020. Combining expertise in monoamine GPCR drug discovery and an AI platform developed by UK-based company Exscientia, the **molecule was identified by using AI to analyse potential compounds** against 'demanding selectivity and development criteria'.[123] The exploratory research phase for the drug candidate lasted 12 months. This is reportedly a reduction of 3.5 to 5 years compared to the average time using conventional research techniques. As such, should the drug be successful through

[123] Exscientia. (2020). Scaling.

clinical trials, this would not only bring significant benefits to patients with OCD, but would represent significantly quicker time to market and reduced R&D costs for the company;[124] and

- In February 2020, an **antibiotic called halicin was identified using machine learning**.[125] Using a library of 2,335 molecules for which antibacterial activity against the bacterium *Escherichia coli* (*E. coli*) was known, the researchers from the Massachusetts Institute of Technology developed and trained a deep learning model to identify molecules that inhibit the growth of *E.coli*. Once trained, the team set the model the task of screening the Drug Repurposing Hub, a repository of around 6,000 molecules, and identifying molecules that would be effective against *E.coli* but differ from conventional antibiotics. The model identified around 100 candidate molecules, one of which – named halicin – was found to be active against a range of pathogens in subsequent tests in mice, including a 'pan-resistant' strain of *Acinetobacter baumannii*.[126] Furthermore, at a more systemic level, the research 'identified eight antibacterial compounds that are structurally distant from known antibiotics',[127] indicating the possible presence of effective antibiotics in molecule types not previously considered by conventional research.

The examples show that AI can accelerate product development lead-times.

Technologies such as **Augmented Reality (AR) and Virtual Reality (VR)**[128] can also help to accelerate product development processes,[129] as product prototypes can be developed using 3D printing and then these can be tested using augmented reality or VR. VR accelerates product design by providing product models for engineers that are close to reality. AR relates to a situation when "*the digital product or information is projected on to a real-world background, rather than a digitally simulated one like VR*".[130] European industry can now plan production and assembly processes in a virtual world, which can speed up the commissioning of new digitalised factories and improve existing production operations.

Moreover, the increasingly widespread availability of these technologies –and price reductions in additive manufacturing which make them accessible to a broader range of firms, including more SMEs - could have implications as regards the reshoring of high-value added manufacturing activities, such as product design.

c. Workforce benefits

Another area of positive impacts related to the deployment of AI solutions in European industry concerns the **workforce**. Although, as discussed further below, there will likely be significant challenges related to the replacement of roles by automation and AI, interviewees from all stakeholder groups stressed that AI implementation also represents an opportunity for significant cultural change within organisations. Key elements of this cultural change will reportedly include improved workplace safety, as workers reskill for safer roles and companies improve their ability to provide safer and more effective training and guidance, including through the use of augmented reality and VR. In a factory context, deploying AI technologies could lead to a reduction in human error.

[124] Exscientia. (2020). Press Release: Sumitomo Dainippon Pharma and Exscientia Joint Development New Drug Candidate Created Using Artificial Intelligence (AI) Begins Clinical Trial.

[125] Marchant, J. (2020). Powerful antibiotics discovered using AI.

[126] Stokes, J. et al. (2020). A Deep Learning Approach to Antibiotic Discovery.

[127] Stokes, J. et al. (2020). A Deep Learning Approach to Antibiotic Discovery.

[128] Greenwald, W. (2018). Augmented Reality (AR) vs. Virtual Reality (VR): What's the Difference?

[129] Chang, P. (2018). How Augmented Reality Can Accelerate Your Time to Market.

[130] Advice Manufacturing. (n.d.). Virtual and Augmented Reality.

A report for the EU-OSHA, *Artificial Intelligence: Occupational Safety and Health and the Future of Work,* notes that *"Amazon has 100,000 AI augmented cobots, which has shortened the need for training workers to less than two days. Airbus and Nissan are using cobots to speed up production and increase efficiency. Many companies are integrating robots onto the shop and factory floor to assist and collaborate with workers"*. AI and machine learning could be used to improve occupational health and safety,[131] for instance, in manufacturing facilities. A further EU-OSHA report[132] indicates that *"robots allow people to be removed from dangerous physical work and environments with chemical and ergonomic hazards"*.

A sector-specific example is now provided. A stakeholder representing the textiles industry noted that AI use in fabric inspection systems will ease the work of employees who would historically conduct intensive manual fabric inspection, while improving accuracy. Another more detailed example is detailed in the below box.

Box 4: Case study: Real-life AI application for workplace safety

Case study: Workplace safety in the telecommunications sector

Context: Health and safety laws require that companies implement measures to protect their workers. At the EU level, the relevant rules are stipulated in the Occupational Safety and Health Framework Directive (Directive 89/391 EEC) and complementary individual Directives on specific tasks, specific hazards, specific workplaces or sectors, specific groups of workers, and certain other work-related aspects. Member States are also able to adopt stricter rules when transposing the legislation.[133]

Challenge: To ensure compliance with the legislative environment and to ensure the safety of its workers, companies across the EU are required to implement workplace safety measures. The UK and Ireland branch of Cisco, a large technology company that also develops and manufactures telecommunications equipment, wanted to examine how technology could reduce the frequency and impact of human errors that result in workplace accidents. At Cisco, a key example of this related to the process of checking the use of appropriate Personal Protective Equipment (PPE) and other safety gear; checks that were conducted by humans and prone to error.

Solution: In 2018, with funding from Innovate UK, the UK government's innovation agency, Cisco UK and Ireland worked in collaboration with AI firm Cortexica to develop and deploy an autonomous monitoring system. This monitoring system – called AI-SAFE (Automated Intelligent System for Assuring Safe Working Environments) – reportedly utilises machine learning and advanced algorithms to analyse real-time video footage of its staff captured via video cameras placed above work environment entry and exit points.

The system can assess if an employee is wearing the correct safety equipment, for example, headgear, eyeware, footwear and other PPE, by comparing it with pre-established rules for entering the work environment. The system will flag non-compliance and the individuals will not be allowed in the work area until appropriately equipped.

Outcomes: The primary impacts achieved as a result of AI-SAFE are reported to include: the ability to monitor health and safety threats automatically; the ability to enact real time threat mitigation and reduce the number of workplace accidents that result from the use of inappropriate PPE; reductions in the cost and time of manual human monitoring; and reductions in the risk of financial

[131] Moore, P. (2019). Artificial Intelligence: Occupational Safety and Health and the Future of Work.

[132] Stacey et al. (2018). Foresight on new and emerging occupational safety and health risks associated with digitalisation by 2025.

[133] European Agency for Safety and Health at Work. (n.d.). European directives on safety and health at work.

or reputational penalties. No quantitative data is available on the scale of the impacts achieved by AI-SAFE; however, it is worth noting that work-related injuries and illnesses represent a significant cost to the EU economy. In 2017, the EU Agency for Safety and Health at Work (EU-OSHA) placed the cost at EUR 476 billion per year.[134]

When considering other uses for this specific AI application (e.g. inspecting use of PPE on a construction site), as well as other AI solutions in the area of occupational health and safety (e.g. for undertaking dangerous tasks), representatives of industry interviewed for this study noted that there is a significant opportunity to use AI applications to drive reductions in such costs.

Source: Chrissos, N. (2018). Introducing AI-SAFE: a collaborative solution for worker safety.

Furthermore, interviewed industry stakeholders anticipated that the impacts on job safety will, in the longer term, lead to an improved image of industrial jobs (less manual, more high-tech and digital) and therefore the scope to increase the supply of skilled workers to meet the increase in demand anticipated. For example, a 2018 survey of stakeholders across a range of industries found that 69% of respondents expect AI to have a positive impact on job creation in the next five years.[135]

d. Wider socio-economic benefits

Beyond the organisational benefits, there is a broad consensus across all stakeholder groups interviewed and literature reviewed for this study that **AI will have significant positive societal and economic impacts**. For instance, a study by Accenture, which analysed 12 developed economies[136] that generate more than 0.5% of the world's economic output, forecasted that, by 2035, AI could lead to a doubling of the annual economic growth rates in these countries.[137] In addition, the study forecasted that AI will: i) lead to a strong increase in labour productivity (between 11% and 37% by 2035) due to innovative technologies enabling more efficient workforce-related time management; ii) create a new virtual workforce capable of solving problems and self-learning; and iii) benefit the diffusion of innovation, which will create new revenue streams.[138]

This research is supported by a 2018 report by the Economist Intelligence Unit, who conducted a survey that examined perceptions of stakeholders across a range of industries on the potential economic impacts of AI.[139] The vast majority of respondents to this survey expect positive impacts for growth (90% of respondents), productivity (86%), innovation (84%) and, as mentioned above, job creation (69%).[140] Research by IBM and Gartner has also produced similar findings. Concerning job creation, for example, Gartner estimates that, in 2020, AI will create around 500,000 more jobs than it eliminates,[141] and IBM finds that 65% of industry respondents to its Institute for Business Value survey anticipate that AI will have a significant to moderate impact on demand for skills in the coming years,[142] with 67% of

[134] European Agency for Safety and Health at Work. (2017). Article: An International Comparison of the Cost of Work-Related Accidents and Illnesses.

[135] Chen, J. et al. (2018). Intelligent Economies: AI's transformation of industries and society.

[136] At the time of the analysis (2016), 10 of the 12 countries analysed were EU Member States: Austria, Belgium, France, Finland, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom. The remaining two countries analysed were Japan and the US.

[137] Purdy, M. and Daugherty, P. (2016). Why AI is the future of growth.

[138] Purdy, M. and Daugherty, P. (2016). Why AI is the future of growth.

[139] Chen, J. et al. (2018). Intelligent Economies: AI's transformation of industries and society.

[140] Chen, J. et al. (2018). Intelligent Economies: AI's transformation of industries and society.

[141] Gartner. (2017). Press release: Gartner Says By 2020, Artificial Intelligence Will Create More Jobs Than It Eliminates.

[142] IBM Institute for Business Value. (2018). The artificial intelligence effect on industrial products: Profiting from an abundance of data.

respondents perceiving that advancements in automation technology will require roles and skills that do not currently exist.[143]

Beyond the anticipated economic benefits, **many stakeholders anticipate some of the most significant positive impacts will be environmental and health-related**. Considering the environmental impacts, not only will there be a cumulative positive impact from greater energy efficiency, more efficient use of raw materials and reduced waste at the organisational level, there will be systemic benefits as a result of AI adoption. Examples include the following:

- Energy companies will have an increased capability to understand user behaviours and energy consumption, allowing those companies to respond more efficiently to those demands at a system wide level;[144] and
- Another example relates to how AI can benefit the renewable energy sector. More specifically, a key challenge facing renewable energy is the impact of unpredictable weather on the supply of energy from solar and wind sources. As highlighted above, AI solutions can increase the ability to understand and accommodate energy demand, as well as better understand the weather to automatically control systems in the present and forecast production needs in the near future. Intelligent Energy Storage (IES) units can also provide greater control over energy allocation.[145]

As noted earlier, in the pharmaceutical sector, greater use of AI could accelerate the development of drugs, but could also strengthen analytical capabilities. The box below illustrates some of the key AI applications that can deliver positive benefits for the healthcare sector.

Box 5: Case study: Real-life applications of AI in the healthcare sector

Case study: The use of AI in the healthcare sector – strengthening predictive analytics to better predict future pandemics and monitor their progression. The role of AI in developing vaccines.

Context: Global health crises, such as the COVID-19 pandemic, heighten the need for industry and publicly funded research to be able to deploy AI to strengthen monitoring and modelling of the spread of future pandemics. AI in healthcare is already well-developed and can be used as a tool to diagnose different diseases. However, some commentators have argued that in the case of the COVID-19 epidemic, AI failed to predict the epidemic in a sufficiently timely way;[146] therefore, lessons could be learned as regards how to better deploy AI technologies in future, for instance in strengthening the accuracy of statistical modelling in future pandemic scenarios, in improving AI's role in predicting the timing of future pandemics in order to strengthen mitigation and preparedness, and as a tool to accelerate the identification of a vaccine.

Challenge: The need for publicly-funded research – working in partnership with European industry – to respond sufficiently quickly to address urgent global health challenges, such as the COVID-19 pandemic.

Here, we present a selection of examples of AI-led solutions that could contribute to tackling such a challenge.

[143] IBM Institute for Business Value. (2019). Research insights: The enterprise guide to closing the skills gap: Strategies for building and maintaining a skilled workforce.

[144] Bilodeau, S. (2019). Artificial intelligence in a "no choice but to get it smart" energy industry!

[145] Georgiou, M. (2019). The Role of AI Technology in Improving the Renewable Energy Sector.

[146] Singh Bisen, V. (2020). Blog: How AI Can Predict Coronavirus like Epidemic Before it Outbreaks?

Solutions: Example 1: A Canada-based global health monitoring platform notified its clients of the coronavirus outbreak on December 31, 2020. The algorithm in Canada used machine learning (ML) and natural language processing (NLP) technology to detect signs of potential disease outbreaks from information collected. This data can then be fed into models and used for training purposes to allow for the refinement and improvement of the accuracy of the data used in such AI models. According to a blog article, the algorithm used a combination of airline ticketing information and news monitoring of the outbreak, including of online forums, blogs and indications of some kind of unusual events taking place. It was then able to accurately predict the virus' rapid spread from Wuhan, China, to large cities in other Asian countries such as Bangkok (Thailand), Seoul (South Korea), and Tokyo (Japan).

Example 2: A report on the use of AI in medical epidemiology [147] predicted dengue fever outbreaks and spread with more than 80% accuracy in Malaysia.

Example 3: Both AI and machine learning could also be at the forefront of research into the development of a coronavirus vaccine. [148] AI can spot patterns in very large datasets and analyse this data using huge computing capacity to make predictions. AI could therefore help to identify which existing drugs offer the most promising hope as regards testing on humans with a view to developing a vaccine in the near future. However, Information Week points out that 'AI requires extensive data to be effective. Even for symptom checking machine learning algorithms, it could be 6-12 months before there is enough peer-reviewed scientific literature to inform the design'. [149]

Lessons learned: These examples demonstrate the value of predictive analytics platforms that use AI. The use cases show how AI could be used to improve predictive capabilities regarding the outbreak and spread of epidemics in future. If potential global health crises could be identified more readily before they actually occur, and their likely degree of severity once there is an outbreak, EU and national policy makers could be alerted earlier, better enabling them to take the necessary prevention measures, facilitate preparedness and resilience planning earlier and to plan, implement and model mitigation measures in a more timely manner.

The use of AI could provide more sophisticated modelling tools to project how an epidemic (or pandemic) is likely to spread over time. The use of machine learning could help in the improved detection of those having succumbed to a disease that may appear asymptomatic and help to accelerate the identification of vaccines.

Benefits of greater use of AI in pandemic modelling and in human testing leading to the development of vaccines: Improving predictive analytics for infectious diseases could reduce the human and societal, as well as the economic costs of future epidemics and pandemics. A significant advantage of AI is the accelerated speed of development of drugs. However, very few AI firms have yet reached clinical trial stage with humans, partly as AI health firms are relatively new, but also because even with accelerated development using big data analytics, clinical trial processes take time, as well as the regulatory testing and licensing process before they can be rolled out to the public.

Source: Singh Bisen (2020), AIME (2019), Grossman (2020) and CSES elaboration.

In addition, many stakeholders have analysed how **AI, through its environmental and health impacts, can make a positive contribution to the UN Sustainable Development Goals** (SDGs). For

[147] AIME (Artificial Intelligence in Medical Epidemiology). (2019). The use of AI in Dynamic Dengue Outbreak Surveillance & Forecasting.

[148] Grossman, G. (2020). Blog: The Role of AI in the Race for a Coronavirus Vaccine.

[149] Grossman, G. (2020). Blog: The Role of AI in the Race for a Coronavirus Vaccine.

instance, concerning climate action, an analysis by PwC and Microsoft found that the use of AI for environmental applications has the potential to reduce global greenhouse gas emissions by between 1.5% and 4% by 2030,[150] as compared to Business as Usual (BAU).[151] This equates to a reduction of 0.9-2.4 gigatons of CO_2e and an overall reduction in carbon intensity of 4.4% to 8.0%.[152]

Considering healthcare, the 2030Vision Global Goals Technology Forum – a partnership of businesses, NGOs and academia – examined how the healthcare sector is using AI to address the SDGs.[153] The health-related AI applications and impacts highlighted by the 2030Vision state of play report on AI and the SDGs reflect those mentioned above; for instance, augmenting and improving diagnosis and treatment, improving foetal health, modelling, predicting and monitoring epidemics and chronic diseases, improving the provision of primary healthcare services, enhancing medical research and drug discovery.[154]

Furthermore, many industry stakeholders interviewed for this study commented that implementing **Industry 4.0 in industry will not be possible without the adoption of AI and machine learning solutions**, thereby placing AI as a central enabler of, and contributor to, the positive anticipated impacts of the fourth industrial revolution, including the following global impacts:[155]

- Estimated manufacturing efficiency gains of 6-8% per year;
- Increased global investment in the industrial internet, reported to increase from USD 20 billion (EUR 18.5 billion) in 2012 to more than USD 500 billion (EUR 462.5 billion) in 2020;[156] and
- Significant value-added gains from the industrial internet, reported to increase from USD 23 billion (EUR 21.3 billion) in 2012 to nearly US 1.3 trillion (EUR 1.2 trillion) in 2020.[157]

In addition, an analysis of the potential impact of industry 4.0 at the national level, focused on Germany, found that benefits would be achieved four areas:[158]

- **Productivity** across all German manufacturing sectors is anticipated to increase by EUR 90-150 billion;
- Around EUR 30 billion in additional annual **revenue growth** is anticipated; this is around 1% of Germany's GDP;
- **Employment** will increase by 6% in the years 2015-2025 as a result of the economic growth driven by industry 4.0. The analysis also noted, however, that, as mentioned above, the growth will rely to a certain extent on a significant shift in the skill profile of employees; and
- **Investment** in adapting production processes and incorporating industry 4.0 will require an estimated EUR 250 billion in investment in the period 2015-2025.

A final potential wider scale positive impact of AI in industry is increased cyber security and privacy protection. Although privacy and cyber security risks rise with the increased connectivity and data collection that enables AI, industry stakeholders interviewed for this study noted that AI also plays an important role in ensuring the robustness and resilience of digital and cyber-physical systems, the

[150] Herweijer, C. et al. (2019). How AI can enable a Sustainable Future.
[151] IPCC. (2018). Special Report on Global Warming of 1.5 Degrees.
[152] Herweijer, C. et al. (2019). How AI can enable a Sustainable Future.
[153] 2030Vision Global Goals Technology Forum. (2019). AI & The Sustainable Development Goals: The State of Play.
[154] 2030Vision Global Goals Technology Forum. (2019). AI & The Sustainable Development Goals: The State of Play.
[155] European Parliamentary Research Service. (2015). Briefing: Industry 4.0: Digitalisation for productivity and growth.
[156] Floyer, D. (2013). Defining and sizing the industrial internet.
[157] Floyer, D. (2013). Defining and sizing the industrial internet.
[158] Gebert, P. (2015). Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries.

management of personal data and responding to cyber-attacks. As the complexity and sophistication of the cybersecurity threat landscape increases, AI is also being used to detect, prevent, analyse and respond to cyber threats.[159] For example, email platforms use machine learning for spam detection, with Gmail reportedly blocking an additional 100 million spam emails a day,[160] and cybersecurity companies use AI to analyse enterprise attack surfaces, automatically collecting and assessing 'up to several hundred billion time-varying signals from the extended network of devices, apps and users'.[161]

2.3.2. Challenges and negative impacts

As with the advent of any new technologies, whilst there are potential significant benefits, there may also be challenges and negative impacts associated with the increased deployment of AI in an industrial context.

In a Factory 4.0 setting, the deployment of AI, machine learning and other technologies falling under Industry 4.0 can have many potential benefits, such as operational efficiencies and improved workplace health and safety due to more limited scope for human error; equally, concerns have been expressed as regards the use of autonomous systems depending on their degree of autonomy without human monitoring.

For example, on February 16, 2017, the European Parliament adopted a legislative initiative resolution in which it recommended a range of legislative and non-legislative initiatives in the field of robotics and AI to the European Commission.[162] The need to strengthen the legal framework to clarify legal liabilities was stressed *"where a robot can take autonomous decisions, the traditional rules will not suffice to give rise to legal liability for damage caused by a robot, since they would not make it possible to identify the party responsible for providing compensation and to require that party to make good the damage it has caused"*.

AI has a clear advantage in that it is already able to replace repetitive tasks in a factory through robotics and automation, which in time will be more able to perform more highly-variable tasks.[163] However, a potential adverse impact of AI deployment is the **risk of some jobs being replaced by robots**, especially in industrial areas. OECD research,[164] for instance, has estimated that, on average, about 14% of jobs in OECD countries are highly automatable and another 32% of jobs could face substantial changes.

As pointed out in the OECD's study *Preparing for the changing nature of work in the digital era*[165], there are already significant impacts across many sectors of AI *"machine learning, which underpins advancements in artificial intelligence (AI), is already being adopted by a range of industries, affecting even high-skill jobs like finance or law"*.

The counterargument to concerns regarding this workforce issue is that, although **AI may replace humans in some jobs, it will create new, higher-value added employment,** and eliminate more mundane and more dangerous tasks, thereby freeing up the factory workforce to do higher-skilled jobs. Indeed, while technological progress can reduce labour intensive activities, process innovations may decrease prices and increase incomes, which will further boost demand and therefore lead to job

[159] EC-Council. (2019). Blog: The Role of AI in Cybersecurity.

[160] Vincent, J. (2019). Article: Gmail is now blocking 100 million extra spam messages every day with AI.

[161] Balbix. (2020). Balbix website homepage.

[162] European Parliament, (2017), Report with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)).

[163] Tilley, J. (2017). Automation, robotics, and the factory of the future.

[164] OECD. (2018). Putting faces to the jobs at risk of automation, Policy Brief on the Future of Work.

[165] OECD. (2019). Preparing for the Changing Nature of Work in the Digital Era.

growth, especially with regard to R&D expenditures.[166] However, these positive employment effects appear mostly in medium-and high-tech sectors, and were not reported in traditional low-tech industries.[167] This will require European industry to prepare for continuing workplace and technological changes, especially in lower tech-intensive factories, to ensure that its workforce and industries are able to benefit from AI.

A further potential negative – at least in the early stages of AI adoption – is that large firms are much better placed to take advantage of the opportunities afforded by AI to derive further competitive advantage over their SME counterparts. This could lead to further **overconcentration in the market of large firms and multinationals** in particular sectors if they are able to derive operational efficiencies. An industry association interviewed for this study mentioned that significant capital investment can be required to make the necessary investments to upgrade factories and production facilities, for instance to become automated and introduce robotics, and to invest in AI software to capture big data and strengthen data analytics capabilities and machine learning. Many SMEs lack access to sufficient finance to make the necessary capital investments, although the costs of automation software have been reduced in the past few years, making some aspects of digitalisation adoption more affordable for SMEs.

A further aspect of AI that may have a negative impact in industry is that **AI lacks the emotional intelligence to know the context and impact of its decisions, and lacks creativity**, which are key competitiveness drivers in some industries, and require human input. However, looked at from another perspective, AI can allow decision-making to be improved using big data and the factory workforce's time can also be freed up from repetitive tasks. This could allow staff to work instead on other tasks and for the firm to focus human interventions more on fostering new ideas and creative solutions, for instance, in industrial applications.

There are also concerns as regards the **use of AI for profiling and decision-making purposes** if there are inadequate safeguards in place. *"Profiling, as part of AI decision-making, could result in repercussions when collecting and processing sensitive data such as race, age, health information, religious or political beliefs, shopping behaviour and income".* For example, people may be turned down for a loan, or for a job application or even in an interview, based purely on a decision made using AI technologies. However, there are mitigating safeguards, such as Art. 22 of the GDPR (see Box 6), which provides safeguards and protections so that decision-making cannot solely be made based on AI. This issue is examined further in Section 3.1.2.

Box 6: Key concepts: Art 22 of the GDPR

Excerpt from Article 22 EU GDPR: Automated individual decision-making, including profiling

Paragraph 1: *"The data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her."*

Source: Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation, GDPR).

There are also **privacy considerations in relation to the use of AI in certain sectors,** the development and use of AI-powered facial recognition technologies has been controversial, when

[166] Piva. M. and Vivarelli, M. (2017). Technological Change and Employment: Were Ricardo and Marx Right?
[167] Piva. M. and Vivarelli, M. (2017). Technological Change and Employment: Were Ricardo and Marx Right?

used for instance for security and law enforcement purposes, and even in industrial contexts. The use of AI algorithms can also be considered intrusive in some instances, by citizens unless deployed carefully by industry. Whilst the GDPR and the e-Privacy Directive (and the proposed e-Privacy Regulation) covers many aspects of privacy, there are concerns that the unauthorised use of facial recognition without the data subject's consent would constitute a privacy breach under GDPR. There is also the negative risk associated with the use of AI to conduct profiling and decision-making (explored later in the report, but prohibited under the GDPR Article 22).

3. REGULATING ARTIFICIAL INTELLIGENCE: STATE OF PLAY AND EUROPEAN PARLIAMENT APPROACH TO SCRUTINY

KEY FINDINGS

Limited legislative activity has been conducted on AI globally. Instead, the AI policy and regulatory environment to date has primarily been characterised by initiatives from industry, civil society and standards bodies. Most prominently, these include: standardisation efforts, the development of codes of conduct and ethical frameworks for AI; and a range of technical and policy tools.

In Europe, **the EU has not taken specific legislative action on AI but has engaged with the topic through various policy documents**. These include the EU's first strategy 'AI for Europe' and the associated Coordinated Plan, which outlined a vision for AI policy focusing on significant public and public-private investment, adaptation of training and education systems, and development of key AI enablers, such as a well-functioning data ecosystem.

In addition, the **EU has conducted significant work on AI ethics**, including through its High-Level Expert Group on AI. In February 2020, the European Commission published a White Paper on AI that presents a framework for developing ecosystems of excellence and trust, while indicating possible mechanisms for future regulation of AI, including placing legal requirements on 'high-risk' AI applications. The Commission also published a European strategy for data, which presents a vision for ensuring a data-agile economy and plans for Common European data spaces, including in manufacturing.

Furthermore, it is important to note that, specifically in relation to data protection and privacy risks related to AI, **the GDPR is a key piece of existing legislation**, as it provides protection against misuse or abuse of personal data using AI, in particular through Art. 22 on automated profiling and decision-making.

It is also notable that **none of the EU's competitors have developed horizontal regulation on AI issues**. However, they have all developed some type of strategy and / or non-binding guidance documents. These strategies, although they may not place a significant focus on ethics, are strongly focused on similar investment and workforce objectives as the EU's approach.

3.1. Regulating Artificial Intelligence – current state of play

To date, the **majority of activities aiming to influence the development and deployment of AI have been enacted by industry, civil society and standards bodies**. These activities include standardisation efforts, the development of codes of conduct and ethical frameworks and the development of technical tools. Additionally, the primary focus of many of these activities has been ensuring the use of AI is ethical.

This section briefly details some of these initiatives before detailing the EU's activities in relation to AI and the activities of key competitor countries. Whilst as outlined in the White Paper on AI, the EU is considering regulation in future to ensure that the potential benefits of AI are exploited in a way which is compliant with European values and fundamental rights, it has not yet done so. Moreover, there do not appear to be any regulatory interventions at Member State level to regulate AI.

3.1.1. Initiatives from industry, civil society and standards bodies

This sub-section discusses prominent initiatives implemented by non-governmental entities, including private companies and industry associations/collaborations, standards bodies and civil society organisations. These initiatives include EU and international-level standardisation efforts, the publication of codes of conduct by a variety of different stakeholder groups and the development of technical tools.[168]

a. Standardisation efforts

Within this group, key actors in standardisation have undertaken initiatives in recent years. These stakeholders include the three European Standards Organisations (ESO) – the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunications Standards Institute (ETSI) – as well as international standardisation bodies, such as the International Organisation for Standardisation (ISO) and the Institute of Electrical and Electronics Engineers (IEEE).

Considering the ESOs, **CEN and CENELEC** support the work of the ISO through the establishment of a Focus Group on Artificial Intelligence in early 2019.[169] This Focus Group aims to develop an AI standardisation roadmap for Europe and fulfils an advisory role towards other CEN-CENELEC technical committees, for example in relation to advanced manufacturing (CEN/TC 438 additive manufacturing; and CEN/TC 310 advanced automation technologies and their applications).[170] The delivery of the AI standardisation roadmap is anticipated in early 2020.[171] **ETSI** is also engaging with AI through the following specific Industry Specification Groups (ISG). Given ETSI's focus on the telecommunications industry, these ISGs tackle issues of network management and cybersecurity:

- ISG on **Securing Artificial Intelligence** (SAI). This group aims to tackle the cybersecurity challenges associated with expanding deployment of AI solutions; namely, 'using AI to enhance security, mitigating against attacks that leverage AI, and securing AI itself from attack';[172]
- ISG on **Experiential Networked Intelligence** (ENI). This group is 'defining a Cognitive Network Management architecture'[173], which uses AI techniques to monitor, analyse and adjust the services provided by networks in response to user needs, business goals and environmental conditions.[174] Specific use cases for this work include optimisation of energy usage or the provision of intelligent software rollouts;[175] and
- ISG on **Zero touch network and Service Management** (ZSM). This group has specified a framework of architectural, functional and operational requirements necessary for fully automated end-to-end network and service management.[176]

[168] Optimity Advisors. (2018). algo:aware, Raising awareness on algorithms, State-of-the-Art Report on algorithmic decision-making, commissioned by DG Connect, European Commission.

[169] ShareWork. (2019). D8.3 Report on the standardisation landscape and applicable standards, Project: H2020-NMBP-FOF-2018 No 820807 on Safe and effective human-robot cooperation towards a better competitiveness on current automation lack manufacturing processes.

[170] CEN-CENELEC. (2019). Artificial Intelligence, Blockchain and Distributed Ledger Technologies.

[171] CEN-CENELEC. (2019). Focus Group on Artificial Intelligence (AI), CEN-CENELEC Roadmap for AI Standardisation, CEN-CLC/AI FG N 004.

[172] ETSI. (n.d.). Industry Specification Group (ISG) Securing Artificial Intelligence (SAI).

[173] ETSI. (n.d.). Experiential Networked Intelligence.

[174] ETSI. (n.d.). Experiential Networked Intelligence.

[175] Sharma, D.C. (2019). TSDSI-IIT Workshop on ML and standards, 5G and Beyond, Presentation delivered by the Seconded European Standardisation Expert in India (SESEI).

[176] ETSI. (n.d.). Zero touch network & Service Management (ZSM).

At the international level, the **ISO** has established the Joint Technical Committee JTC 1/SC42 to tackle AI-related standardisation issues. The Committee currently has eleven working groups focusing on the areas of Big Data, foundational AI standards, AI trustworthiness, ethical and societal concerns, applications, use cases, AI governance implications and computation approaches of AI.[177] To date, the Committee has solely published standards on Big Data[178] but it is developing a range of other standards, for example related to bias in AI systems, governance implications of the use of AI by organisations, a framework for AI systems using ML, and an overview of computational approaches for AI systems.[179]

Additionally, the **IEEE** is undertaking a range of AI-related activities, including the work of the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems, which focuses on how to apply ethical AI principles in practice through its treatise on Ethically Aligned Design.[180] In addition to addressing the ethical challenges related to AI, the IEEE is developing standards on specific aspects. These include through IEEE Digital Reality, an IEEE Future Directions initiative that aims to develop and maintain standards related to VR, AR and related areas through collaboration between global technologists, engineers, regulators and ethicists.[181]

There is a consensus among stakeholders that standards will play a key role in supporting and complementing regulation of AI applications by providing implementers with practical guidance on ensuring regulatory objectives and requirements are met.[182] As such, many industry stakeholders interviewed for this study stressed that EU policy-makers should promote engagement in global standardisation of AI and consider how standards can support the EU's policy and regulatory response to challenges faced in the implementation of AI applications.

b. Codes of conduct and ethical frameworks

Given the challenges associated with the deployment of AI in many scenarios, a long list of stakeholders have developed codes of conduct, ethical principles and ethical frameworks for AI development and implementation.[183] In fact, a 2019 analysis identified 84 such documents providing ethical guidelines or principles for AI.[184] These guidelines include:

- **Industry-led initiatives**. including from industry associations, private companies and other collaborations. A prominent example of such an initiative is the Partnership on AI, which was formed by six companies in 2016 (Apple, Amazon, Google/DeepMind, Facebook, IBM and Microsoft) and now brings together more than 100 companies, academic institutions and non-profit organisations to develop best practice, foster discussion and improve public understanding of AI. The partnership on AI works across six thematic pillars: i) safety critical AI; ii) fair, transparent and accountable AI; iii) AI, labour and the economy; iv) collaborations between people and AI systems; v) social and societal influences of AI; and vi) AI and social good.[185] Additional examples from industry include guidance on Ethical Principles for AI and

[177] ISO/IEC JTC 1. (2019). ISO/IEC JTC 1/SC 42 Artificial Intelligence.

[178] ISO. (n.d.). Standards by ISO/IEC JTC 1/SC 42: Artificial intelligence, Published standards.

[179] ISO. (n.d.). Standards by ISO/IEC JTC 1/SC 42: Artificial intelligence, Standards under development.

[180] IEEE. (n.d.). Ethics in Action: The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems.

[181] IEEE. (n.d.). IEEE Digital Reality: Standards.

[182] DigitalEurope. (2019). DIGITALEUROPE recommendations on standardisation in the field of Artificial Intelligence.

[183] Optimity Advisors. (2018). algo:aware, Raising awareness on algorithms, State-of-the-Art Report on algorithmic decision-making, commissioned by DG Connect, European Commission.

[184] Jobin, A., Ienca, M. and Vayena, E. (2019). Artificial Intelligence: the global landscape of ethics guidelines.

[185] Partnership on AI. (n.d.). About Us, Our Goals, Our Work.

Data Analytics from the Software and Information Industry Association (SIIA)[186] and the development of AI Policy Principles by the Information Technology Industry Council (ITI).[187] Individual companies have also taken it upon themselves to develop frameworks for AI development, such as Bosch who developed an ethical code for its use of AI;[188] and

- **Civil society and academia-led initiatives**. A vast number of civil society groups and academic collaborators, both globally and within the EU, have developed principles, codes or frameworks to support the implementation of AI applications from an ethical perspective. Prominent examples include: the NESTA public sector principles, which relate specifically to AI use in the public sector;[189] the *Algorithmenethik* (Ethics of Algorithms) initiative;[190] the Future of Life Asilomar principles for AI research, ethics and values and longer-term challenges;[191] the Montreal declaration for responsible AI development;[192] and an ethical framework developed by academics Cowls and Floridi that draws parallels with bioethics approaches.[193]

c. Policy and technical tools

To complement the commitments made through the abovementioned ethics codes and frameworks, a number of academic, civil society and private sector stakeholders globally have **developed practical tools to tackle the challenges posed by AI**. For example, the AI NOW Institute, through its report 'Algorithmic Impact Assessments: a practical framework for public agency accountability'[194] and its Algorithmic Accountability Policy Toolkit,[195] proposed a framework to monitor and understand AI systems and their impacts, as used in the public sector. These practical tools guide public agencies on evaluating potential impacts on fairness, bias, justice and other challenges, as well appropriate review processes and public disclosure policies.[196]

Additional prominent examples include: i) the Center for Democracy & Technology's (CDT) 'Digital Decisions Tool',[197] which details a series of questions to be considered and addressed in the process of designing and implementing an algorithm so that the end product reflects ethical practices; and ii) the algorithmic fairness evaluation tool developed by the Alan Turing Institute and Accenture. This tool aims to provide developers with a means to examine the data to be used with issues such as sensitive variables (e.g. gender, race etc.) front of mind.[198]

3.1.2. EU regulatory approach to AI

This sub-section sets out existing EU legislation relevant to AI and considers the evolution of EU policy as regards AI, and possible new legal developments in future.

[186] Software & Information Industry Association (SIIA). (2017). SIIA Issue Brief: Ethical Principles for Artificial Intelligence and Data Analytics.
[187] ITI. (n.d.). AI Policy Principles.
[188] Bosch. (2020). In brief: Bosch code of ethics for AI.
[189] NESTA. (2018). Blog: 10 principles for public sector use of algorithmic decision making.
[190] Ethics of Algorithms. (2020). From principles to practice: How can we make AI ethics measurable?
[191] Future of Life Institute. (2017). Asilomar AI Principles.
[192] Déclaration de Montréal. (2018). Press release: Official Launch of the Montréal Declaration for Responsible Development of Artificial Intelligence.
[193] Cowls, J, and Floridi, L. (2018). Prolegomena to a White Paper on an Ethical Framework for a Good AI Society.
[194] AI NOW. (2018). Algorithmic Impact Assessments: A Practical Framework for Public Agency Accountability.
[195] AI NOW. (2018). Algorithmic Accountability Toolkit.
[196] Optimity Advisors. (2018). algo:aware, Raising awareness on algorithms, State-of-the-Art Report on algorithmic decision-making, commissioned by DG Connect, European Commission.
[197] Center for Democracy & Technology. (2017). Digital Decisions Tool.
[198] Accenture and The Alan Turing Institute. (2018). Accenture challenge: Fairness in algorithmic decision-making.

a. Existing EU legislation which impacts on AI

It is important to note that, whilst there is no dedicated EU legal framework on AI, existing EU legislation, especially the General Data Protection Regulation (GDPR), already impacts industries and firms that integrate AI into their production processes and their business processes and activities. The GDPR also impacts on other digital technologies, for example the Industrial IoT.

In an EU industrial policy context, stakeholders consulted mentioned **data protection and privacy concerns** as regards the **collection of big data and use of AI in such data collection in Global Value Chains**. In addition, firms deploying AI to carry out data analytics and the potential implications of this were raised.

Whilst the **GDPR (Regulation (EU) 2016/679)** provides a legal framework for collection and processing of personal data, which covers these elements, research in academic literature points to potential legal gaps as regards implementing GDPR in an AI and industrial and consumer IoT context, which is inherently more complex than in a traditional web-based internet environment. Moreover, ensuring full GDPR compliance may not be that easy from an economic operator's perspective. For instance, obtaining consent when personal data collected using big data mining techniques is collected automatically and autonomously is not straight forward. A number of pieces of research raise important questions as to whether the **GDPR is AI-proof**.[199]

The GDPR also already provides some protection to prevent misuse and / or abuse of AI, for instance as regards automated profiling and decision-making, which is addressed in Article 22. The incorrect use of personal data could have significant ramifications for the individuals concerned. Article 22[200] on this aspect of GDPR notes that *"the problem is that existing AI system logic takes automated decisions without user consent. Since data is the engine behind AI, this Article impacts every industry hoping to leverage the power of technology to drive efficiencies through automated means"*. Article 22 states that AI — including for profiling purposes — cannot be used in automatic decision-making without the consent of the affected individuals, a requirement for the performance of a contract or the national legislative framework of a Member State, if such decision has 'legal' and 'significant effects' in order to protect the rights and freedom of individuals as well as preventing discrimination; such as the automatic rejection of a loan applicant through the application of a numerical AI rule discarding applicants under a certain threshold[201]. However, GDPR does not exclude the application of an AI process in the assessment of individuals when organisations might take decisions that may have legal and significant effects, enabling organisations to benefit from the gains brought by automatic decision-making, as long as the AI system is reliable and the decision never only relies on AI and occurs in a supervised setting according to the European Data Protection Board.[202] A possible equivalent measure would be to employ an AI mechanism to validate human-made decisions. Such safeguards could help to ensure that industry and business can maximise the use of AI whilst ensuring some consumer protection safeguards, however it raises the question as to whether automatic decision-making might be allowed for decisions concerning the testing of products.

The GDPR is an important piece of legislation to regulate data protection and privacy, however it does not cover the privacy of communications, which is addressed in the e-Privacy Directive 2002. The

[199] Mitrou, L. (2019). Data Protection, Artificial Intelligence and Cognitive Services, Is the General Data Protection Regulation (GDPR) "Artificial Intelligence-Proof"?

[200] Winston, E. (2019). GDPR — How does it impact AI?

[201] Digital Transformation. (n.d.). Navigating GDPR rules for AI and personal data.

[202] European Data Protection Board. (2019). Guidelines 4/2019 on Article 25 Data Protection by Design and by Default.

proposed ePrivacy Regulation 2017 is meant to protect the fundamental rights to privacy and the protection of personal data in a digital age.

As regards the **business perspective**,[203] whilst some commentators argued that GDPR-compliance may limit deployment of AI in some instances, others have taken a more positive stance that privacy is important and that having an enabling regulatory framework in place is positive overall, as companies know what the legal parameters are in which they should operate, and handle personal data and protect customers' privacy. There is however a trade-off between ensuring high levels of data protection and privacy through EU legislation and allowing companies to deploy innovative technologies like AI and other internet-connected data gathering, such as through the industrial and consumer IoT, to ensure Europe remains competitive. The fact that the GDPR has promoted data protection by design and default (Art. 25), and organisational and technical measures to ensure data protection (Art. 24) has helped to strengthen awareness among industry about the need to integrate privacy considerations from the outset of the design of data collection processes, including those using AI technologies and big data analytics. However, there are a lack of studies and evaluations available on this subject, reflecting the fact that the GDPR only came into effect in May 2018.

There is an issue as to the extent to which the general data protection and privacy rules implemented through the GDPR have given US and Chinese companies a competitive advantage, as major global competitors have either not yet introduced such legislation, or where they have, may not have gone as far as the GDPR. However, this argument can be counteracted with the point that many companies operate globally and the GDPR has had significant extraterritorial impacts in third countries (e.g. large US tech firms have had to adapt their websites and online platforms to be GDPR-compliant).

In addition, there have been legal developments outside the EU to strengthen privacy, such as in the State of California, and a growing number of GDPR-type data protection and privacy laws in countries such as Brazil. This is a trend that is likely to increase in future as there have been many data breaches due to hacking and evidence of misuse and personal data insecurity.

As regards possible legal gaps, both France's data protection authority, the CNIL, and the European Commissioner at DG CNCT have **questioned the legality of facial recognition technology** given GDPR, and this is a legal issue that could warrant urgent investigation, to allow time for EU regulation to catch up with technological developments.

Although this discussion on the role of GDPR in ensuring appropriate collection and processing of personal data by industry is important, it should also be noted that representatives of a variety of industries interviewed for this study stressed that many industrial applications of AI do not collect or process personal data.

b. Evolution in the EU policy approach to AI and possible future EU legal framework

To date, the rising implementation of AI in European industry has evolved with limited regulatory engagement at the EU level. Prior to the publication of the White Paper on AI in February 2020[204], the primary developments as regards AI related to the development of ethical codes of conduct and guidelines. Below is a summary of policy initiatives taken at EU-level in the years 2017-2019 to respond to the growth of AI technologies and to consider the possibility of developing an enabling regulatory framework. More detail is provided for each EU policy initiative in Annex 2.

[203] Rogynskyy, O. (2019). What GDPR Means For Businesses With An AI Strategy.

[204] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

Box 7: Summary of EU policy initiatives on Artificial Intelligence

Timeline of EU policy initiatives on AI

2017

In 2015, the European Parliament's Committee on Legal Affairs (JURI) established a working group on the development of AI and robotics in the EU, with a civil-law aspect.[205] As a result of discussions and research conducted through 2015 and 2016,[206][207] the JURI committee published a **report with recommendations to the Commission on Civil Law Rules on Robotics in January 2017**.[208]

The **European Economic and Social Committee issued an opinion on AI in May 2017**.[209] This recommended that the EU take the lead on developing clear global AI policy objectives, driven by European values and fundamental rights. The EESC highlighted issues related to ethics, safety, privacy, transparency and accountability, work, and education and skills.

In its **mid-term review of the Digital Single Market strategy** (May 2017), the European Commission highlighted the importance of being in a leading position in the development of AI technologies, stated that it would 'consider the possible need to adapt the current legal framework'[210], including on AI, and highlighted specific investment of EUR 300 mn for the development of next generation digital industrial platforms, continued investment in key technologies, including AI and their integration along the value chains.[211]

In October 2017, the **European Council invited the Commission to put forward a European approach to AI by early 2018**, calling for a sense of urgency with regard to addressing emerging technology trends in the context of successfully building a Digital Europe.[212]

2018

In March 2018, the European Group on Ethics in Science and New Technologies published a **statement on Artificial Intelligence, Robotics and 'Autonomous' Systems**,[213] highlighting the 'increasingly urgent and complex moral questions'[214] posed by AI, robotics and autonomous technologies.

A **Declaration of Cooperation on AI** was signed by 25 European countries[215] in April 2018, with the aim of collaboration on 'the most important issues raised by AI; from ensuring Europe's

[205] European Parliamentary Research Service. (2017). Civil law rules on robotics: At a glance.

[206] European Parliament. (2016). European Civil Law Rules in Robotics, Study for the Legal Affairs Committee (JURI).

[207] European Parliamentary Research Service. (2016). Scientific Foresight study: Ethical Aspects of Cyber-Physical Systems.

[208] European Parliament. (2017). Report with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)).

[209] European Economic and Social Committee. (2017). Opinions: Artificial Intelligence.

[210] European Commission. (2017). Communication on Mid-Term Review on the implementation of the Digital Single Market Strategy: A Connected Digital Single Market for All, COM(2017) 228 final.

[211] European Commission. (2017). Communication on Mid-Term Review on the implementation of the Digital Single Market Strategy: A Connected Digital Single Market for All, COM(2017) 228 final.

[212] European Council. (2017). European Council meeting (19 October 2017) – Conclusions, EUCO 14/17.

[213] European Group on Ethics in Science and New Technologies. (2018). Statement on Artificial Intelligence, Robotics and 'Autonomous' Systems, Brussels, 9 March 2018.

[214] European Group on Ethics in Science and New Technologies. (2018). Statement on Artificial Intelligence, Robotics and 'Autonomous' Systems, Brussels, 9 March 2018.

[215] List of original 25 signatory countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, UK, Norway.

competitiveness in the research and deployment of AI, to dealing with social, economic, ethical and legal questions'[216]. By July 2018, an additional four countries had joined the initiative.[217]

The intent signalled by the Declaration was strengthened through 2018 by two key European Commission publications. On 25 April, as a response to the European Council's calls, the Commission adopted the **Communication Artificial Intelligence for Europe** – the first EU strategy on AI.[218] This Communication establishes a vision and framework for ensuring the EU plays a leading role globally in AI policy development.[219]

The Communication was accompanied by a Commission Staff Working Document (SWD) specifically **examining the issue of liability in relation to emerging digital technologies**, such as AI.[220]

In December, the groundwork laid by the Communication on AI for Europe was built on by the Commission's **Coordinated Plan on Artificial Intelligence**.[221] The coordinated plan presented detailed actions to be taken in 2019-2020. These actions aim to strengthen and support AI development in the EU by: boosting investment; strengthening AI research; adapt training and educational systems; ensuring a well-functioning data ecosystem; supporting ethical AI development; and ensuring security-related aspects are considered with regard to AI applications and infrastructure.

Furthermore, the plan encouraged Member States to develop national AI strategies by mid-2019. These national strategies should, as a minimum, outline investment levels and implementation measures. With the support of the Joint Research Centre's AI Watch[222], the Commission also pledged to agree common indicators by which AI uptake and development could be monitored and the success of the strategy could be assessed.[223]

2019

The EP adopted an own-initiative report on a **Comprehensive European industrial policy on artificial intelligence and robotics** in February 2019.[224] After highlighting the context of opportunities and challenges, this text addresses specific societal issues, making recommendations on the labour market and malicious use of AI, before discussing the technological roadmap and the EP positions on research and development, investment, innovation and key enablers of AI.[225]

The **High-Level Expert Group on AI** presented Ethics Guidelines for Trustworthy Artificial Intelligence on April 2019. This initiative came off the back of an initial publication of the guidelines' first draft in December 2018 and an open consultation.[226]

[216] European Commission. (2018). EU Member States sign up to cooperate on Artificial Intelligence.
[217] Romania, Greece and Cyprus joined in May 2018; Croatia joined in July 2018.
[218] European Commission. (2018). Communication Artificial Intelligence for Europe.
[219] European Commission. (2018). Communication Artificial Intelligence for Europe.
[220] European Commission. (2018). Staff Working Document on Liability for emerging digital technologies accompanying the Communication on Artificial intelligence for Europe, Brussels, 25.4.2018, SWD(2018) 137 final.
[221] European Commission. (2018). Communication Coordinated Plan on Artificial Intelligence, Brussels, 7.12.2018, COM(2018) 795 final.
[222] European Commission. (n.d.) Joint Research Centre, Knowledge for policy, AI Watch.
[223] European Commission. (2018). Communication Coordinated Plan on Artificial Intelligence, Brussels, 7.12.2018, COM(2018) 795 final.
[224] European Parliament. (2019). A comprehensive European industrial policy on artificial intelligence and robotics.
[225] European Parliament. (2019). A comprehensive European industrial policy on artificial intelligence and robotics.
[226] AI HLEG. (2019). Ethics guidelines for a trustworthy AI.

In April 2019, the European further published a **Communication: Building Trust in Human Centric Artificial Intelligence**, which among others, described how privacy and data governance are some of the seven key requirements that AI applications should respect.[227]

The **Expert Group on Liability and New Technologies – New Technologies Formation** published a **Report on liability for Artificial Intelligence and other emerging technologies** in November 2019, providing recommendations on how liability regimes should be designed or updated in the EU to address the challenges deriving from rapid technological change.[228]

Source: Various EU institutions, bodies and expert groups, and CSES elaboration.

Although no specific regulatory action has been taken at the EU level, a range of activities, as detailed in the abovementioned strategies and plans, have been implemented. Most visibly, key activities have been undertaken to tackle the ethical challenges posed by AI. The below box summarises these activities in more detail.

Box 8: EU level policy developments on ethics and AI

Ethical and AI: EU activities

The European Commission established two key fora for discussions on AI: the High-Level Expert Group on AI (AI HLEG); and the European AI Alliance. The latter, for which the AI HLEG is the steering group, is an online platform for broad multi-stakeholder discussion and collaboration, open to all members of society. The European AI Alliance therefore represents a strong commitment to broad, pan-European dialogue on AI issues.[229]

In June 2018, the Commission appointed 52 experts to a new **High-Level Expert Group on AI** (AI HLEG), which includes the participation of academia, industry and civil society. The aim of the group is to ensure the implementation of the European strategy and coordinated plan on AI is achieved on the basis of a human-centric and ethical approach to AI. The AI HLEG has two working groups: on ethics and on policy and investment recommendations. This box will cover the former with investment discussed later in this section.

In December 2018, the AI HLEG published its first draft of the **Ethics Guidelines for Trustworthy AI**.[230] The Guidelines establish that, in order to be trustworthy, AI systems must satisfy three components; they must be: lawful, ethical and robust. On this basis, the Guidelines detail seven key requirements that the development, deployment and use of AI systems should meet to realise these three components. These requirements relate to: human agency and oversight; technical robustness and safety; privacy and data governance; transparency; diversity, non-discrimination and fairness; environmental and societal well-being; and accountability. Furthermore, the Guidelines presents an assessment list designed to guide the operational implementation of the seven key requirements. The list consists of 63 questions that could provide a blueprint for enabling a self-regulating and trustworthy AI industry in the EU.

Following a public consultation, as well as discussions in the European AI Alliance, an updated version of the Guidelines was presented in April 2019 alongside a Commission Communication on

[227] European Commission. (2019). Communication on Building Trust in Human-Centric Artificial Intelligence, Brussels, 8.4.2019, COM(2019) 168 final.

[228] European Commission. (2019). Liability for Artificial Intelligence.

[229] Stix, C. (2019). A survey of the European Union's artificial intelligence ecosystem.

[230] European Commission. (2018). Draft Ethics guidelines for trustworthy AI.

'Building Trust in Human-Centric Artificial Intelligence'[231]. From 26 June to 1 December 2019, the assessment list[232] underwent a pilot process,[233] with testing conducted and feedback received by more than 350 organisations.[234] The HLEG will revise its guidelines on the basis of this feedback by June 2020.[235]

A second deliverable of the HLEG AI was the report on Policy and Investment Recommendations for Trustworthy AI (June 2019).[236] This document proposes 33 recommendations that can guide AI towards sustainability, growth and competitiveness, as well as inclusion, while putting the EU at the forefront of ethical AI development. The fulfilment of this second deliverable would enable Europe to lead in the development of trustworthy AI which contributes to both individual and societal well-being.

Source: Stix (2019), European Commission (various) and High-Level Expert Group on AI.

In addition to the European Commission's work on ethics, **providing and encouraging investment** has been a key focus of the EU's approach to AI to date. For example, the following pledges were made in the Coordinated Plan with regard to EU funding programmes:[237]

- Investments in AI under Horizon 2020 will increase by 70% to EUR 1.5 bn in the period 2018-2020, as compared with 2014-2017;
- Bring together stakeholders to establish strong investment partnerships, beginning with the robotics and big data public-private partnership (PPP); and
- A minimum of EUR 1 bn per year from the upcoming Horizon Europe and Digital Europe Programme 2021-2027 will go towards AI.

Furthermore, the European Commission committed to exploring additional funding options:

- **European Fund for Strategic Investments (EFSI)**: which involve the use of leveraged investments loans backed by guarantees provided for and managed by the European Investment Bank (EIB); and
- **European Structural and Investment Funds (ESIF)**: which involve the partial (usually co-financed) transfer of EU resources from the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD), the European Social Fund (ESF), and the European Maritime and Fisheries Fund (EMFF) to Member States.

The below box represents an example of an AI initiative funded by the European Regional Development Fund (ERDF).

[231] European Commission. (2019). Communication on Building Trust in Human-Centric Artificial Intelligence, Brussels, 8.4.2019, COM(2019) 168 final.

[232] AI HLEG. (2019). Ethics guidelines for a trustworthy AI.

[233] European Commission. (2019). Futurium, Ethics Guidelines for Trustworthy AI, Pilot the Assessment List of the Ethics Guidelines for Trustworthy AI.

[234] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[235] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[236] AI HLEG (2019). Policy and investment recommendations for trustworthy AI.

[237] European Commission. (2018). Communication Coordinated Plan on Artificial Intelligence, Brussels, 7.12.2018, COM(2018) 795 final.

Box 9: EU investment in AI: Smart specialisation partnership in AI and HMI

Smart Specialisation: AI and Human Machine Interface (HMI)

The smart specialisation approach aims to strengthen innovation and boost growth and jobs in Europe's Regions by allowing them to identify and focus on their competitive advantages. This is to be achieved through collaboration across a range of stakeholder groups. The policy as a whole was expected to result in 15,000 new products being brought to market, the creation of 140,000 new start-ups and 350,000 new jobs by 2020.[238]

In the field of AI and HMI, a smart specialisation partnership has been established, bringing together stakeholders from regions in Italy (co-leader), Slovenia (co-leader), Spain, the Netherlands, Germany, Sweden, Austria, Hungary and France.[239] This partnership aims to support the adoption of AI-driven HMI and AI-enhanced cyber-physical systems through interregional collaboration on four main sub-themes:

- Physiological and biomechanical data analysis to improve the workers experience and performance (user experience data analytics);
- Machine / system user-centred design to leverage the operators' skills (user centred design);
- AI enhanced Cyber-Physical Automation; and
- HMI evolution, including new interfaces, local and remote devices and technologies.

To achieve these aims in these topic areas, the partnership is creating a GRID of regional LABS working as a coordinated network, alongside SMEs and large enterprises with specialised workstreams on AI.

Source: AI and HMI Partnership (2020).

Despite all the spending commitments made by the EU over the next few years, it is still to be established whether the impact of a prolonged COVID-19 crisis and recovery period might have an effect on the EU's ability to maintain its funding objectives, including the possibility of investment gaps. However, given the political priorities of the current European Commission, AI and other digital investments might continue, especially in the backdrop of the fight against COVID-19.[240, 241]

c. White Paper on Artificial Intelligence – A European Approach to Excellence and Trust

Building on the policy developments conducted to date, and reflecting the focus placed on the issue of a legal framework for ethical AI by Commission President Ursula von der Leyen in her political Guidelines,[242] the Commission published a **White Paper on AI** in February 2020.[243] This White Paper – part of the new European Digital Strategy[244] – aims to ensure Europe achieves a leading global position

[238] European Commission. (n.d.). Smart Specialisation: Strengthening Innovation in Europe's Regions.

[239] AI & HMI Partnership. (2020). IM Platform, AI & HMI Position Paper, Submitted for this study.

[240] Naujokaitytė, G. (2020). Commission launches new €122M coronavirus research funding call.

[241] Naujokaitytė, G. (2020). European Innovation Council gets extra €150M after surge in applications.

[242] European Commission. (2019). Political guidelines for the next European Commission 2019-2024.

[243] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[244] European Commission. (n.d.). Shaping Europe's digital future, The European Digital Strategy.

in the development and application of safe and trustworthy AI. Building on the EU's AI strategy (as described above), the White Paper details a vision for the future of AI in Europe focused on:

i. **Capitalising on Europe's strengths in industrial and professional markets**. The White Paper highlights these strengths, in particular noting the excellence Europe possesses in terms of research and innovation and **robotics**, as well as competitive manufacturing and services sectors, including the healthcare, energy and automotive sectors. On this basis, the European Commission White Paper calls for Europe to leverage these strengths, with a particular focus on B2B software applications, e-government and deploying AI in manufacturing. Furthermore, the White Paper recognises that research and investment is limited compared to other regions worldwide and calls on significant increases in investment.[245]

ii. **Taking advantage of new waves of available data**. The White Paper recognises that the EU is currently at a disadvantage with regard to data access as a result of the dominance of other regions, particularly the US, in the fields of consumer applications of AI and its use on online platforms. However, the White Paper also notes that 'major shifts in the value and re-use of data across sectors are underway', highlighting the rapid growth in the production of data globally. As such, the White Paper posits that ensuring Europe is 'data-agile' as an economy, there will be opportunities to address the existing competitiveness issues related to data access. In particular, the White Paper suggests that the strength of European businesses in the development of low-power electronics and neuromorphic solutions, the ability of AI to mimic human cognition such as interpretation and learning, as well as its academic strengths in quantum computing and the algorithmic foundations of AI, could act as catalysts for improved data competitiveness in the future.[246, 247]

To achieve this vision, the White Paper establishes two objectives: the first aims at developing an ecosystem of excellence, while the second focuses on establishing an ecosystem of trust. For each objective, the White Paper presents a range of possible policy options:[248]

Ecosystem of excellence: Under this objective, the White Paper presents actions across a range of areas, including: working with Member States; focusing on the research and innovation community; skills; public-private collaboration; promotion by the public sector; securing access to data and computing infrastructures; global cooperation; and focus on SMEs.

Specific actions detailed include: establishing a new PPP on AI and robotics in the context of Horizon Europe; strengthening and connecting AI research excellence and testing centres, including with funding from the Digital Europe Programme and Horizon Europe; ensure every Member State has at least one digital innovation hub specialised in AI; ensure access to equity financing for innovative AI development, with the support of the European Investment Fund; and establishing an 'Adopt AI programme' to improve public procurement processes and guide public procurement of AI.

Ecosystem of trust: This objective represents the regulatory side of the European Commission approach and, as such, it begins with a problem definition that details the challenges a regulatory response could address, for example the risks posed to fundamental rights (including data protection and privacy), safety issues and challenges related to liability. Subsequently, the Commission presents possible areas for amendment of the existing EU regulatory framework and sets out possibilities for a

[245] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[246] Intel. (n.d.). Beyond Today's AI.

[247] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[248] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

future regulatory framework. Considering the future regulatory framework, the White Paper discusses the types of legal requirements that may be required of 'high-risk' AI applications (see definition in the below box).

The types of requirements noted relate to: training data; data and record-keeping; information to be provided; robustness and accuracy; human oversight; and specific requirements related to particular AI applications. Following an examination of these possible requirements, the Commission discusses practical issues related to the regulation, including: the responsibilities of stakeholders, compliance and enforcement for AI applications considered to be high-risk, voluntary labelling for 'low risk' AI applications and governance.

Box 10: White Paper on Artificial Intelligence: Definition of high-risk AI applications

White Paper on Artificial Intelligence: Definition of high-risk AI applications

The White Paper recognises that such a risk-based approach requires clear, easily understandable and easily applicable criteria to ensure the regulatory approach is proportionate. In this respect, the White Paper states that AI applications should generally be determined to be high-risk when **both the intended use and the sector of use involve significant risks**, in particular considering issues of safety, consumer rights and fundamental rights.

Sector of use. The White Paper noted that the new regulatory framework would specifically and exhaustively list all relevant sectors and highlights healthcare, transport, energy and parts of the public sector as prime examples.

Intended uses. The White Paper suggests that the assessment of the level of risk of a particular use could be determined by the impact on any affected parties, highlighting AI applications with legal effects and AI applications that pose risk of injury, death or significant damage.

Source: European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust.

As highlighted in the White Paper on AI, the availability and access to data is a key enabler of the development and deployment of AI systems. However, there are a range of data-related challenges that could act as a barrier to AI adoption in European industry. These challenges, amongst others, include the availability and sharing of data, imbalances in market power, data interoperability and quality, data governance and data infrastructures and technologies. These points are reflected in the Commission's **European strategy for data**[249], published alongside the White Paper in February 2020. This strategy presents a vision for a single European data space that will drive a competitive EU data economy, considering "*data stored, processed and put to valuable use in Europe*"[250], and comprise part of an industrial strategy for a data-agile economy.

To address the challenges identified, the data strategy aims to implement actions on the basis of four pillars:

- **Cross-sectoral governance framework for data access and use** through an enabling legal framework and exploration of legislative action on data sharing challenges based on relations between different public and private stakeholder groups;
- **Investment in enablers**, such as European capabilities in hosting, processing and using data, as well as the interoperability of those capabilities;

[249] European Commission. (2020). Communication on A European strategy for data, Brussels, 19.2.2020, COM(2020) 66 final.
[250] European Commission. (2020). Communication on A European strategy for data, Brussels, 19.2.2020, COM(2020) 66 final.

- **Developing competences** of individuals as well as businesses and specifically SMEs across Europe; and
- **Establishing common European data spaces in strategic sectors and domains of public interest**. In particular, it is worth noting the commitment to establishing such data spaces in relation to manufacturing (Common European industrial data space) and Green Deal priority actions (Common European Green Deal data space), as well as health, mobility, energy and agriculture.

More concretely on the Common European industrial data space, the Commission highlighted that the potential value of non-personal data use in the manufacturing sector is estimated to be EUR 1.5 trillion by 2027. In attempting to release this potential, the Commission committed to: i) attempting to tackle usage rights issues in relation to co-generated industrial data through a wider Data Act; and ii) engage with key players in the manufacturing sector to discuss the terms on which data sharing could occur.

In addition, the Commission highlights a range of **particular challenges for SMEs**. For instance, the data strategy highlights that SMEs are less able to access fragmented high-value datasets that are not available under the same conditions across the EU. The cumulative effects of such challenges will only exacerbate the challenges already experienced by SMEs in relation to AI adoption.

d. Intersection of AI and industrial policy

With regard to industrial policy, the future industrial role of AI was first highlighted in the **Commission's 2016 strategy to digitise industry**, which recognised that, along with other emerging technologies such as the IoT and cloud computing, AI was going to drive significant change.[251] This viewpoint was furthered in the **Commission's 2017 EU Industrial Policy Strategy**.[252] This document stated that 'the future of industry will be digital', highlighting the extent to which AI and other new technologies could impact the society and the economy.

Considering the White Paper on AI's goal of an ecosystem of excellence, the European Commission's **Communication on Artificial Intelligence**[253] was a seminal policy development, as it built on the recognition in industrial policy documents and developed the initial considerations of EU policymakers on how to **optimise the use of AI in industry to maximise its economic and social benefits**. This is furthered by the AI White Paper, which, as described above, presents a range of actions to further the advancement of AI technologies in the EU and their adoption.

However, the April 2018 Communication also acknowledged that the rapid technological developments made in respect of **AI could raise regulatory considerations** due to the integration of advanced automation and robotics into production processes, in particular as part of wider developments linked to Industry 4.0. For example, the growing use of AI in advanced manufacturing technologies could raise issues relating to occupational health and safety. As summarised in the below table, the Commission is in the process of assessing the fitness for purpose of core industrial product legislation with regard to new technologies, including AI. Key examples of relevant legislation include: the Machinery Directive (2006/42/EC); the Radio Equipment Directive (2014/53/EU); the Low Voltage Directive (2014/35/EU); and the Electromagnetic Compatibility Directive (2014/30/EU).

[251] European Commission. (2016). Communication on Digitising European Industry: Reaping the full benefits of a Digital Single Market, Brussels, 19.4.2016, COM(2016) 180 final.

[252] European Commission. (2017). Communication on Investing in a smart, innovative and sustainable Industry: A renewed EU Industrial Policy Strategy, Brussels, 13.9.2017, COM(2017) 479 final.

[253] European Commission. (2018). Communication Artificial Intelligence for Europe.

Table 11: Key EU industrial product legislation and AI

EU legislation	Overview of core objectives and engagement with AI
Machinery Directive (MD) 2006/42/EC	• The MD promotes free movement of machinery within the single market and guarantees a high level of protection for EU workers and citizens. • **The MD and AI**: The Directive has been referred to as the 'EU's central safety framework for AI robots'.[254] Although the 2018 evaluation of the MD found that the Directive allows for 'technological developments in a digital era',[255] it also encountered questions related to its effectiveness with the advent of emerging digital technologies. As such, in its 2019 inception impact assessment, the European Commission highlighted the need for further analysis on the MD's fitness for purpose with regard to such digital developments, including AI.[256]
Radio Equipment Directive (RED) 2014/53/EU	• The RED establishes requirements for radio equipment to ensure the protection of safety and health of users, an adequate level of electromagnetic compatibility and the efficient use of radio spectrum. • **The RED and AI**: A series of delegated acts could be activated under Art. 3(3), including several pertaining to cybersecurity aspects, for example (3(3)(e) on data protection and privacy; Art. 3(3)(f) on protection from fraud; and Art. 3(3)(i) on software compliance. In the context of consumer IoT products and devices, developments in AI could impact privacy, for example, if the product usage is monitored and analysed using AI and the data is transmitted back to the manufacturer and / or third parties. Impact assessments are being conducted in relation to the adoption of these three delegated acts.
Low Voltage Directive (LVD) 2014/35/EU	• The LVD ensures that electrical equipment meets requirements related to protection of health and safety. • **The LVD and AI**: In 2019, an interim evaluation of the LVD was conducted. It assessed the status of the LVD in relation to new technologies, finding that the objectives and provisions of the Directive are still relevant despite technological advancements due to their technologically neutral composition.[257]
Electromagnetic Compatibility Directive (EMCD) 2014/30/EU	• The EMCD regulates the electromagnetic compatibility of equipment, in particular to limit levels of electromagnetic disturbance and ensure appropriate levels of electromagnetic immunity. • **The EMCD and AI**: The EMCD is currently being evaluated for the first time in its 30-year history. As highlighted in the Commission's evaluation roadmap, a key question to be considered throughout the evaluation relates to 'the adequacy of the Directives' provisions in light of scientific and technological progress'[258]. Although it is not anticipated that significant issues will arise, particularly in relation to AI, this is part of the assessment being conducted.

Source: European Commission (various) and CSES elaboration.

However, it has been stressed by those interviewed that these industrial product rules were designed under the New Approach[259], and latterly the New Legislative Framework, to be technologically neutral, and to allow technological changes.[260] Moreover, the Commission Communication on AI highlighted the flexibility of the EU legal framework underpinning product safety, noting its capacity to

[254] European Commission. (2019). Inception Impact Assessment: Revision of the Machinery Directive, Ref.Ares(2019)132242 – 10/01/2019.

[255] European Commission. (2018). Staff Working Document, Evaluation of the Machinery Directive, Brussels, 7.5.2018, SWD(2018) 160 final.

[256] European Commission. (2019). Inception Impact Assessment: Revision of the Machinery Directive, Ref.Ares(2019)132242 – 10/01/2019.

[257] European Commission. (2019). Interim evaluation of the Low Voltage Directive 2014/35/EU, October 2019.

[258] European Commission. (2020). Evaluation Roadmap: Evaluation of the Electromagnetic Compatibility Directive, Ref.Ares(2020)423666 – 23/01/2020.

[259] Council Resolution of 7 May 1985 on a new approach to technical harmonization and standards, (85/C 136/01).

[260] European Commission. (n.d.). Webpage: New legislative framework.

accommodate technological changes through its emphasis on harmonised technical standards. More specifically, the Communication stated that the existing legal framework *"already addresses the intended and foreseeable (mis)use of products when placed on the market. This had led to the development of a solid body of standards, in the area of AI-enabled devices that are continuously being adapted in line"*[261]. Furthermore, it states that *"the further development and promotion of such safety standards and support in EU and international standardisation organisations will help enable European businesses to benefit from a competitive advantage and increase consumer trust"*.[262]

Nevertheless, EU consumer organisations, and some workers' organisations, along with some national authorities and politicians have raised the question as to whether the existing legal framework should be reviewed to allow for technological developments to be accommodated, including possible general unforeseen risks and consequences applicable to all products, rather than those that can only be dealt with through product-specific technical standards.

This is further stressed by the EU's New Industrial Strategy,[263] published in March 2020, which notes that 'the single market depends on robust, well-functioning systems for standardisation and certification', which ensure legal certainty and support market growth.

In addition to its focus on standardisation, the new industrial strategy pledged the development of an EU data economy as a follow-up action from the new European Data Strategy, as well as a Common European Energy data space to specifically support industry in achieving the goals of the European Green Deal, and a focus on retraining and reskilling to support the 'unparalleled shift' in skills that will be required as a result of 'digitisation, automation and advances in artificial intelligence'.[264] Furthermore, in the SME Strategy accompanying the industrial strategy, the Commission promised a range of initiatives to help SMEs reap the benefits of new technologies.[265] These include: the development of Digital Crash Courses in AI for SME employees; the support of the Digital Innovation Hubs across Europe; and the launch of a 'digital volunteers' programme to facilitate the sharing of digital competencies.

3.1.3. Third country approaches to regulating AI

This section provides an insight into the approaches currently being taken by key third countries with regard to regulation. In particular, the assessment focuses on the US and key Asian nations, such as China and Japan.

At present, it is notable that neither at EU level, in individual Member States, nor globally have any **countries proposed or implemented horizontal regulation on AI**.[266] A small number of countries, including the US, Canada and Australia, as well as certain EU Member States, have implemented regulation related to liability, specific sectors or specific applications; however, the majority of these existing regulatory activities relate to autonomous driving.[267] Examples are provided below.

The European Parliament has also put forward a resolution to the European Commission as to the need to look into the possible regulation of robotics and AI, including the resolution of liability issues that could help to foster the development of these industries.

[261] European Commission. (2018). Communication Artificial Intelligence for Europe.

[262] European Commission. (2018). Communication Artificial Intelligence for Europe.

[263] European Commission. (2020). Communication on A New Industrial Strategy for Europe, Brussels, 10.3.2020, COM(2020) 102 final.

[264] European Commission. (2020). Communication on A New Industrial Strategy for Europe, Brussels, 10.3.2020, COM(2020) 102 final.

[265] European Commission. (2020). Communication on An SME Strategy for a sustainable and digital Europe, Brussels, 10.3.2020, COM(2020) 103 final.

[266] NESTA. (2020). AI Governance Database.

[267] NESTA. (2020). AI Governance Database.

Issues relating to the regulation of AI

- **Liability**: As highlighted throughout the above, including references across all EU policy documents related to AI, liability is a key challenge facing a range of AI applications. Having examined approaches in a range of third countries, it is clear that limited concrete actions have been taken. For instance, within the current Chinese legal framework, liability sits primarily with the manufacturer of a device and further exploration of liability in the context of AI appears to be limited.[268, 269] Similarly in Japan, discussions on product liability in the context of AI have only been initiated in 2019.[270] It is found that general criminal and civil rules on liability are considered to be applicable to autonomous robots in some cases and, in such cases, liability is mostly placed with the operator or owner of the autonomous device.[271] Contrastingly, with regard to liability and AI, the US is more advanced. This is primarily because case law is vital in understanding liability in relation to the implementation of AI and such cases have more frequently been experienced in the US.[272] Initial cases established relatively strict requirements for human control over an autonomous device; however, more recent cases have provided greater leniency to manufacturers and operators with regard to liability;[273] and

- **Specific sectors / applications**: Considering the regulation of specific sectors or uses of AI, the most developed examples come from North America. Canada, for instance, has adopted a Directive on Automated Decision-Making for Federal Institutions, which regulates the use of AI-automated decision systems by federal institutions.[274] Although not at the federal level, **California** in the US has made notable developments with regard to AI regulation; for example, a 2018 law requires automated political and commercial accounts on social media, websites and online platforms to clearly disclose that they are bots.[275] A further 2019 law in California outlawed AI-generated deepfakes.[276] At the federal level, the US Congress introduced two major legislative proposals in 2017 related to autonomous transportation: the Safely Ensuring Lives Future Deployment and Research In Vehicle Evolution (SELF DRIVE) Act;[277] and the American Vision for Safer Transportation Through Advancement of Revolutionary Technologies (AV START) Act.[278] Although both proposals failed initially[279], with the latter failing to pass the Senate on the basis that it did not do enough to address safety concerns, the drive to legislate on autonomous transportation reportedly received new impetus in 2019.[280] Furthermore, US states have been active in this regard. As of January 2019, 64 legislative items have been adopted across 30 US states on automated vehicle-related issues, including on commercial use of such vehicles, cybersecurity of such vehicles and insurance and liability.[281]

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268 ICLG. (2018). Product Liability 2018 – China.

269 Covington & Burling LLP. (2018). China's Vision for The Next Generation of Artificial Intelligence, *National Law Review*, 25 March 2018.

270 Ikeda, J., Fujii, T., Mochizuki, N., Ohno, N. and Tsunematsu. (2019). Product Liability and safety in Japan: Overview.

271 Matsuo, T. (2017). 'The Current Status of Japanese Robotics Law: Focusing on Automated Vehicles', in Hilgendorf, E., Seidel, U., *Robotics, Autonomics, and the Law*, Nomos, Baden-Baden, 2017, pp. 151-170.

272 For example: *Brouse v. United States*, 83 F. Supp. 373 (N.D. Ohio 1949).

273 *Ferguson v. Bombardier Services Corp*, 244 F. App'x 944 (11th Cir. 2007); *Royal Insurance Company of America v. Crowne Investments*, 903 So.2d 802 (Ala. 2004).

274 Government of Canada. (2019). Directive on Automated Decision-Making.

275 Senate Bill No. 1001 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1001.

276 Deepfakes are A.I.-modified videos, often featuring one person's likeness digitally superimposed onto the body of another.

277 US Congress, *SELF DRIVE Act*. Available at: https://www.congress.gov/bill/115th-congress/house-bill/3388.

278 US Congress, *AV START Act*. Available at: https://www.congress.gov/bill/115th-congress/senate-bill/1885.

279 Shepardson, D. (2018). Article: U.S. Congress will not pass self-driving car bill in 2018: senators, Reuters Technology News, 19 December 2018.

280 Hawkins, A. (2019). Article: Congress takes another stab at passing self-driving car legislation, The Verge, 28 July 2019.

281 National Conference of State Legislatures. (2020). Autonomous Vehicles & Self-driving vehicles: Database of enacted legislation.

Although there has been limited regulatory engagement with the topic of AI, **many countries globally, particularly OECD member countries, have published AI strategies and developed non-binding standards and guidelines**. More specifically, select third countries have approached AI strategy development as follows:

- The **US strategy** on AI is established by the American AI Initiative[282], established by Executive Order 13859 in February 2019. Alongside this strategy, the USA's engagement with the topic takes the form of annual White House Summits on AI,[283] which focus on 'removing barriers to innovation' – at present, arguing that government regulation isn't needed at this stage of AI's development. Further highlighting the US focus on R&D and investment, in 2016 the US developed a National AI R&D Strategic Plan, which was refreshed in 2019.[284, 285] This publication highlights the eight key strategic priorities for US Federal investment in AI R&D, which include: making long-term investments in AI research; ensuring safety and security in AI systems; better understanding workforce needs with regard to AI; and expanding PPPs.[286] These steps were supported in June 2019 by the publication of the Federal Data Strategy, which aims, amongst other objectives, to promote efficient and appropriate data use, including specifically through actions related to improving data and model resources for AI Research and Development;[287]
- Although US Federal activity has been limited to this focus on R&D and investment, the strength of Silicon Valley and major tech companies based in California has resulted in state legislatures passing and discussing regulation related to AI. More specifically, the California Consumer Privacy Act (CCPA), in a similar vein to the EU's GDPR, aims to ensure appropriate use of the personal data of consumers, which are commonly used in AI applications.[288] As such, alongside the 2018 Bots Disclosure Act and the 2019 Anti-Deepfake Bill mentioned above, California is taking steps to tackle some of the impacts of AI;[289]
- Regarding **China,**[290] there is reportedly a difference between what is published and what is actually happening. Whilst China has published various AI strategies, including the 2017 New Generation of Artificial Intelligence Development Plan, these may not reflect their actual aims or priorities in this area. Furthermore, China has established an AI Industry Development Alliance focused on the development of a public service platform to accelerate growth.[291] Given the forms of governance in China, it is a fair assumption that ethical considerations and protections for consumers, particularly with regards to privacy, are less of a concern than in the EU;
- Although initially discussed in the context of **Japan**'s 2016 Society 5.0 ambitions,[292] AI was first covered via the **2017 AI Technology Strategy**.[293] This strategy established an industrialisation

[282] White House. (2019). Executive Order on Maintaining American Leadership in Artificial Intelligence.

[283] The White House Office of Science and Technology Policy. (2019). Summary of the 2019 White House Summit on Artificial Intelligence, September 2019.

[284] National Science & Technology Council. (2016). The National Artificial Intelligence Research and Development Strategic Plan, Report by the Networking and Information Technology Research and Development Subcommittee, October 2016.

[285] National Science & Technology Council. (2019). The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update, Report by the Select Committee on Artificial Intelligence, June 2019.

[286] National Science & Technology Council. (2019). The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update, Report by the Select Committee on Artificial Intelligence, June 2019.

[287] US Office of Science and Technology Policy. (2019). Federal Data Strategy: Leveraging Data as a Strategic Asset.

[288] World Economic Forum. (2019). Article: Here's how California is approaching the ethics of AI, 18 October 2019.

[289] World Economic Forum. (2019). Article: Here's how California is approaching the ethics of AI, 18 October 2019.

[290] FLIA. (2017). China's New Generation of Artificial Intelligence Development Plan.

[291] Future of Life. (2020). AI Policy – China.

[292] Japanese Cabinet Office. (2016). Presentation: Realizing Society 5.0.

[293] Strategic Council for AI Technology. (2017). Artificial Intelligence Technology Strategy, 31 March 2017.

roadmap, highlighting activities related to productivity, health, medical care and welfare, and mobility as particular areas of focus for AI implementation. In June 2019, this strategy was updated by the AI for Everyone strategy,[294] which highlighted strategic objectives related to: i) developing a base of AI-relevant human resources; ii) strengthening industrial competitiveness by leading globally in the real-world application of AI; iii) utilising AI and other technologies to realise a sustainable society; and iv) playing a key role in international research, education and social infrastructure networks in AI.[295] This strategy is further guided by the Japanese government's seven Social Principles of Human-Centric AI, published in March 2019.[296] These principles mirror many of the requirements of ethical and trustworthy AI proposed by the European Commission's AI HLEG; for instance, the Japanese principles include focus on privacy, security, fairness, accountability and transparency; and

- Furthermore, the Japanese Ministry of Economy, Trade and Industry (METI) has been publishing policy and safety guidelines on robotics since 2004.[297]

Whilst there are differences between the national strategies implemented by these nations – for instance, the emphasis placed on ethics – the strategies have much in common. For instance, most include significant investment programmes and highlight the importance of training and attracting people with the skills to develop AI.

In addition to national activities related to AI, international bodies have taken significant steps to support policymaking in relation to AI. As detailed in the below box, a key contributor in this regard is the OECD.

Box 11: OECD Activities on AI

Organisation for Economic Co-operation and Development (OECD): Activities on AI

At the international level, the OECD has an influential history in international standard setting, particularly with regard to ethical issues. For instance, the OECD Privacy Guidelines, developed in 1980, have strongly influenced the development of modern privacy laws and frameworks globally. As such, it is worth noting the OECD's activities with regard to AI policy.

In May 2019, the OECD published **AI Principles** through its Recommendation of the Council on Artificial Intelligence, the first intergovernmental standard on AI and the basis for the G20 human-centred AI Principles.[298] Building on this, February 2020 saw the launch of the **OECD AI policy observatory**. The observatory aims to share and shape AI policy through global multi-disciplinary collaboration and partnerships and evidence-based analysis. More specifically, it will develop practical guidance on the implementation of the OECD AI Principles; assess developments in specific policy areas, including jobs, skills, data, health and transport; collect data on the basis of OECD metrics and analyse trends with regard to AI development and policy; and present and assess the approaches of countries and other initiatives on AI.[299]

Source: OECD (various).

[294] Integrated Innovation Strategy Promotion Council Decision. (2019). AI Strategy 2019, AI for Everyone: People, Industries, Regions and Governments, 11 June 2019.

[295] Integrated Innovation Strategy Promotion Council Decision. (2019). AI Strategy 2019, AI for Everyone: People, Industries, Regions and Governments, 11 June 2019.

[296] Japanese Council for Social Principles of Human-Centric AI. (2019). Social Principles of Human-Centric Artificial Intelligence.

[297] Robotics Business Review. (2012). The Global Race to Robot Law: 1st Place, Japan.

[298] OECD. (2019). Recommendation of the Council on Artificial Intelligence, OECD/LEGAL/0449, Adopted on 22/05/2019.

[299] OECD. (2020). OECD.AI Policy Observatory: A platform to share and shape AI policies.

3.2. Assessing EU rules on Artificial Intelligence

KEY FINDINGS

The European Commission's REFIT programme, in conjunction with the Better Regulation guidelines and approaches to analysing the impacts of AI in impact assessments and evaluations, provide an **opportunity to assess both quantitatively and qualitatively the impacts of proposed new legislation**. However, such frameworks need customisation to meet the specific challenges in optimising the potential benefits of AI for Europe's industrial competitiveness, whilst mitigating the potential adverse consequences (e.g. citizen's privacy being compromised). Moreover, there is a need to strengthen attention to managing the potential risks posed by new technologies, including unintended consequences, in the Better Regulation guidelines. Furthermore, there is limited guidance within the Better Regulation guidelines and toolbox on the assessment of impacts related to new technologies, including AI.

The **European Parliament has a crucial role to play in scrutinising the regulatory fitness of proposed new EU legislation** in the area of AI and in ensuring that impact assessments and evaluations: i) strike the right balance between respecting European values whilst capitalising on the opportunities of AI; and ii) ensure that impact assessments (including technical supporting inputs and Staff Working Documents) integrate a risk-based approach to regulating AI that reflects different types of risks (for example, for EU citizens, to European values, to data protection and privacy and with regard to possible dual uses).

On the basis of this assessment and the analysis of the technological, impact and regulatory state of play, this study has **developed a checklist that could support scrutiny of EU legislation in the context of AI**. Utilising elements of the Better Regulation approach (namely, the aspects of the intervention logic), this checklist covers issues related to suitability of regulatory objectives, assessment of legal considerations, assessment of trade-offs between opportunities and challenges, assessment of unintended consequences, coherence with existing legislation and the extent to which risk levels associated with AI applications have been considered and assessed.

This study required the development of an evidence-based methodology for scrutinising the fitness for purpose of EU industrial policy and emerging regulations regarding AI. This section sets out key considerations in this regard and puts forward a practical checklist to help the European Parliament in assessing and commenting on the regulatory fitness for purpose of Commission regulatory proposals on AI.

3.2.1. Existing methods to assess EU rules

Core to the assessment of EU legislation in the area of industrial policy is the concept of 'public risk management', described by the Risk Forum as 'one of the fundamental ways in which governments solve problems and meet the expectations of citizens'.[300] Public risk management can broadly be defined as any government action designed to prevent, reduce or re-allocate risk and can include actions to manage risks posed by technologies, economic activity and lifestyle choices. This approach has, for example, been fundamental in the development of legal frameworks across policy areas from trade and investment to protecting citizens and the environment.[301]

[300] European Risk Forum. (2018). Strengthening the EU's Better Regulation Strategy: Ideas from the European Risk Forum, Communication.
[301] European Risk Forum. (2018). Strengthening the EU's Better Regulation Strategy: Ideas from the European Risk Forum, Communication.

At present, EU citizens are more expectant than ever with regard to receiving high levels of consumer protection whilst continuing to benefit from technological and scientific developments and investments. At the same time, effective risk management requires an increasingly comprehensive understanding and knowledge of technological applications as regulation needs to consider the management of smaller, heterogeneous and more complex threats to users as opposed to the well-established and large risks posed by new technologies in the past.[302]

The EU aims to ensure appropriate regulatory activity and conduct public risk management through its **Better Regulation agenda**, including the Regulatory Fitness and Performance (REFIT) programme and the Better Regulation Guidelines and related Toolboxes.

Box 12: Objectives and key mechanisms of the EU's Better Regulation agenda

Better Regulation agenda: Objectives and key mechanisms

The Better Regulation agenda, published in 2015[303] and developed further in 2017,[304] aims to ensure that: decision-making is open and transparent; citizens and stakeholders are given the opportunity to contribute throughout the policy cycle; policy and legislative activities are based on evidence and an understanding of the impacts; and the regulatory burdens are kept to a minimum. To achieve this, the Commission developed a set of principles and measures related to three pillars: i) new proposals are accompanied by impact assessments; ii) all legislative revisions are preceded and informed by an evaluation; and iii) all assessments throughout the policy cycle are underpinned by stakeholder engagement activities. One of the concrete activities related to the Better Regulation agenda was the development of the **Better Regulation guidelines and toolboxes**, which provide practical guidance on implementing common standards for regulatory development throughout the policy cycle. This includes relevant toolboxes on Risk assessment & management #15; Identification / screening of impacts #19; Research & innovation #21; and Digital economy and society & ICT issues #27.

Another mechanism developed in 2015 to support the achievement of these Better Regulation goals was the **REFIT Programme**, within which the REFIT Platform was established.[305] The REFIT Platform aims to gather the views of Member State governments and stakeholder groups to: i) support the process of simplifying EU law and reducing regulatory burdens; and ii) making recommendations to the Commission. Here, the engagement of these initiatives for Better Regulation with the topic of regulating new technologies and AI in particular are examined.

Source: European Commission (various) and CSES elaboration.

Whilst the **Better Regulation guidelines and related toolboxes stress the need for new legislation to be technology-neutral, this report finds that limited advice is available to the Commission in relation to how to analyse and manage the potential risks posed by new technologies**. There is an emphasis on the need to ensure that unintended consequences are considered; however, the deployment of AI may raise specific issues, including ethical and liability considerations, possible risks related to dual use, and the risk of inadvertent privacy breaches despite the GDPR. For instance, as

[302] European Risk Forum. (2018). Strengthening the EU's Better Regulation Strategy: Ideas from the European Risk Forum, Communication.

[303] European Commission. (2015). Communication on Better regulation for better results – An EU agenda, Strasbourg, 19.5.2015, COM(2015) 215 final.

[304] European Commission. (2017). Communication on Completing the Better Regulation Agenda: Better solutions for better results, Strasbourg, 24.10.2017, COM(2017) 651 final.

[305] European Commission. (2015). Communication on The REFIT Platform: Structure and Functioning, Strasbourg, 19.5.2015, COM(2015) 3260 final.

regards the latter, there is the issue of complexity in Global Value Chains (GVCs), making GDPR compliance in a Big Data era difficult for data protection authorities to monitor and / or enforce.

In relation to the dynamic nature of regulation, for example, the Better Regulation approach has increased its recognition of the potential impacts of regulation on innovation, in particular through the Research and Innovation Tool #21. This reportedly reflects significant improvements, in particular in relation to: the recognition of the role of corporate investment in R&D cycles; the emphasis on understanding potential innovation issues through industry consultations; the need to consider regulatory design, resulting in improved coherence and certainty; and the preference for technologically-neutral and outcome-based interventions and rules.[306]

However, there are weaknesses and gaps in this tool. For example, the references to innovation focus on technological innovation, whereas under the Oslo definition,[307] innovation applies for instance across product and process and organisational innovation, not only technological. Moreover, the focus is on innovation by start-ups.[308] As demonstrated in section 2 of this report, although there are undoubtedly innovative start-ups developing and deploying AI solutions in the market, the adoption of AI solutions at organisational level to derive operating efficiencies is more prevalent in larger organisations.

Furthermore, the **other Better Regulation tools highlighted above make limited mention of the assessment of the positive and negative impacts of new technologies**, including AI. For instance, Tool #15 on Risk assessment & management only briefly mentions new technologies when discussing how uncertainty is inherent in risk assessments, noting that 'it is difficult to foresee the unknown unknowns'.[309] Although more attention is paid to new digital technologies in Tool #27 on Digital economy and society & ICT issues, the focus is primarily on how the regulation will impact the new technology as opposed to the possible impacts of the technology on the policy area under examination.[310]

Beyond the guidelines and toolbox, the **REFIT programme** supports the Better Regulation process and is taken into account in the preparation of the annual Commission work programmes, which include proposals for new initiatives and a quality review of existing EU legislation. There is strong complementarity with the Better Regulation agenda, as it is designed to investigate the five key evaluation issues (*coherence, relevance, effectiveness, efficiency* and *EU added value*), but complemented by a focus on overall **regulatory fitness for purpose as a cross-cutting theme**.

If dedicated EU legislation on AI is indeed adopted in future, the European Parliament's role will then move beyond scrutinising the legislation at ex-ante stage through a review of Commission impact assessments and will extend to reviewing evaluations carried out ex-post. As regards the efficacy of the REFIT programme, individual evaluation studies have provided an in-depth assessment of particular pieces of legislation that have been identified as needing a review, for instance, if the legislation has been questioned by external stakeholders, and / or if a fundamental review is needed to check whether the regulatory approach is fit for purpose.

[306] European Risk Forum. (2018). Strengthening the EU's Better Regulation Strategy: Ideas from the European Risk Forum, Communication.

[307] The Oslo Manual also distinguishes between innovation as an outcome (an innovation) and the activities by which innovations come about (innovation activities). See: https://www.oecd.org/sti/inno/oslo-manual-2018-info.pdf.

[308] European Risk Forum. (2018). Strengthening the EU's Better Regulation Strategy: Ideas from the European Risk Forum, Communication.

[309] European Commission, Better regulation toolbox, Tool #15 Risk assessment & management.

[310] European Commission, Better regulation toolbox, Tool #27 Digital economy and society & ICT issues.

However, there has also been **some criticism of REFIT and suggestions as to how it might be improved**; for instance, through a report by the European Court of Auditors (ECA)[311] on *Ex-post review systems* at the EU level. Although the ECA report did not directly comment on the approach of the Better Regulation guidelines and the REFIT programme to the assessment of new technologies, such as AI, it presents general insights into the functioning of the Commission's evaluation system and the role of the REFIT programme that is useful in the context of this study.

On the positive side, the ECA reported that ex-post evaluations at EU level were found to compare well to Member State equivalents, and that the EU evaluation system is well-managed and quality-controlled. On the other hand, the rationale and strategy of the REFIT programme was seen as being unclear, as were the selection criteria for labelling individual initiatives as REFIT. This raises questions as to the role and added value of the programme. A further challenge identified by the ECA was that external communications regarding the role of the REFIT programme and the results from individual studies was lacking. In particular, the REFIT scoreboard was not viewed as being user-friendly or providing clear results.[312] Furthermore, in its 2017 REFIT scoreboard summary, the Commission placed limited focus on ensuring EU rules take into account new technologies. In a horizontal sense, this sentiment was only mentioned once, in relation to work on Priority 7: Upholding the Rule of Law and linking up Europe's Justice Systems.

With that said, in 2017/18, the REFIT Platform developed a range of opinions on horizontal matters, including technological-neutrality.[313] In this opinion, the **REFIT Platform echoed the abovementioned indications that technological-neutrality is a key principle of the EU's Better Regulation approach** pointing to its inclusion as a concept in the GDPR and the Directive on Network and Information Security (NIS Directive (EU) 2016/1148). Furthermore, the Platform recommended that the concept be is taken into account in all policy areas in both national and EU legislation, stressing that a future-proof and technology-neutral regulatory framework is essential for the development of the digital economy.[314]

Bringing these regulatory assessment mechanisms together, the Commission undertook a stocktaking exercise with regard to the Better Regulation approach in 2019. The roadmap for this exercise **did not suggest any focus on understanding how Better Regulation tackles issues of emerging technologies or the topic of technology-neutrality** and, as such, the output of this exercise did not provide insight into how this issue had been tackled over the preceding years.[315,316] Furthermore, the 2018 annual report of the Regulatory Scrutiny Board did not cover the topic either of assessing how EU legislation should tackle the emergence of new technologies, such as AI.[317]

In summary, although the approach to better regulation generally has been positive, there is limited engagement with the issue of how to assess the interactions of new technologies and regulatory interventions and assessments. Furthermore, the mandate of the REFIT Platform ended in October 2019 and although a new high-level group – the Fit for Future Platform – is planned, limited details on its mandate and workings are known.

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311 European Court of Auditors. (2018). Special Report: Ex-post review of EU legislation: a well-established system, but incomplete (pursuant to Article 287(4), second subparagraph, TFEU).

312 European Court of Auditors. (2018). Special Report: Ex-post review of EU legislation: a well-established system, but incomplete (pursuant to Article 287(4), second subparagraph, TFEU).

313 European Commission. (2018). The European Union's Efforts to Simplify Legislation: 2018 Annual Burden Survey.

314 REFIT Platform. (2017). Opinion on Intention, Digitalisation and Technology Neutrality, Adopted 23/11/2017.

315 European Commission. (2019). Better regulation: taking stock and sustaining our commitment, 15 April 2019.

316 European Commission. (2019). Staff Working Document: Taking Stock of the Commission's Better Regulation Agenda, Accompanying the document on Better Regulation: taking stock and sustaining our commitment, COM(2019) 178.

317 European Commission. (2018). Regulatory Scrutiny Board, Annual Report 2018.

In addition to the Commission's work on Better Regulation, it is also important for the co-legislators to play their roles in the process. As AI is of central importance across EU industrial policy, and research and innovation policies, along with many other different policy areas, it is therefore important that the ITRE committee scrutinises the legislative proposals from an industrial competitiveness perspective, and considers the trade-offs involved between promoting wider diffusion of AI across more sectors, and its increased usage by SMEs to derive operational efficiencies, whilst at the same time considering how lack of regulation could create legal uncertainty for economic operators.

The timeliness of a response to any studies linked to regulatory proposals on AI should also be highlighted. As the abovementioned ECA report points out, the Parliament only reacted to Commission ex-post evaluations within six months of publication in 17 out of 77 examples.[318] Given the Better Regulation toolbox calls on the Commission to draft a follow-up action plan within six months of publication of an ex-post review, the timely engagement of the co-legislators could bring significant additional benefits. This otherwise represents a missed opportunity to inform the Commission's next steps and further work on a particular topic, potentially weakening the Better Regulation policy cycle.[319]

3.2.2. Proposed approach to assessing EU rules on Artificial Intelligence

Based on the review of existing methods to assess EU rules, a suggested checklist has been developed to support scrutiny of EU legislative proposals, as well as ex-post evaluations and impact assessments, in the context of AI. The aim is to equip the ITRE committee with an initial set of questions that could be the springboard for assessing some of the specific complex trade-offs involved in regulating AI, including the trade-off between having no regulation at all (which could hinder the free circulation of data and the potential commercial benefits of big data, whilst at the same time respecting core European values).

Alternatively, as is the case with cybersecurity, a key issue relating to the design of the future regulatory framework to maximise the potential and opportunities of AI (whilst restricting the potential drawbacks and risks) is the policy challenge as to whether AI is best regulated through a dedicated horizontal regulatory framework, and / or should AI-related considerations be integrated into existing EU legislation beyond the GDPR, such as in industrial product legislation.[320]

[318] European Court of Auditors. (2018). Special Report: Ex-post review of EU legislation: a well-established system, but incomplete (pursuant to Article 287(4), second subparagraph, TFEU).

[319] European Court of Auditors. (2018). Special Report: Ex-post review of EU legislation: a well-established system, but incomplete (pursuant to Article 287(4), second subparagraph, TFEU).

[320] For instance, the European Commission's DG GROW undertook an impact assessment of the Machinery Directive which considered whether the Directive should be updated and recast or whether the integration of AI and machine learning could be best integrated through the development of a new generation of state-of-the-art technical standards.

Box 13: Checklist: Scrutinising possible new EU legislation on AI

- Are the objectives set out in a new regulatory proposal at EU level proportionate and fit for purpose? Are they Specific, Measurable, Achievable, Relevant and Time-bound (i.e. S.M.A.R.T) considering the AI components of the proposals?
- To what extent has the regulatory proposal struck an appropriate balance between business and industry interests on the one hand (e.g. in implementing AI as part of Industry 4.0 practices, harnessing big data to maximise value added from customer data) and European values, and the need to foster a trust-based ecosystem on the other?
- To what extent does the regulatory proposal consider the global regulatory and competitiveness situation in relation to the specific issue being examined?
- To what extent have all legal considerations been considered in the development of the regulatory proposal? *(e.g. civil liabilities and existing parameters in EU legislation, such as GDPR)*
- How far is the proposed EU regulatory approach likely to bring about a trust-based ecosystem? Are there ways in which this could be further enhanced?
- To what extent is the proposed regulatory framework likely to drive, or conversely hinder innovation? How will this affect specific aspects *(e.g. digitalisation of industry, adoption of Industry 4.0 practices, collection of big data and data analytics)*?
- How far has the risk of unintended consequences relating to the deployment of AI been considered in the development of proposed regulation in AI? *(e.g. ethical considerations, dual-use possibilities, misuse and going beyond the intended use of technologies)*
- Is the proposed new EU regulatory framework set out in the AI White Paper sufficiently holistic and coherent with other EU legislation? i.e. have issues such as the free movement of data, and big data collection and analytics been factored into the design of the legislation? *(example – e-Privacy Regulation is a longstanding piece of legislation which had to be aligned with the GDPR)*
- To what extent have the characteristics of the AI applications addressed by a regulation been understood and assessed?
- To what extent have the nature and characteristics of the risks associated with different applications of AI been comprehensively assessed? *(e.g. in an impact assessment, commented on by the Regulatory Scrutiny Board)*
- To what extent have relevant existing industrial product legislation at EU level been fitness-proofed to consider new technological developments relating to AI?
- How far has this been achieved through revisions to existing legislation or through the development of further harmonised standards reflecting state of the art?
- To what degree is EU legislation actually necessary, as opposed to alternative means of regulating the market? *(e.g. self-regulation, using harmonised standards to embody new state of the art to respond to technological developments whilst retaining existing EU legislation)*
- To what extent does the regulatory proposal consider areas of particular socio-economic potential with regard to AI? *(e.g. environmental and healthcare impacts)*
- To what extent does the regulatory proposal specifically consider the challenges and impacts of AI on SMEs?

Source: CSES elaboration.

If regulators lack an in-depth understanding of the technological issues, it will be more difficult to produce relevant and useful legislation able to strike the delicate balance between fostering industrial competitiveness and ensuring data protection and privacy and respect for fundamental rights and other European values.[321] Sometimes AI will raise ethical considerations that go beyond the existing EU legal framework and / or which were not thought about when the existing legal framework was drawn up. The European Parliament has a clear role in scrutinising whether unintended consequences have been fully analysed and thought through.

An example in this regard is the use of AI in facial recognition technologies, which could have industrial and consumer applications, for example in the security industry and for the public sector (e.g. policing and real-time monitoring in urban areas), but raise major privacy issues that could be construed as questionable as regards GDPR compliance. A temporary pause on the deployment of such technologies until the issues can be investigated further was proposed (see statements by French President Emmanuel Macron and Commissioner Thierry Breton at DG CNCT). However, a possible 5-year ban on the use of these technologies was not included in the AI White Paper.[322]

Navigating AI regulation will be made more complex due to the technological and legal challenges that it presents. Therefore, scrutinising EU legislation on AI will require that the European Commission conduct evaluations and impact assessments on existing legislation with a specific focus on assessing their ongoing fitness for purpose in light of new technological developments, including AI. Recent examples where such issues have been explicitly considered are the 2018 Evaluation of the Machinery Directive (2006/42/EC), the subsequent *Impact assessment of the Machinery Directive*[323] and the *Interim Evaluation of the Low Voltage Directive (LVD)* 2014/35/EU.[324]

The latter study found that the provisions of the Directive are formulated in a technologically-neutral way and that the objectives are still relevant despite technological advancements. It further noted that standardisation is an effective means to ensure the adaptability of the Directive to market trends, including technological innovation. Furthermore, the below box presents a detailed look at how the ongoing impact assessment of the Machinery Directive is engaging with the topic of AI.

Box 14: Case study: Assessment of AI impacts in the context of the Machinery Directive (2006/42/EC)

Impact assessment of the Machinery Directive (2006/42/EC)

The REFIT evaluation of the Machinery Directive, referred to in the Communication on Artificial Intelligence (25 April 2018) identified the MD as the key legislation for robots using AI technologies ranging to completely automated production lines. The impact assessment of the Machinery Directive 2006 explicitly considered whether emerging technologies such as autonomous robots, Artificial Intelligence, and the industrial Internet of Things (IIoT) required a different regulatory approach.

The Directive does not explicitly address certain aspects of emerging digital technologies, due to the technologically-neutral nature of the legislation, combined with the fact that the essential requirements are short, and the detail is often left to harmonised standards to accommodate

[321] Joint Research Centre, European Commission. (2019). Legal and regulatory implications of Artificial Intelligence (AI): The case of autonomous vehicles, m-health and data mining.

[322] Khalid, A. (2020). The EU's agenda to regulate AI does little to rein in facial recognition.

[323] The impact assessment of the Machinery Directive is ongoing at the time of writing. An IA roadmap, inception impact assessment and consultation was undertaken and can be found here: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/2019-Revision-of-the-Machinery-Directive.

[324] European Commission. (2020). Interim evaluation of the low voltage directive 2014/35/EU.

emerging technologies. The Commission examined whether such technological developments required legislative changes.

The use of advanced AI in robots and other autonomous systems is not generally regulated in international competitor countries. However, with regard to GDPR, the EU seeks to develop a well-balanced regulatory framework that can ensure occupational health and safety, and where autonomous systems are designed to have a degree of human intervention when necessary. Through initiatives such as GDPR, the EU might seek to gain the advantage by becoming a global regulatory first-mover.

Nevertheless, industry stakeholders responding to the consultation on the roadmap published position papers suggesting that strengthening standardisation to cope with emerging technologies such as AI could be more effective than changing long-established legislation, which is considered to be effectively-functioning by most industry participants.

Source: European Commission. (2019). Proposal for a revision of the Machinery Directive, and CSES elaboration.

4. CONCLUSIONS AND RECOMMENDATIONS

Artificial intelligence (AI) is one of the most important technologies of our age and has become a key driver for socio-economic development globally. As an area of key strategic importance, AI has the potential to disrupt many sectors of the European economy, including health, transport, industry, communication and education. It can increase the efficiency with which things are done and improve decision-making processes by analysing and harnessing the potential of Big Data.[325] It can also lead to the creation of new services, products, markets and industries, thus boosting consumer demand and generating new revenue streams. However, AI applications can also raise challenges and concerns, for example related to privacy, liability, transparency and accountability to name a few, and there is a noticeable geopolitical dimension to efforts to strengthen competitiveness with the support of new technologies, including AI, as well as in the development of AI solutions.

This study aims to assist the ITRE committee by providing insights into the opportunities provided by AI, as well as the challenges and the global dynamics of AI and its application in industrial sectors. To achieve this, the study assesses the state of play regarding AI in the EU from a technological, economic, policy and regulatory perspective, highlighting industrial areas in which the integration of AI will bring significant socioeconomic benefits and drawing comparisons to global competitors, such as the US and China. On this basis, the study presents a methodology to support the ITRE committee in scrutinising the fitness for purpose of the EU policy and regulatory framework in the context of AI.

4.1. AI technology: state of play

Considering the implementation of AI by European industry, this study finds that a range of different types of AI application can be distinguished. These applications broadly fit into two categories. The first relates to **enhancing the performance and efficiency of industrial processes** through intelligent monitoring, as well as optimisation or control applications with automatic decision-making and cognitive capabilities (for example, through online learning). The second broad category relates to **human-machine collaboration**, which can include optimising the human-machine interface, automation of personnel management and virtual/augmented reality applications (for example, for remote and on-the-job training purposes).

Such applications are currently being implemented across a broad range of European industries, most prominently including high-tech, automotive, telecommunications, electric power and natural gas, pharmaceuticals, healthcare more broadly and part of the engineering sector characterised by advanced manufacturing technologies and Key Enabling Technologies (KETs). However, a key finding is that the types of AI applications in use differs across these industries. For instance, economic operators active in the automotive and packaged consumer goods industries are much more likely to implement physical robotics applications than other industries, whereas in the telecommunications industry, the AI solutions in use are more likely to comprise virtual agents or conversational interfaces.

Moreover, some industries, in particular more traditional industries such as the chemicals and paper industries, are less mature with regard to development and deployment of AI solutions. With this in mind, **clear barriers to industry adoption have been identified**, whereas the need of incorporating AI maturity self-assessment tools for manufacturing SMEs could be a starting point towards for any organisation to assess its current AI maturity. Internal to organisations, these include the lack of a clear organisational AI strategy, the existence of IT functions as silos, cultural resistance, a lack of knowledge and talent, financial considerations and enterprise size. In addition, external factors, such as the lack of

[325] European Parliament. (2019). Economic impacts of AI.

adequate venture capital environment, also play a role in preventing firms from adoption of AI solutions.

With regard to the **competitive position** of the EU in this regard, the study findings echo the sentiment of the European Commission's White Paper on AI that there is '*fierce global competition*' on AI. This is driven not only by economic and technological drivers but by geopolitical considerations, with the EU, the US and China all declaring ambitions to be world leaders in AI. Furthermore, the EU faces challenges with regard to ensuring the strategic autonomy of European industry and thus the digital sovereignty of the EU and its Member States.

Considering competitiveness elements in more detail, it is found that the balance of strengths differs across key criteria. For instance, the EU and the US are relatively equal with regard to **access to talent and research capabilities in AI** and seemingly well placed compared with China. However, Europe has a clear disadvantage with regard to **venture capital funding**, as compared with the US and China, and all three have committed significant public funding for AI development and deployment.

Furthermore, Europe is considered to be less developed than the US but in a better position than China with regard to Big Data generation (see Table 11) and behind with regard to practical adoption of AI solutions and the development of hardware and components. However, although China is considered to be leading with regard to practical adoption, **Europe is considered to have competitive strengths in certain industries, such as automotive, healthcare, energy, financial services, media and the tech sector**. In order for Europe to ensure a globally leading competitive position in AI, as well as the strategic autonomy of its industry and digital sovereignty, the pace of adoption of digital technologies and AI needs to accelerate, building on longstanding technological and industrial strengths.

4.2. AI opportunities and challenges: State of play

The implementation of AI in European industry has achieved a wide range of positive impacts already, and further different types of impacts can be expected in future as more firms across a broader range of sectors implement AI. These impacts range from improvements in the efficiency and effectiveness of existing industry practices to the development of entirely new industrial applications and positive impacts on the workforce. Furthermore, impacts achieved at an organisational level within industry as a whole and in individual companies are expected to drive positive societal and economic changes at both the national and EU levels.

With regard to efficiency benefits, these can result from many of the application types highlighted above and can deliver **increased production output, increased production quality and reduced maintenance costs** ultimately leading to higher revenues and profits. In fact, a recent study estimated that the overall impact potential of AI with regard to IIoT applications was approximately EUR 200 billion. In addition, important environmental benefits can be achieved, such as improved energy efficiency, more efficient use of raw materials and reduced waste. In fact, the potential scale of the environmental benefits of AI suggest that it is one of the areas with the greatest potential for significant socio-economic impact.

Considering impacts to the effectiveness of industry, **the opportunities for greater product personalisation, improved customer service and the development of new product classes, new business models and even new sectors are significant**. In addition, although system-wide changes to workforce demands will occur as a result of the adoption of AI and other new technologies, significant workforce benefits are also anticipated. These positive impacts include improved workplace safety, more effective training and guidance and improved attractiveness of industrial careers.

In combination, these benefits are also anticipated to contribute to significant society and economy wide impacts. More specifically, significant benefits are expected in relation to growth, productivity, innovation and job creation. Concerning productivity, for example, one estimate forecasts **increases in labour productivity of between 11% and 37% by 2035**. Furthermore, AI is expected to support positive contributions to the UN Sustainable Development Goals (SDGs), be crucial for the implementation of Industry 4.0 initiatives and, in particular, have important positive societal impacts in the following areas:

- ***Environmental***: As highlighted above, industry will achieve gains from **improved energy efficiency**, reduced waste and more efficient use of raw materials, as well as a greater ability to manage energy supply and demand, and the ability to tackle key challenges facing the renewable energy sector. In relation to the UN SDGs, AI could contribute to reduced global greenhouse gas emissions of between 1.5% and 4% by 2030; and
- ***Health-related***: The use of AI could accelerate new drug identification and development, as well as repurposing of existing drugs and could strengthen analytical capabilities. More specifically, with regard to the UN SDGs, it has been highlighted AI could: augment and improve diagnosis and treatment; improve foetal health; predict and monitor epidemics and chronic diseases; improve the provision of primary healthcare services; and enhance medical research and drug discovery. In addition, the benefits and opportunities of AI have also been evident in tackling the COVID-19 crisis, with AI technologies and tools used to: understand the virus and accelerate medical research, detect and diagnose the virus, predict the virus' evolution and spread, providing personalised information and learning, and monitoring recovery.

On the other hand, AI will also bring certain challenging impacts. Most prominent, as mentioned above, are the workforce changes AI will require. AI applications are expected to result in the **elimination of a large number of jobs**, requiring significant workforce adaptation. More specifically, OECD research has estimated that, on average, around 14% of jobs in OECD countries are highly automatable and another 32% could face substantial changes. However, as mentioned above, AI will also drive significant job creation and allow humans to focus on higher-skilled roles. Preparation for this change, with regard to both education and retraining / reskilling, is vital to implement AI and achieve the significant benefits foreseen, as those displaced will typically not have the skills currently to profit from new roles. In this direction, findings of the ongoing standardization process on CEN/TC 478 "ICT Professionalism and Digital Competences" can set the groundwork for the optimal integration of AI skills in the workforce of the future.[326] In addition, there is a concern that large firms are much better placed to take advantage of the opportunities provided by AI, which could lead to overconcentration in the market of large firms and multinationals.

Furthermore, as documented in a significant range of assessments of AI, there are a range of ethical, trust and legal challenges. In summary, these can include issues related to security, robustness and resilience of AI systems; privacy and data protection; transparency and accountability of AI systems; fairness, discrimination and explainability of AI systems; and liability issues.

4.3. AI policy and regulatory approaches: State of play

To date, limited governmental activity has been conducted on AI. Instead, the AI policy and regulatory environment in the EU and globally has been characterised by the implementation of initiatives from industry, civil society and standards bodies. Key examples of these 'self-regulatory' initiatives include:

[326] CEN/TC 428 – ICT Professionalism and Digital Competences.

efforts to develop international standards on AI, including by the ISO and the IEEE; the development of a substantial number of **codes of conduct and ethical frameworks** for AI development; and the development of a range of **technical and policy tools**, primarily for assessing how AI tackles the ethical challenges noted above.

In Europe, the EU has not taken any specific legislative action on AI. From 2017-2019, a range of policy initiatives and activities were undertaken with regard to AI, most prominently including the EU's first AI strategy (AI for Europe) and the associated Coordinated Plan on AI. Amongst other elements, these policy documents pledged significant public and public-private investment, adaptation of training and educational systems, and development of key AI enablers and infrastructure, such as a well-functioning data ecosystem. This was accompanied by significant work on how to address the ethical and legal challenges of AI (for example through the High-Level Expert Group on AI and the Expert Group on Liability and New Technologies) and followed up in early 2020 by the European Commission's White Paper on AI, part of the European Digital Strategy. The White Paper presents a vision to develop ecosystems of excellence and trust, while indicating possible mechanisms for future regulation of AI, including placing legal requirements on 'high-risk' AI applications. The European data strategy was also published alongside the White Paper, presenting a vision for a single European data space and commits, amongst other activities, to Common European data spaces in manufacturing, Green Deal priority actions and health.

In addition to these initiatives, the Commission has been engaging specifically with AI through industrial policy since 2016 and, more recently, has incorporated the need to assess the impact of new technologies, including AI, into assessments of existing legislation. For example, this is most prominently illustrated in relation to core industrial product legislation such as the Machinery Directive (2006/42/EC).

Furthermore, it is important to note that, in relation to data protection and privacy concerns, the GDPR is a vital piece of existing legislation relevant to the deployment of AI. More specifically, the GDPR includes specific protection to prevent misuse and / or abuse of AI, for example through Art. 22 on automated profiling and decision-making. Although it is argued by some that the GDPR could negatively impact innovation in AI development and deployment, others have stressed that privacy is important and a positive enabler of appropriate AI development. Furthermore, given its relatively recent adoption and inclusion of AI-relevant texts prior to the significant acceleration of AI regulatory considerations, a full understanding of its effectiveness is not yet known.

Considering the regulatory environment in key third countries, it is also notable that **no horizontal regulation on AI has been proposed or implemented globally**. A small number of countries have implemented specific regulation on liability in the context of AI, or on AI applications in specific sectors, in particular on autonomous driving. Furthermore, many nations globally have developed AI strategies, as well as non-binding standards and guidelines. For key third countries, such as the US, Japan and China, these strategies on the whole focus on similar issues to the EU developments. For example, they all contain prominent investment strategies and workforce adaptation plans. However, the emphasis on ethics is generally limited when compared to the EU policy approach.

Another important dimension relating to the EU's policy and regulatory framework is the concept of **reinforcing Europe's strategic autonomy in AI** as a means of ensuring that European industry can capitalise on the benefits of AI, whilst operating within a legal framework that ensure respect for European ethical values. **Strategic independence in AI will be key to the development and growth of the European data economy, and also to** fostering the development of **EU industries**, including those that are strategically important either to the European economy as a whole (e.g. engineering

industries) or to its security (e.g. space, 5G), and where autonomy regarding access to, and the deployment of AI technologies is likely to continue to be important.

With the regulatory state of play established, it is important to note the possible impact of the COVID-19 crisis. As highlighted above, the opportunities of AI to bring societal and economic benefits have been evident throughout the crisis; however, the impacts of the crisis, from an economic and regulatory perspective, as well as the path to recovery are still unclear. Prior to the publication of the European Commission's Recovery plan for Europe, a wide range of industry associations called for many ongoing legislative discussions to be delayed due to the current climate, including possible amendments to the Machinery Directive and AI-related policy developments.[327]

On 27 May 2020, the European Commission published its Recovery plan for Europe.[328] The recovery plan reiterates the position of digital transition goals as a policy priority and states that "*recovery investment will be channelled towards strategic digital capacities and capabilities, including artificial intelligence*".[329] An overview of key AI-relevant details from the recovery plan are presented in the below box.

Box 15: EU Recovery Package and its relevance to AI

EU Recovery Package and AI

5G, AI, cybersecurity and renewable energies are all expected to receive investments under EU coronavirus recovery plan. The Commission has committed in a Communication from May 27th, 2020 to a two-fold response to the COVID-19 crisis through: i) the new Next Generation EU recovery instrument, which will provide EUR 750 billion of new financing between 2021-2024 (EUR 500 billion in grants and 250 billion in loans to Member States); and ii) a reinforced long-term EU budget, providing EUR 1,100 billion over the period 2021-2027.

Through these means, the Commission has stated that strengthening Europe's digital capacities and capabilities is a key priority, even more so than before the crisis. The pillars of support provided by the Next Generation EU instrument reflect this message. For instance:

- Under the pillar to **support Member States with investments and reforms**, support for digital transitions, including AI, is mentioned in relation to both the new EUR 560 billion Recovery and Resilience Facility and the EUR 55 billion REACT-EU initiative;
- Within the **kick-starting the economy and mobilising private investment** pillar – the most relevant with regard to industrial AI adoption – the Commission has pledged to drive investment in key sectors and technologies, in particular, through the Solvency Support Instrument and by strengthening the InvestEU programme, including through the new Strategic Investment Facility. The plans for these measures all include specific reference to supporting digitalisation; and
- Considering the pillar focused on **learning the lessons of the crisis and addressing Europe's strategic challenges**, the Commission makes specific commitments relating to reinforcing Horizon Europe in part to support the digital transition.

The channelling of investment towards strategic digital capacities and capabilities "*will be a priority in the Recovery and Resilience Facility, InvestEU and the Strategic Investment Facility. The investment guidelines for the new Solvency Support Instrument will also reflect the need to prioritise digital investments*".[330]

[327] For example: Orgalim. (2020). Orgalim requests concerning Commission work in 2020 in light of COVID-19, 22 April 2020.

[328] European Commission. (2020). Recovery plan for Europe, 27 May 2020.

[329] European Commission. (2020). Communication, Europe's moment: Repair and Prepare for the Next Generation, Brussels, 27.5.2020, COM/2020/456 final.

[330] European Commission. (2020). Communication, Europe's moment: Repair and Prepare for the Next Generation, Brussels, 27.5.2020, COM/2020/456 final.

In addition to the above measures, the Commission has adjusted its 2020 Work Programme. Although some delays are envisaged to AI-related policy developments (e.g. the follow-up to the White Paper on AI will now be delivered in early 2021 rather than late 2020), the Commission is still committed to completing its key digital policy goals in late 2020 and early 2021.[331]

Source: European Commission (various).

4.4. Scrutinising EU policy and regulation in the context of AI

The European Commission's REFIT programme, in conjunction with the Better Regulation guidelines and toolbox, provide an opportunity to assess both quantitatively and qualitatively the impacts of proposed new legislation. However, such frameworks **need customisation** to meet the specific challenges in optimising the potential benefits of AI for Europe's industrial competitiveness, whilst mitigating the potential adverse consequences (e.g. citizen's privacy being compromised). Moreover, there is a need to strengthen attention to managing the potential risks posed by new technologies, including unintended consequences, in the Better Regulation guidelines.

The European Parliament has a crucial role to play in scrutinising the regulatory fitness of proposed new EU legislation in the area of AI and in ensuring that impact assessments and evaluations: i) strike the right balance between respecting European values whilst capitalising on the opportunities of AI; and ii) ensure that impact assessments (including technical supporting inputs and Staff Working Documents) integrate a risk-based approach to regulating AI that reflects different types of risks (for example for EU citizens, to European values, to data protection and privacy and with regard to possible dual uses).

On the basis of this assessment and the analysis of the technological, impact and regulatory state of play, **this study has developed a checklist that could support scrutiny of EU legislation in the context of AI**. Utilising elements of the Better Regulation approach (namely, the aspects of the intervention logic), this checklist covers issues related to suitability of regulatory objectives, assessment of legal considerations, assessment of trade-offs between opportunities and challenges, assessment of unintended consequences, coherence with existing legislation and the extent to which risk levels associated with AI applications have been considered and assessed.

4.5. Policy recommendations

On the basis of the findings of the research on the technological, impact and regulatory state of play of AI in Europe, compared to key competitor countries, this study presents the following recommendations. In particular, these include considerations on the need for new policies and the relevant domains of applicability and the need for an improved and / or refined implementation of existing actions and activities.

4.5.1. Recommendations on fostering the use of AI in industry

This report demonstrates that there are many different use cases for the deployment of AI across different industries in Europe. Whilst some industries and large firms have already embraced AI and invested significantly both in capital investment linked to Industry 4.0 and in software and data collection using AI, many firms have yet to do so, especially SMEs. Furthermore, strong competition from key third countries, such as the US and China, threatens to undermine the strategic autonomy of European industry and thus the digital sovereignty of the EU and its Member States. As such, the EU needs to act in order to ensure an enabling environment – with a supportive regulatory framework –

[331] European Commission. (2020). Adjusted Commission Work Programme 2020, Annex I: New initiatives, 27 May 2020.

conducive to the wider adoption of AI applications across European industry. A successful enabling environment will, at the least, require investment and support to improve digital infrastructure, governance, to improve skills and to foster collaboration. These recommendations aim to address these elements while considering existing, as well as possible new, activities.

Recommendation 1: Encourage the European Commission to implement and monitor SME support and digitalisation programmes to ensure their effectiveness in facilitating digitalisation. As highlighted through this study, SMEs face particular barriers and challenges in relation to the adoption of AI. Although there are many EU and national, public and private programmes to support digitalisation and AI, the effectiveness of these interventions should be proactively encouraged, given the crucial importance of SMEs to the adoption of AI across European industry.

Recommendation 2: The EP should ensure that the Commission continues to support the digital transformation of SMEs by ensuring adequate access to finance to invest in digitalisation through its COVID-19 Recovery Plan. As the key barriers to SME adoption of AI are mainly financial, it will be key to ensure investment and financing support for SMEs, in particular, are appropriately targeted and effective. It is also particularly important that the Commission continues to support the digital transformation of SMEs through its COVID-19 recovery plan. Furthermore, the monitoring process can be coupled with self-assessment AI maturity tools during their duration (i.e. at the beginning and the end of such programmes), which can enable justifiable benefits of SMEs participating in such accelerator projects.

Recommendation 3: The proportion of resources devoted to AI within the Digital Europe Programme (DEP) could be reviewed and made subject to an evaluation. The EU already provides significant funding support for AI (e.g. EUR 2.5 billion in the DEP). Whilst other thematic priorities within the DEP (e.g. high performance computing, cybersecurity and trust at EUR 2 billion; and advanced digital skills at EUR 700 million) are crucially important to Europe's economic competitiveness, there may be an argument for increasing the funding share for AI within the programme, to help Europe catch-up with its global competitors (especially the US and China, where public research funding for AI is greater than in Europe).

Recommendation 4: Encourage the Commission to support actions to increase resilience of European supply chains in a Global Value Chains (GVCs) context using AI and other emerging technologies.[332] This could avoid future supply bottlenecks for European industry due to economic or supply shocks. Big data analysis using AI could help in the early identification of problems. The diversification of suppliers and consideration of reshoring some aspects of production to Europe, facilitated by AI and other emerging technologies, could help to reduce risks. This could help to boost European SMEs if large firms and multinationals were to invest in near-shore outsourcing to more localised manufacturers. Considering the impacts of the COVID-19 crisis, the automotive sector is a key example of a sector that suffered from supply chain dislocations.

Recommendation 5: Encourage the Commission to increase support for showcasing, demonstration and piloting of AI applications, in particular for stakeholders (including SMEs) and in industrial sectors that are less digitally mature (e.g. pulp and paper, or pumps industries). Key barriers to adoption are cultural resistance and a lack of clear organisational strategies for AI, in part due to a lack of understanding of the benefits AI can deliver to businesses and how to achieve those benefits. Such pilot applications, which could also be supported through European Digital Innovation Hub

ecosystems, will foster increased trust in AI solutions and thus facilitate increased adoption. This support could be financial or via exposure through promotional campaigns and will facilitate the strategic autonomy of EU industry by demonstrating possible applications and highlighting European solutions.

Recommendation 6: Strengthen the attractiveness of European AI development by promoting collaborative, EU-wide and ambitious research and development projects. A key barrier to AI adoption in European businesses is the lack of skilled personnel and a key challenge for the EU AI research community is difficulties collaborating between pockets of excellence. Furthermore, the ambitious research projects being initiated regularly by large US tech firms are attractive to Europe's most talented researchers, who wish to be at the pinnacle of their fields. Promoting large-scale, Europe-wide, collaborative and most importantly ambitious research projects that tackle the biggest research issues in AI will build trust in skilled AI researchers that European academia and industry can offer fulfilling careers and projects. Ensuring European talent is retained in Europe, by European industry will also reinforce EU digital sovereignty. This could include projects funded through Horizon Europe or supporting / promoting privately developed collaborative AI research platforms, such as the Confederation of Laboratories for AI Research in Europe (CLAIRE) which was launched in 2018 and has garnered support from more than 1,000 AI experts across Europe, as well as the AI Digital Innovation Hubs (DIH) Network[333] that was recently launched by the European Commission as a fundamental action to establish a framework for continuous collaboration and networking between Digital Innovation Hubs focusing on Artificial Intelligence (AI).

Recommendation 7: Be at the forefront of AI adoption by public authorities. Lead industry and garner trust in the adoption of AI by taking steps to explore the ability for AI to support EP work. For instance, there are examples of AI being used in Finland as a tool to produce consolidated texts and assist law-drafters and lawmakers.[334] In addition, through the adoption of such AI systems, the EP and other EU institutions could support European AI developers and thus support EU aims for digital sovereignty.

Recommendation 8: Encourage the Commission to implement measures to foster private sector investment in AI across Europe: A key challenge for AI adoption relates to the availability of venture capital funding, as compared to the US. In particular, the recommendation of the AI HLEG to set up a European Coalition of AI Investors could be a solution, not only to deliver greater investment in AI but also to establish an ecosystem that ensures greater understanding between investor and the AI industry.

Recommendation 9: Ensure investment in AI and other digital transformation topics is protected considering COVID-19: In light of the COVID-19 crisis and the publication of the European Commission's recovery plan, it will be key to ensure investments in digital transformation and adoption of AI across industry are protected. In particular, given the significant demonstrable benefits delivered by AI in relation to many aspects of the crisis and the increasing use of and reliance on digital technologies by many businesses.

Recommendation 10: Ensure a policy focus on AI and other digital transformation topics is protected considering COVID-19: Building on recommendation 8, on ensuring investment continues to be strong following the COVID-19 crisis, it will also be important to ensure the Commission's policy

[333] AI Digital Innovation Hubs Network, https://ai-dih-network.eu.

[334] Office of the Chancellor of Justice, Finland. (2019). Competitive Europe and the Regulation of Artificial Intelligence (AI) and Other Emerging Technologies? Principles of Better Regulation in the Context of AI and the Future of Better Regulation, 27.6.2019.

plans to advance on topics of AI and data, in particular, continue to be prioritised and do not face significant delays.

Recommendation 11: Encourage the Commission to specifically consider AI applications and deployment within policy development in key areas: Given the impact COVID-19 has already had on digital transformation across European industry, it is vital that this momentum and the opportunity for AI and other digital technologies to play an important role in economic recovery is not lost. As such, and in particular because a range of deliverables have been delayed in the Adjusted 2020 Work Programme, the Commission should be encouraged to specifically consider the role of AI, in particular, in areas where AI applications can deliver significant socio-economic benefits. For instance, this could include:

- the Policy Objective 'Protecting Health', where AI should be specifically considered in the Pharmaceutical Strategy for Europe, expected to be delivered in Q4 2020;
- select environmental policy objectives, for example the Strategy for sustainable and smart mobility, expected in Q4 2020;
- the policy on the European Research Area, where for example the Communication on the Future of Research and Innovation and the European Research Area (expected Q4 2020) could take particular note of AI-related considerations; and
- the role of AI should also be considered explicitly in the New Strategy for the Implementation of the Charter of Fundamental Rights, expected Q4 2020.

4.5.2. Recommendations for the ITRE committee regarding scrutiny of EU legislation in the context of AI

Recommendation 1: Strengthen risk assessment of AI-related regulations: As the basis of the problem definition development, assess and establish the characteristics of different types of risks and threats, including technological risks, and define these on the basis of scientific and technical knowledge.

Recommendation 2: Encourage the European Commission to strengthen the assessment of the impacts of new technologies in impact assessments and evaluations: Currently, the Better Regulation guidelines and toolbox make limited mention of how to approach the assessment of the positive and negative impacts of new technologies. As such, the methodologies and parameters used to conduct such assessments can differ across the Commission. The Better Regulation guidelines could be complemented by some more specific guidance that extends beyond explaining the conventional technology-neutral nature of legislation, and explore the implications of the more widespread adoption of specific new technologies, such as AI, which will have a significant horizontal impact across policy areas. Within this context, it will be necessary to assess both positive and negative, as well as intended and unintended consequences.

Recommendation 3: Encourage increased focus on the impact of new technologies, including AI, through the REFIT programme: In addition to the above recommendation on the Better Regulation guidelines and toolbox, it is notable that the REFIT programme has placed limited focus on assessing the impact of new technologies on the EU's legislative framework. Encouraging greater focus and reporting of results on the envisaged impact of new technologies, including AI, on the fitness of existing legislation will facilitate better analysis and evaluation of AI throughout the policy cycle.

Recommendation 4: Engage industry and legal experts to strengthen the quality of regulatory scrutiny by EP:[335] Such experts should be engaged by the EP in the context of studies or in the context of the EP's Artificial Intelligence Observatory (EPAIO) to help provide the necessary combination of technological and industrial understanding to be able to provide a detailed reaction to regulatory proposals from the European Commission in a timely and informed manner. Although current practices exist in this regard, it will be essential to ensure in particular that experts in state-of-the-art AI, industry practices and legal experts are brought together when scrutinising legislation on AI.

Recommendation 5: The European Parliament should ensure that it adopts a holistic approach to AI across the different European Parliament committees: Given the horizontal impact of new technologies, such as AI, across different and diverse EU policy areas, a number of European Parliament committees are conducting research on the topic. Coherence between these efforts needs to be ensured to allow the European Parliament to develop a holistic approach to AI. A special committee on AI has been suggested, which would help to address the cross-cutting dimension of AI.

Recommendation 6: Deepen assessment of impacts of AI regulation to sectoral level to avoid superficial analysis: The implications of regulating AI will need to be examined not only overall but also on a sector-by-sector basis. The ITRE committee should therefore check that a representative sample of sectors are covered in the Commission impact assessment. In particular this sample should cover sectors with a range of digital maturities and positions within value chains, as well as a combination of traditional and newer sectors. The aim is to ensure that the implications for industry have been properly assessed across traditional sectors of the European economy, digital-related and advanced manufacturing sectors.[336] Furthermore, the ITRE committee could commission its own assessment to understand the risks present per sector.

Recommendation 7: Conduct a study (or encourage the Commission to do so) on the implementation of the GDPR and e-Privacy Directive (and the implications of the proposed e-Privacy Regulation) on AI in an industrial setting, including the global value chains dimension. Although GDPR is technology-neutral, there is a lot of evidence that the implications of AI for GDPR compliance, including monitoring and enforcement aspects are complex, not well understood and have not yet been evaluated. For example, the IA on GDPR was undertaken as far back as 2012, the legislation only came into effect in May 2018 and there have already been privacy concerns as regards issues such as deployment of AI in facial recognition technologies. This could not have been anticipated at the time of the original IA, as such technologies were not that developed.

Recommendation 8: When scrutinising EU regulatory proposals, the EP should ensure that European digital and technological autonomy in AI has been factored into impact assessment studies. Given that AI is of strategic importance to the European economy, a check should be made that impact assessment studies published by the European Commission consider this dimension in relevant regulatory proposals.

[335] Joint Research Centre, European Commission. (2019). Legal and regulatory implications of Artificial Intelligence (AI): The case of autonomous vehicles, m-health and data mining.

[336] Joint Research Centre, European Commission. (2019). Legal and regulatory implications of Artificial Intelligence (AI): The case of autonomous vehicles, m-health and data mining.

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ANNEX 1: LIST OF ORGANISATIONS INTERVIEWED

Stakeholder type	Organisation
Academia	German Research Centre for AI (DFKI)
Academia	Sorbonne Université
Company	Bosch Center for Artificial Intelligence
Company	Orange
Company	Valmet (x3)
Consumer association	The European Consumer Organisation (BEUC) (x2)
EU body / institution	European Commission Joint Research Centre (JRC): (x2) • AI and Big Data • Digital Economy Unit
Industry association	Confederation of European Paper Industries (CEPI)
Industry association	DigitalEurope (x2)
Industry association	European Chemical Industry Council (CEFIC) (x3)
Industry association	European Transmission System Operators (ENTSO-E)
Industry association	Federation of German Industries (BDI)
Industry association	Orgalim (x2)
Industry association	WindEurope (x2)
Intergovernmental organisation	Organisation for Economic Co-operation and Development (OECD) (x3)
National authority	Central Sweden Regional Authority
Other	StepChange
R&D&I stakeholders	Artificial Intelligence and Human Machine Interface Smart Specialisation Platform
R&D&I stakeholders	ECSEL Joint Undertaking (x2)
R&D&I stakeholders	European Time Machine Project
R&D&I stakeholders	Fraunhofer Institute for Applied Optics and Precision Engineering
R&D&I stakeholders	Institute for Textile Technology

ANNEX 2: TIMELINE OF EU POLICY DEVELOPMENTS

The below table provides a summary of EU policy initiatives on AI in the period 2017-2020. This table provides more detail on each of the policy initiatives listed in section 3.1.2.

Timeline of EU policy initiatives on AI

2017

- In 2015, the European Parliament's Committee on Legal Affairs (JURI) established a working group on the development of AI and robotics in the EU, with a civil-law aspect.[337] As a result of discussions and research conducted through 2015 and 2016,[338, 339] the JURI committee published a **report with recommendations to the Commission on Civil Law Rules on Robotics in January 2017**.[340] This establishes the context and challenges of AI and robotics development and a vision of the regulatory role the EU could play on AI and robotics, before indicating that civil liability issues are an appropriate first issue to tackle and detailing a range of recommendations. These recommendations covered a range of issues, including: general principles; research and innovation; ethical principles; intellectual property rights and the flow of data; standardisation, safety and security; liability; education and employment; and specific applications, such as autonomous means of transport.[341] To illustrate the EU's acknowledgement of the wide-reaching impact of AI, a number of different European Parliament Committee's issued opinions on the report; notably, these include those on Industry, Research and Energy (ITRE),[342] Transport and Tourism (TRAN), Civil Liberties, Justice and Home Affairs (LIBE), and Employment and Social Affairs (EMPL);
- The **European Economic and Social Committee issued an opinion on AI in May 2017**.[343] This recommended that the EU take the lead on developing clear global AI policy objectives, driven by European values and fundamental rights. Given its remit, the opinion follows by identifying areas where AI poses societal challenges. Mirroring those discussed throughout this report, the EESC highlighted issues related to ethics, safety, privacy, transparency and accountability, work, and education and skills;
- In its **mid-term review of the Digital Single Market strategy** (May 2017), the European Commission highlighted the importance of being in a leading position in the development of AI technologies and stated that it would 'consider the possible need to adapt the current legal framework to take account of new technological developments'[344], including on AI. Furthermore, it highlighted specific investment of EUR 300 mn for the development of next generation digital industrial platforms, as well as continued investment in key technologies, including AI and their integration along the value chains.[345] Research activities primarily include funding for projects and pilots, e.g. through FP7 and Horizon 2020;[346] and

337 European Parliamentary Research Service. (2017). Civil law rules on robotics: At a glance.

338 European Parliament. (2016). European Civil Law Rules in Robotics, Study for the Legal Affairs Committee (JURI).

339 European Parliamentary Research Service. (2016). Scientific Foresight study: Ethical Aspects of Cyber-Physical Systems.

340 European Parliament. (2017). Report with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)).

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343 European Economic and Social Committee. (2017). Opinions: Artificial Intelligence.

344 European Commission. (2017). Communication on Mid-Term Review on the implementation of the Digital Single Market Strategy: A Connected Digital Single Market for All, COM(2017) 228 final.

345 European Commission. (2017). Communication on Mid-Term Review on the implementation of the Digital Single Market Strategy: A Connected Digital Single Market for All, COM(2017) 228 final.

346 European Commission. (2017). Communication on Mid-Term Review on the implementation of the Digital Single Market Strategy: A Connected Digital Single Market for All, COM(2017) 228 final.

- In October 2017, the **European Council invited the Commission to put forward a European approach to AI by early 2018**, calling for a sense of urgency with regard to addressing emerging technology trends in the context of successfully building a Digital Europe.[347]

2018

- In March 2018, the European Group on Ethics in Science and New Technologies published a **statement on Artificial Intelligence, Robotics and 'Autonomous' Systems**.[348] Highlighting the 'increasingly urgent and complex moral questions'[349] posed by AI, robotics and autonomous technologies, the statement called for the EU to initiate a process to develop a 'common, internationally recognised ethical and legal framework for the design, production, use and governance'[350] of these technologies;
- A **Declaration of Cooperation on AI** was signed by 25 European countries[351] in April 2018, with the aim of collaboration on 'the most important issues raised by AI; from ensuring Europe's competitiveness in the research and deployment of AI, to dealing with social, economic, ethical and legal questions'[352]. By July 2018, an additional four countries had joined the initiative.[353] Although non-binding, the Declaration was considered a significant illustration of the intent of European nations to collaborate on AI leadership;[354]
- The intent signalled by the Declaration was strengthened through 2018 by two key European Commission publications. On 25 April, as a response to the European Council's calls, the Commission adopted the **Communication Artificial Intelligence for Europe** – the first EU strategy on AI.[355] This Communication establishes a vision and framework for ensuring the EU plays a leading role globally in AI policy development, by tackling the challenges associated with AI and fully realising the economic and social benefits of AI implementation. More specifically, the Communication proposed a three-step approach: (i) boosting technological and industrial capacity and AI uptake across the EU, including through increases in public and private investment; (ii) preparing for socio-economic changes brought by AI; and (iii) ensuring an appropriate ethical and legal framework, based on European values and respect for fundamental rights;[356]

  The Communication was accompanied by a Commission Staff Working Document (SWD) specifically **examining the issue of liability in relation to emerging digital technologies**, such as AI. The SWD raised key questions with regard to liability and new technologies and pledged to analyse these questions with the help of the Commission Expert Group on liability, comprising two formations: the New Technologies formation; and the Product Liability Directive formation;[357]
- In December, the groundwork laid by the Communication on AI for Europe was built on by the Commission's **Coordinated Plan on Artificial Intelligence**.[358] The coordinated plan presents

[347] European Council. (2017). European Council meeting (19 October 2017) – Conclusions, EUCO 14/17.

[348] European Group on Ethics in Science and New Technologies. (2018). Statement on Artificial Intelligence, Robotics and 'Autonomous' Systems, Brussels, 9 March 2018.

[349] European Group on Ethics in Science and New Technologies. (2018). Statement on Artificial Intelligence, Robotics and 'Autonomous' Systems, Brussels, 9 March 2018.

[350] European Group on Ethics in Science and New Technologies. (2018). Statement on Artificial Intelligence, Robotics and 'Autonomous' Systems, Brussels, 9 March 2018.

[351] List of original 25 signatory countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, UK, Norway.

[352] European Commission. (2018). EU Member States sign up to cooperate on Artificial Intelligence.

[353] Romania, Greece and Cyprus joined in May 2018; Croatia joined in July 2018.

[354] Stix, C. (2019). A survey of the European Union's artificial intelligence ecosystem, Leverhulme Centre for the Future of Intelligence, University of Cambridge.

[355] European Commission. (2018). Communication Artificial Intelligence for Europe.

[356] European Commission. (2018). Communication Artificial Intelligence for Europe.

[357] European Commission. (2018). Staff Working Document on Liability for emerging digital technologies accompanying the Communication on Artificial intelligence for Europe, Brussels, 25.4.2018, SWD(2018) 137 final.

[358] European Commission. (2018). Communication Coordinated Plan on Artificial Intelligence, Brussels, 7.12.2018, COM(2018) 795 final.

detailed actions to be taken in 2019-2020. These actions aim to strengthen and support AI development in the EU by: boosting investment; strengthening AI research; adapt training and educational systems; ensuring a well-functioning data ecosystem; supporting ethical AI development; and ensuring security-related aspects are considered with regard to AI applications and infrastructure; and

Furthermore, the plan encouraged Member States to develop national AI strategies by mid-2019. These national strategies should, as a minimum, outline investment levels and implementation measures. With the support of the Joint Research Centre's AI Watch[359], the Commission also pledged to agree common indicators by which AI uptake and development could be monitored and the success of the strategy could be assessed.[360]

2019

- The EP adopted an own-initiative report on a **Comprehensive European industrial policy on artificial intelligence and robotics** in February 2019.[361] After highlighting the context of opportunities and challenges related to the interaction between industrial policy and AI, noting healthcare applications in particular, this text addresses specific societal issues, making recommendations on the labour market and malicious use of AI, before discussing the technological roadmap. Within this latter discussion, the report sets out the EP positions on research and development, investment, innovation and key enablers of AI, before commenting on the adoption of AI in specific industrial sectors, including healthcare, transport, energy, agriculture and the food chain;[362]
- The **High-Level Expert Group on AI** presented Ethics Guidelines for Trustworthy Artificial Intelligence on April 2019. This initiative came off the back of an initial publication of the guidelines' first draft in December 2018 and an open consultation;[363]
- In April 2019, the European further published a **Communication: Building Trust in Human Centric Artificial Intelligence**, which among others, described how privacy and data governance are some of the seven key requirements that AI applications should respect;[364] and
- The **Expert Group on Liability and New Technologies – New Technologies Formation** published a **Report on liability for Artificial Intelligence and other emerging technologies** in November 2019, providing recommendations on how liability regimes should be designed or updated in the EU to address the challenges deriving from rapid technological change.[365]

2020

- In February 2020, the Commission published the European digital strategy, alongside a **White Paper on Artificial Intelligence**[366] and a **European strategy for data**.[367]

Source: European Commission (various) and CSES elaboration.

[359] European Commission. (n.d.). Joint Research Centre, Knowledge for policy, AI Watch.

[360] European Commission. (2018). Communication Coordinated Plan on Artificial Intelligence, Brussels, 7.12.2018, COM(2018) 795 final.

[361] European Parliament. (2019). A comprehensive European industrial policy on artificial intelligence and robotics.

[362] European Parliament. (2019). A comprehensive European industrial policy on artificial intelligence and robotics.

[363] AI HLEG. (2019). Ethics guidelines for a trustworthy AI.

[364] European Commission. (2019). Communication on Building Trust in Human-Centric Artificial Intelligence, Brussels, 8.4.2019, COM(2019) 168 final.

[365] European Commission. (2019). Liability for Artificial Intelligence.

[366] European Commission. (2020). White Paper On Artificial Intelligence – A European approach to excellence and trust, Brussels, 19.2.2020, COM(2020) 65 final.

[367] European Commission. (2020). Communication on A European strategy for data, Brussels, 19.2.2020, COM(2020) 66 final.

This study focuses on presenting the technological, impact and regulatory state of play in the EU, as compared to key competitor countries. This study also highlights industrial areas in which AI will bring significant socioeconomic benefits, before presenting a methodology for scrutinising the fitness of the EU policy and regulatory framework in the context of AI.

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