STUDY

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European Parliament

European Artificial Intelligence (AI) leadership, the path for an integrated vision

Policy Department for Economic, Scientific and Quality of Life Policies
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Author: Laura DELPONTE (CSIL)
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European Artificial Intelligence (AI) leadership, the path for an integrated vision

Abstract

As a general-purpose technology Artificial Intelligence (AI) is expected to bring about far-reaching effects on business and society. Worldwide, governments have launched ambitious programmes to support the development of AI-based technologies and achieve technology leadership. Against this background, this study was commissioned by the Policy Department A upon request of the ITRE Committee to feed into the general debate on how Europe could seize the opportunity of progress made in AI.

This document was requested by the European Parliament's Committee on Industry, Research and Energy.

AUTHORS
Laura DELPONTE, Centre for Industrial Studies (CSIL) with contributions from Guglielmo TAMBURRINI, Università Federico II Napoli

ADMINISTRATOR RESPONSIBLE
Frédéric GOUARDÈRES

EDITORIAL ASSISTANT
Irene VERNACOTOLA

LINGUISTIC VERSIONS
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To contact the Policy Department or to subscribe for updates, please write to:
Policy Department for Economic, Scientific and Quality of Life Policies
European Parliament
B-1047 Brussels
Email: Poldep-Economy-Science@ep.europa.eu

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
DEP	Digital Europe Programme
EC	European Commission
EIT	European Institute of Innovation and Technology
EP	European Parliament
ESIF	European Structural and Investment Fund
GDPR	General Data Protection Regulation
ICT	Information and Communication Technologies
ITRE	The Committee on Industry Research and Energy
OECD	Organisation foe Economic Development and Cooperation
R&D	Research and Development
SMEs	Small and Medium Enterprises
TDM	Text and Data Mining
UK	United Kingdom
US	United States
XAI	Explainable Artificial Intelligence

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EXECUTIVE SUMMARY

Background

Artificial Intelligence (AI) is gradually emerging as a general-purpose technology that could have far-reaching effects in several sectors and cause disruptive changes in value chains and business models. As AI systems act increasingly more autonomously and become more widely used across different sectors, AI safety, transparency, and accountability concerns, including those related to poor decision-making, discrimination biases, job losses and malevolent uses of AI (e.g. in weaponry and cyberconflicts) become more and more relevant. Against this backdrop, AI global governance is gradually being discussed by national governments and international organisations

Amid concerns that Europe is losing ground to the US and China, in October 2017, the European Council asked the European Commission (EC) to develop a European approach to AI. In April 2018, in its Communication "Artificial intelligence for Europe", the EC laid down the European approach to AI, which is based on three pillars: i) being ahead of technological developments and encouraging uptake by the public and private sectors; ii) preparing for socio-economic changes brought about by AI; and iii) ensuring an appropriate ethical and legal framework.

Aim

This analysis looks at the current state of development of AI technologies and at the policy mix and industrial policy tools that Europe and its Member States have to put in place to ensure that Europe is in the most advanced position in terms of developing applications of AI in industry. By gathering on the existing evidence, this analysis seeks to provide policy advice to the ITRE Committee of the European Parliament (EP) on how European citizens and businesses could benefit from the digital revolution and opportunities brought about by AI in accordance with European core ethical and social values.

Findings

A market in rapid evolution. AI is not a new technology, having existed since the 1950s. While some markets, sectors and individual businesses are more advanced than others, AI is still at a relatively early stage of development, so that the range of potential applications, and the quality of most existing applications, have ample margins left for further development and improvement. The US, followed by China and Israel, has the most developed and vibrant AI landscape. However, contrary to common belief, Europe, as a whole, is not lagging behind in developing AI technologies and is particularly strong in AI fundamental research.

A limited number of strong AI global players. The development of AI in Europe can rely on a number of significant drivers (e.g. a highly educated labour force and excellent research institutions). But it has been less successful in developing globally scalable business models. As a result, the EU AI ecosystem is still too much reliant upon technologies developed in non-EU countries.

A combination of political, legal and technical factors can both hinder or accelerate the uptake of AI in Europe. While developing AI capacity, European industry and SMEs face three types of barriers: i) those related to the internal technical capacity, ii) those concerned with AI policy and regulatory risks, and iii) those related to the early stage of development of AI applications in business and social acceptance of AI. The creation of the Digital Single Market, including the free flow of data across borders, is a key driver for the uptake of AI.

AI benefits from strong political support worldwide. An AI race for leadership has just started and sees the US, China and Europe (mostly the UK) as the largest players. Israel and Canada, have smaller AI public funded programmes, but a vibrant AI landscape in specific technology niches.

The amount of resources required to keep up with the latest AI developments cannot be met by a single Member State, creating a clear rationale for EU intervention. The characteristic feature of the approach laid down by the EC in April 2018 is that it is based on addressing the risk-benefit duality of AI technologies. This implies developing an approach that does not merely focus on the potential impact of AI on competitiveness but also on the social and ethical implications of an increased deployment of AI systems.

The deployment of AI creates several pressing policy challenges at the global and European level. Thus far, the response to the legal, societal and ethical challenges posed by AI development has not been able to keep up with AI scientific progress. There are too many disparate initiatives that try to mitigate existing risks instead of anticipating them. Malevolent use of AI may have dreadful effects for humanity. No government or international organisation has yet taken leadership for developing a general guidance and framework for the deployment of AI along universal human values.

There is not yet robust evidence of AI applications used for addressing significant real-life problems or societal challenges. As a matter of fact, the pace and direction of technological progress in AI are difficult to predict, even in the short-term and it is rather difficult to separate the "marketing story" from the "implementation story".

In Europe, AI research resources are abundant but scattered and skewed in academia and public research organisations, while technology transfer and commercialisation of AI applications in business take up more slowly than in the US. This implies that strong European AI ecosystems are yet to emerge. A competition for attracting talented data scientists has already started and the countries with the most vibrant AI landscape are better positioned. This virtuous cycle of capital and human resources accumulation in AI R&D and innovation activities reinforce the existing advantages.

Recommendations

In order to maximise AI benefits, while addressing risks related to the diffusion of AI technologies in products and services, and promoting an informed and open debate about AI, the EP could consider the following actions.

Promote genuine progress in AI global governance and discussions about the societal risks of these technologies. Gathering upon its founding social and ethical values, the EP could launch a process that would start a discussion about a common, internationally recognised ethical and legal framework for the design, production and use of AI, robotics, and their increasingly autonomous systems. This framework should provide a roadmap for promoting and protecting human values and welfare by responsible uses of these technologies.

Promote the development of a general ethical framework governing AI technologies' design in Europe. This implies creating a coherent and trusted regulatory framework by regulating broad AI principles. This general ethical framework should be inspired by the principle of human-centric AI (i.e. AI tightly developed under human oversight and control), embed the principles of fairness and justice in algorithms, applied in all phases of AI systems' design, implementation and testing, while following through bias complaints and other undesired effects reporting. In relation to this dimension, the EP should ensure that the development of AI based products and services developed in Europe integrate core European values.

Prioritise AI applications that effectively address societal challenges. The use of AI in critical industrial applications is a relatively untested field**.** The literature shows that the potential of AI, as compared to other technologies, might be presently over-estimated and might be driven by unrealistic expectations about what these technologies can effectively achieve in terms of generating economic and social value. As a matter of fact, even the business community has recently started to take a more cautious approach. While substantial investment in AI research should be tested against alternatives, the combination of AI with other technologies and megatrends should be better explored and based upon empirical evidence.

Ensure consistency in regulations and policies that are linked to AI, such as those affecting the access, use and storage of data. This goes in the direction of removing barriers to the cross-border access, use and storage of data. Since many new AI applications are developed by start-ups, regulatory impact assessments should also consider to what extent new or revised regulations disproportionally affect these companies. The possibility of introducing regulatory sandboxes should be carefully considered to test the use of AI in heavily regulated sectors, such as finance and healthcare. These could be introduced at the European level to facilitate collaborative projects and avoid a further fragmentation of the Digital Single Market.

Ensure that EU support for AI leverages and complements actions undertaken in Member States. As the European countries develop their national policy responses to promote the uptake of AI and mitigate its risks, European institutions should play a key role in coordinating such efforts, filling in policy gaps that cannot be addressed solely at the national level and support the widespread development of competitive AI ecosystems throughout Europe. This also requires seizing synergies between the EU framework research programme, the newly established Digital European Programme and the European Structural and Investment Fund (ESIF).

Finally, engage with Member States to prepare business and society for the upcoming transformations. Although statistics on the impact of AI on the labour market need to be taken with cautions, policy makers have to be aware of the possible different outlooks and become prepared to address short-term or even long-term effects of technological unemployment which AI developments may significantly contribute to bring about. Adaptation of welfare and education systems will be necessary to protect the people whose skills become obsolete and to mitigate the amplification of power asymmetries and inequalities generated by increased automation.

1. INTRODUCTION

1.1. Background

Artificial Intelligence (AI) is a branch of computer science referring to "*the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings*". *The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience"* (Encyclopaedia Britannica). AI started in the late 1950s as a multifaceted computer science research programme, but the main underlying ideas and proof-of-concept computer programs had been developed already in the late 1940s by Alan Turing and other pioneers of computer science and computer engineering on both sides of the Atlantic Ocean. However, only in recent years AI has made rapid advances in a wide range of application areas, such as voice and image recognition, machine translation, control of assisted driving and autonomous vehicle navigation. This progress has been made possible by advances in computing capacity and data availability, as well as by the development of new machine learning methods, and especially by neuro-inspired learning algorithms, notably deep learning algorithms (Tegmark, 2017).

Due to the flexibility and wide range of AI-based applications, AI is gradually emerging as a general-purpose technology that could have far reaching effects in several sectors and cause disruptive change in value chains and business models (McKinsey Global Institute, 2017). Currently, AI is properly described as *narrow* AI, which is concerned with systems that perform specific and specialized intelligent tasks, while the possibility of developing *general* AI (i.e. computing and robotic systems achieving wide-ranging, flexible and integrated cognitive abilities such as those possessed by humans) is still uncertain. While the general AI take-over scenario is ruled out or regarded as a remote possibility by most AI scientists, the uptake of narrow AI in business and society is bringing about significant social and ethical implications. As AI systems are set to act increasingly more autonomously and to become more widely used, AI safety, transparency, and accountability concerns, including those related to poor decision-making, discrimination biases, job losses and malevolent uses of AI (e.g. in weaponry and cyberconflicts) become more and more relevant in the AI policy agenda (European Group on Ethics in Science and New Technologies, 2017).

AI is expected to trigger a "Fourth Industrial Revolution", and, as such, AI breakthrough developments rank high in the international policy agenda. Policy makers around the globe are increasingly considering that the country that achieves the lead in AI is set for having a technological, economic and security advantage. To this end, China and US are competing to dominate Big Data, which is the raw material that makes AI work.

Amid concerns that Europe is losing ground to US and China, in October 2017, the European Council asked the EC to develop a European approach to AI. In April 2018, in its Communication "Artificial intelligence for Europe", the EC laid down the European approach to AI, which is based on three pillars: i) being ahead of technological developments and encouraging uptake by the public and private sectors; ii) prepare for socio-economic changes brought about by AI; and iii) ensure an appropriate ethical and legal framework (EC, 2018a). At the 2018 EU Digital Day, EU Member States signed a declaration to support an EU approach to foster the development of AI in Europe that is based on the following key principles: i) access to public sector data; ii) mitigation of the socio-economic challenges brought about by progressing AI-based technologies; and iii) development of a legal and ethical framework for AI that is built upon EU fundamental rights and values, including privacy, protection of personal data and the principles of transparency and accountability (EU Member States, 2018).

EU Members States, led by the example of France and the UK, are also preparing AI development strategies and investment plans to facilitate transition to AI technologies in industry and society.

Against this background, the Committee on Industry, Research and Energy (ITRE) requested a study on the current state of play of European AI leadership to nurture the general debate on how Europe should embrace the digital revolution and open up digital opportunities for people and businesses.

1.2. Objectives and research questions

This analysis looks at the policy mix and industrial policy tools that Europe and its Member States have to put in place to ensure that Europe does not lag behind in the development and applications of AI. This entails developing a policy response that support European industry and SMEs (Small and Medium Enterprises) to fully seize the benefits of AI, while mitigating the social and ethical risks associated with a diffusion of AI-based applications. In particular, the analysis addresses the following issues.

- Which investments and regulatory conditions do the EU need to put in place to position Europe at the vanguard of AI research, development and applications? Are the existing and planned support measures sufficient?
- What are the bottlenecks that hold back a faster and more diffuse uptake of IA in Europe?
- How can the EU harvest the economic and societal potential of AI, while minimizing its negative impact?
- What should be the role of EU institutions and how should Europe coordinate with Member States in supporting AI?

1.3. Methodology of the research

This report is based on an extensive desk research drawing upon policy documents, position papers, the most recently available published data on the deployment of AI in the European industry and on foresight studies concerning the market potential of AI in Europe and the related risks and benefits of such increasing uses of AI applications in business and society. The analysis also benefited from the contributions of AI experts in science, industry and public institutions (Annex I) that helped gain a better insight into the policy challenges and opportunities for European Institutions in relation to the development of a coordinated policy response for supporting the uptake of AI across Europe. The variety of information sources applied in this study contributes to mitigate the high uncertainties related to the future development of AI, as well as controversial issues related to AI social and ethical implications.

2. AI MARKET DEVELOPMENT AND MARKET POTENTIAL

KEY FINDINGS

AI is not a well-defined technology and no universally agreed definition exists. It is rather a cover term for techniques associated with data analysis and pattern recognition.

AI is not a new technology, having existed since the 1950s. While some markets, sectors and individual businesses are more advanced than others, AI is still at a relatively early stage of development, so that the range of potential applications, and the quality of most existing applications, have ample margins left for further development and improvement.

The US, followed by China and Israel, has the most developed and vibrant AI landscape. However, contrary to common belief, Europe, as a whole, is not lagging behind in developing AI technologies. Europe ranks second worldwide in terms of number of AI start-ups and there are several examples of European fast-growing AI companies.

Europe is strong in core AI systems (e.g. fundamental research in AI not targeted at a specific sector or activity), but it is underrepresented, with respect to its potential, in industrial applications, such as those related to IoT, autonomous vehicles and robotics.

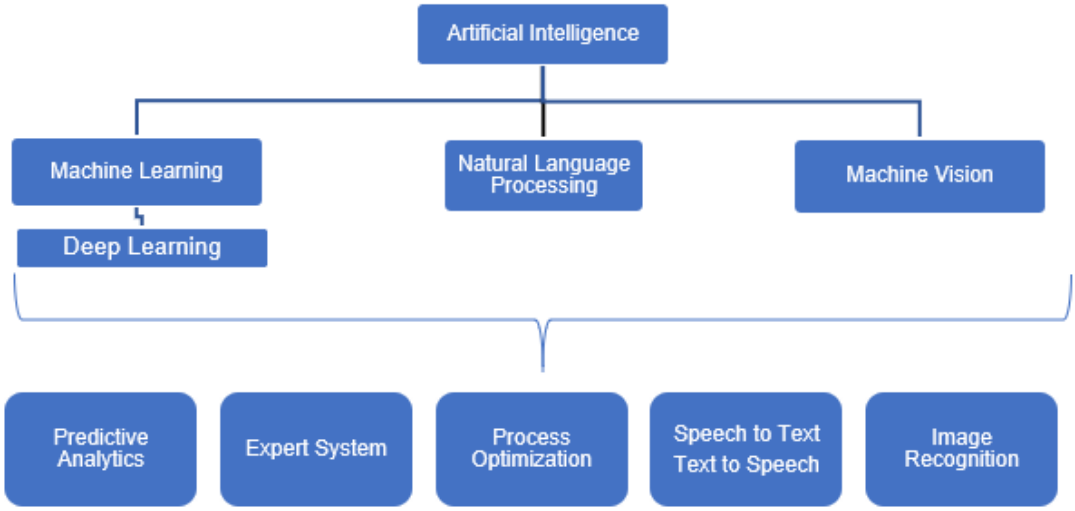
The development of AI in Europe can rely on a number of significant drivers (e.g. a highly educated labour force and excellent research institutions). But it has been less successful in developing globally scalable business models. As a result, the EU AI ecosystem is still too much reliant upon technologies developed in non-EU countries.

The creation of the Digital Single Market, including the free flow of data across borders, is a key driver for the uptake of AI. Most of the potential of deploying AI at the European level is linked to progress made in digitalisation, data access and in deepening the Digital Single Market.

1.4. The disruptive market potential of AI

AI has developed as a field of research but also as a technology that expands across a wide range of applications. AI is not a well-defined technology and no universally agreed definition exists, depending on whether AI technologies are classified from a research or a commercial perspective. AI is rather a cover term for techniques associated with data analysis and pattern recognition. What differentiates AI from other digital technologies is that AI are set to learn from their environments in order to take autonomous decisions. AI, machine learning and deep learning are often used interchangeably, but this is conceptually imprecise. A simplified illustration of major technologies and applications is presented in the figure below.

Figure 1: The AI scientific and technology landscape



Source: Grand View Research, Inc., USA

AI-based systems can be purely software-based, (e.g. conversational assistants, image analysis software, search engines, speech and face recognition systems) or can be integrated in hardware devices (e.g. autonomous cars, drones, medical devices, advanced robots). Although the AI revolution is often depicted in terms of physical machine that can replace the work of humans, the largest AI impact is expected to come from (big) data analytics, vision and language perception capabilities.

From business perspective, AI covers a number of enabling technologies delivering several advantages that lead to increased productivity. The most commonly reported benefits of AI reside in forecasting, empirical decision-making, operations automation, personalised customer services, enhanced user experiences, process and product optimization, new business models, greater access to services, and even improved environmental and public health. These benefits can be attributed to the AI capacity to improve decision-making by expanding beyond human reach the number of empirical observations on which a decision is taken.

From society perspective, AI is expected to bring about substantial benefits, including improved disease diagnosis, better environmental resource management, better care for people with disabilities and improved public services (Accenture, 2018). In this respect, the EC Communication on Artificial Intelligence for Europe compares AI to disruptive technologies such as electricity and steam engine (EC, 2018a). Worldwide, governments are equally convinced that the uptake of AI will lead to radical changes in business models and labour markets.

AI implementation tends to be strong in sectors that are already prominent digital adopters (e.g. FinTech). According to McKinsey, industry sectors currently leading in AI deployment worldwide are automotive, financial services, high tech, telecommunications, manufacturing, energy, aerospace, travel and transportation and logistics (McKinsey Global Institute 2017d). An exemplary list of applications based on AI systems across different sectors is presented in the table below.

Table 1: Example of AI use cases across different industries

Industry	Use case	Description
Healthcare	Medical imaging diagnostic	A growing number of algorithms are learning how to spot and diagnose specific disease. This is for instance the case of the software program, called IDx-DR, which was granted authorization from the US Food and Drug Administration to detect a form of eye disease by looking at photos of the retina.
Transport	Traffic management operations	By converting traffic sensors into 'intelligent' agents using cameras AI can help predict and detect traffic accidents and traffic conditions.
Energy	Autonomous grid	AI can help analyse massive amount of data on energy supply and consumption, bringing stability and efficiency in electricity grids fuelled by different sources, such as wind, solar, and traditional carbon fossil fuels. Companies involved in this domain include Deep Mind (UK) and Siemens (DE).
Banking	Real time fraud detection	AI systems are used to spot divergence in client's financial behaviour patterns by using rule-based learning to identify transactions that indicate fraudulent activities. These include for instance attempt of money laundering, fraudulent use of credit cards and on-line bank accounts and check tampering.
Telecommunication	Intelligent network deployments	AI technologies can be used to self-diagnose, self-heal, and self-orchestrate on-demand network resources. They can enable faster decision making by gathering and processing network data in real time and automating network functions. In self-healing networks, AI systems are trained to look for patterns, detect, predict and localize anomalies or other network issues, and take proactive steps to fix the service before customers are impacted.
Retail	Shopping recommendations	Cognitive/AI natural language tools search through millions of social media conversations, blogs, forums, ratings and reviews, to learn user preferences and come up with a list of recommended items that users are less likely to discover by themselves. Customer personalized recommendation are already used by Amazon and Netflix.

Source: authors' elaboration from several sources.

According to Statista (2018), the AI market worldwide in 2018 is worth approximately EUR 6,29 billion. However, it is difficult to quantify the exact size of the market for AI, as there are varying definitions of

what constitute AI and the market has been expanding rapidly. ***Market studies from different sources unanimously depict a scenario of exponential growth for revenues generated by the deployment of AI systems across different industrial sectors***. An example of these foresight scenario exercises is illustrated in the table below.

Table 2:The potential value of AI (analytics techniques) by sectors

Impact level	Industry
High (at least approximately EUR 0.3 trillion dollar)	Retail, transport and logistics, travel, consumer packaged goods, public and social sector, automotive
Medium (between EUR 0.25 and EUR 0.17 trillion)	Health care systems, banking, advanced electronics, basic materials, high tech, oil and gas, insurance, telecommunications, media and entrainment, agriculture, chemicals,
Low (below EUR 0.17 trillion)	Pharmaceuticals, aerospace and defence

Source: McKinsey Global Institute analysis, 2018

AI technologies are set to drive changes across different sectors and business processes but are also establishing a new AI-related value chain made of AI hardware suppliers, system integrators and end users. Within this value chain new niche markets are opening up and progress in the upstream market segment is set to fuel the development of AI applications in even more business cases (Box 1). In addition to that, a more significant introduction of AI can potentially generate a variety of impacts with the potential to alter entire value chain structures across different industries. This can occur for instance if the application of an AI technology leads to shortening certain value chains, by removing individual stages as long as these become unnecessary. AI can also help streamline and automate various processes across multiple value chains. Machine-learning technologies could optimize the delivery of goods while balancing supply and demand and optimising warehouse management. AI in logistics and shipping (e.g. the applications for autonomous vehicles) can reduce lead times, labour cost and transportation expenses. These impacts are difficult to quantify, but are at the very heart of the expected transformational and revolutionary power of AI technologies.

Box 1: AI impacts on the chipmaking industry

The semiconductor industry has been dominated for many years by the American Intel and the British ARM. However, the semiconductor industry is being revived by increasing demand for computing capacity generated by AI. AI is generating its own demand for application-specific integrated circuits that cannot be met by the existing central processing units and it is thus opening opportunities for newcomers, such as the start-ups Graphcore (UK) and Cerebras (US). It is expected that the market for AI chips could hit EUR 25.7 billion by 2020, which is higher than what Intel is currently making from selling processors for server computers.

Source: The Economist, June 9th-15th 2018

Generally, countries that have been early digital adopters and that have a highly educated workforce have a comparative advantage in terms of seizing the benefit of AI technologies. In terms of AI impact on the European national economies, Finland is the EU country that is projected to gain most out of the AI revolution. For Finland, the expected economic growth once the impact of AI has

been absorbed into the economy, is predicted to reach 4.1% of GDP. The UK, Sweden and the Netherlands follow (Accenture, 2018).

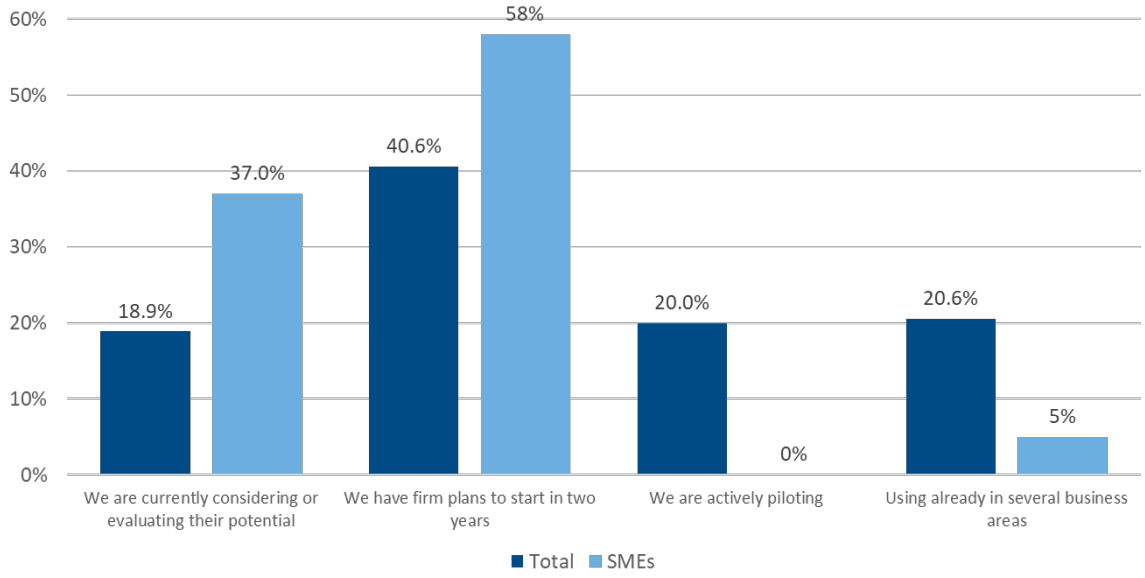
1.5. The uptake of AI in European business

According to a study carried out by Roland Berger and Asgard (2017) on the global AI ecosystem based on data from start-ups, the following trends emerge:

- the US is the global market leader for AI with a 40% market share;
- China and Israel follow with strong AI ecosystems;
- most other countries lack the needed combination of research, entrepreneurship, funding and merger and acquisition to build a sustainable and competitive AI ecosystem; and
- in Europe, the UK has the most developed AI ecosystem, which makes the UK the fourth largest AI players worldwide.

According to a survey carried out by IDC (Figure 2), ***there is huge interest across European industry to deploy AI solutions, although only 20% of European organizations have actually used these technologies*** and this figure in much lower in the case of SMEs. IDC estimates that the on-going largest investments in AI technologies in the European industry are directed to the following activities: sales process recommendation and automation systems, fraud analysis and investigation systems, quality management investigation and recommendation systems, automated threat intelligence and prevention systems, and IT automation systems. Banking, retail and manufacturing are the three sectors where most investments by European industry focus.

Figure 2: Use of AI solutions or services in Europe (Total vs SMEs)



Source: IDC's Western Europe AI/Cognitive Solutions Survey, June 2018 (n = 350)

Contrary to common perception, Europe, as a whole, is not lagging behind in developing AI technologies. Europe ranks second worldwide in terms of number of AI start-ups and there are several examples of European fast-growing AI companies (see for instance Box 2). The weakness of Europe stems from the fact that the Digital Single Market has not been completed yet and that Member States individually have little weigh in the international AI arena. There is also a large geographical divide in the distribution of European AI start-ups. The UK (London), France (Paris) and Germany (Berlin) have

the most vibrant and mature AI landscapes in Europe, while many other regions lag behind in terms of being capable to develop digital eco-systems (Accenture 2018).

Box 2: AI-powered European scale ups

KONUX is a Munich-based company offering industrial IoT solutions combining smart sensors, data fusion and AI-based analytics to increase asset availability and optimize maintenance planning in the railway industry. It was founded in 2014 to enable the digitization of the rail industry and in 2015 raised US 2 million seed funds from Silicon Valley business angels. In 2017 it raised additional funding to increase its AI capabilities (https://www.konux.com/about-us/).

Checkpoint Cardio is a promising Bulgarian scale up founded in 2014, that has developed patented wearables, which allow constant streaming of cardiac and other significant biometric data, providing a whole system for online diagnostics, prevention and emergency reaction for cardiovascular diseases. It is one of the most advanced telemedicine systems for the transmission and monitoring of patient's vital parameters in real time. This reduces visits to the doctor and can prevent sudden cardiac death (http://checkpointcardio.com/).

Metron is a French scale-up providing AI algorithms to reduce energy consumption of industrial plants. The company offers its customers with an energy intelligence platform, which collects, aggregates and analyses in real time all types of data generated by industrial systems, while interfacing directly with energy markets. Metron AI-based algorithm, allow its customers to predict and proactively reduce energy consumption, reducing thus costs and achieving regulatory compliance (http://www.metronlab.com/).

Sentiance is a Belgian data science company turning IoT sensor data into rich insights about people's behavior and real-time context. These insights enable companies to understand how customers go through their everyday lives, discover and anticipate the moments that matter most, and adapt their engagement to real-world behaviour and real-time context. Through the development of AI-enabled solutions, Sentiance has positioned itself to become the leader in contextual intelligence for lifestyle-based insurance, contextual marketing & commerce, smart mobility, connected health, smart home, smart city and connected car. Sentiance was founded in 2015 and today employs over 70 people from 19 different nationalities, 85% of which are computer scientists, mathematicians, and physicians. Sentiance continues to grow and has opened offices in 6 different countries (Belgium, Lithuania, Canada, US, China, and UK) (https://www.sentiance.com/).

Source: based on material provided by interviewees

In terms of developing AI technologies, Europe is strong in core AI systems (e.g. fundamental research in AI not targeted at a specific sector or activity), ***but it is underrepresented, with respect to its potential, in industrial applications***, such as those related to IoT, autonomous vehicles and robotics (Asgard and Roland Berger, 2018).

Europe has a world-leading AI research community, which accounts for 32% of AI research institutions worldwide (30% in the US). In the UK, the universities of Cambridge and Oxford lead the development of AI technologies, having generated three start-ups that were later purchased by US

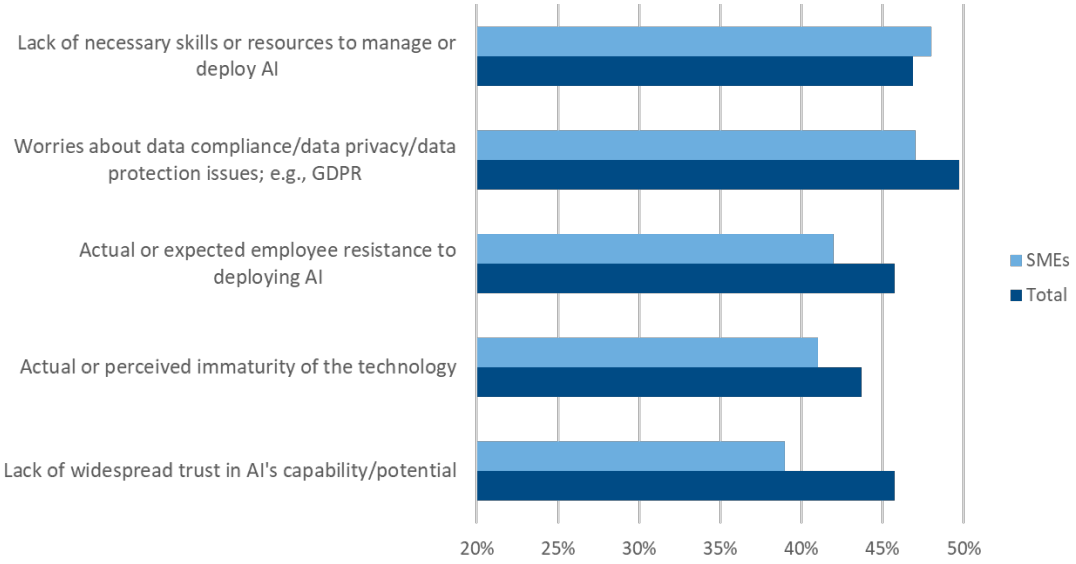
tech giants[1]. In 2015, as a result of a government recommendation, five British universities (Cambridge, Edinburgh, Oxford, UCL and Warwick), together with the UK Engineering and Physical Sciences Research Council, established the Alan Turing Institute. The Institute's researchers work across multiple disciplines with the purpose of developing AI theoretical applications that can be applied to real world problems.

In Germany, the German Research Centre for Artificial Intelligence (DFKI - Deutsches Forschungszentrum für Künstliche Intelligenz) is one of the world's largest AI research institutes. DFKI is considered a centre of AI excellence in the international scientific community and, in terms of number of employees and funding, it is one the largest research centre worldwide in the area of AI theoretical and industrial development worldwide.

1.6. Key drivers and barriers of AI adoption

The development of AI in Europe can rely on a number of significant drivers (e.g. a highly educated labour force) but is also facing some obstacles (e.g. transfer of AI R&D in globally scalable business models). According to an IDC survey carried out in 2018 amongst European industry and SMEs three types of barriers can be identified: i) those related to the internal technical capacity, ii) those concerned with AI policy and regulatory risks, and iii) those related to the early stage of development of AI applications in business and social acceptance of AI (Figure 3).

Figure 3: Key barriers inhibiting faster deployment of AI systems in Europe (Total vs SMEs)



Source: IDC's Western Europe AI/Cognitive Solutions Survey, June 2018 (n = 350)

1 In 2014, Google in 2014 bought DeepMind (neural networks). In 2015, Apple purchased VocalIQ (voice interfaces), and in 2016 Microsoft purchased SwiftKey (smart keyboards).0

2.3.1 Political drivers and barriers

AI research and industrial applications currently benefit from a strong and unprecedented political support (see chapter 3). This support is however founded on potential industrial applications that should come along with improvements and combination of existing AI technologies and systems with a variety of other technologies. AI researchers are aware that this high political support could dry up if AI systems cannot provide substantial evidence about their capacity to effectively address and solve a wide variety of real-life problems and societal challenges. In the past, periods of sustained R&D progress alternated with periods of stagnation (the so-called "AI winters") which badly affected the AI job market and the AI fertilization of business and industry alike.

The social acceptability of AI is undermined by various factors. To begin with, there is a widespread misconception concerning the term 'intelligence' as this is used in contemporary AI. The intelligence of the existing AI is restricted to narrow tasks, such as chess playing, but cannot presently compete with human intelligence in many different ways, notably in contextual adaptivity, social interaction intelligence and pondered reason-giving judgement. The misconception of AI as general intelligence outperforming and dominating humans constitutes a major acceptability barrier. Other barriers to social acceptability include the inability of many sophisticated AI systems to explain their processing steps, decisions and actions to human users and the widespread neglect for better integrating in the design features of newly generated AI systems major ethical concerns. Additional ethical issues concern malevolent uses of AI (e.g. drone and cyber-attacks), AI for massive and indiscriminate surveillance, and the loss of human control on AI-enabled life-and-death decisions (e.g., by autonomous weapons systems) (see chapter 4).

2.3.2 Technical issues

Data is the raw material on which many applications of Machine Learning (ML) and narrow AI are based, as these technologies make it possible to identify regular patterns in available data and to use these patterns for a wide variety of analysis, decision-making, and prediction purposes. Thus far, successful applications of AI technologies have taken advantage of the availability of human-generated data and the collection and exploitation of personal data is largely dominated by US big tech firms, such as Google and Facebook. However, new potentials for further progress in AI will come by parallel developments in the Internet of Things (IoT), which will feed AI algorithms with data generated by networked sensors. In addition to that, the combination of AI with other key technologies, such as big data analytics and blockchain, can unleash exponential growth of AI-powered applications. At the same time, the ability to process larger and more complex datasets at greater speed offers new opportunities to significantly increase both the speed and complexity of information processing. Improved computing combined with sensing, networking, and data generation can also expand the AI application areas. One should be careful to note, however, that more complex AI applications may face in the long term a technological barrier with regard to the inability to further reduce hardware size and processing speed, so as to allow for faster and more massive processing on smaller devices. For SMEs, barriers to entry also refers to the costly process of acquiring and storing enormous set of data, along with the need to dispose of facilities and technology tools for training deep learning algorithms. Finally, the application of AI in robotics towards increasingly intelligent control of robotic systems might be slowed down by longer project development cycles, and the related inability of robots to act and interact outside structured and highly predictable environments.

2.3.3 Legal issues

Data policy and liability regulations are two major regulatory domains that can either facilitate or hold back the uptake of AI in European businesses. Data have been defined as the "new oil" of the data-driven economy. While large tech companies have access to large data from their own customers, for SMEs and start-ups, it is more difficult and costlier to build an AI system without having access to huge streams of data. Regulations that make collecting data harder and more expensive may hinder the deployment of the most innovative AI applications that are usually developed by start-ups. A number of EU existing and planned regulations have a quite significant impact on the use of AI technologies. The General Data Protection Regulation (GDPR) that came into effect on May 25, 2018 deals with individuals' freedom to control their personal data.

It is a broad regulation that defines how companies can legally collect and use individual personal data, along with EU citizens' rights concerning those data. The regulation has had important effects on European businesses, but it has also been instrumental to lay down the foundations for a more reliable and trustable use of AI applications (Box 3).

Box 3: Experts' views about the impact of the GDPR on the use of AI technologies

"GDPR is a necessary and useful law, but it has generated additional administrative costs, which can be significant in SMEs "

"Some of the privacy and ethical issues related to the use of data could be better addressed by developing products that embed these values in their design features. "

"The 'Right to an explanation' for algorithmic-driven decisions can be difficult to apply because of current technological limitations (e.g. for a sophisticated AI system involving machine learning techniques, the creators can't always explain fully why the AI system behaves as it does and how it makes its decisions."

"GDPR created the foundations for a more responsible and transparent use of AI applications based on personal data".

"The usefulness of the GDPR has been shown retrospectively by the Cambridge Analytica scandal".

Source: interviews

The creation of a Digital Single Market, including the free flow of data across borders, is a key driver for the uptake of AI. According to an EP study, the cost of non-Europe (i.e. the potential efficiency gains) in the area of the Digital Single market amounts to EUR 415 billion per year (EP, 2017). The geographical fragmentation of the Digital Single Market is a barrier for companies that plan to scale up rapidly within the European market. As an example, too many barriers still hamper the free flow of goods and online services across national borders. Under the existing rules, companies have to comply with different national regulations (e.g. data localisation restrictions) and to deal with different regulatory authorities. Although the economic impact of data localisation restrictions applied in some Member States is difficult to estimate, and can be overcome by specific solutions (e.g. use of on-line platforms), it creates additional administrative burdens for SMEs and start-ups because of the lack of a unified framework for regulating such restrictions. This does not compare well with the ambition of the Digital Single Market Strategy to build a European data economy. To accelerate progress in this area, as foreseen in the mid-term review of the Digital Single Market strategy, the EC is working on a legislative proposal that is set to facilitate the re-use of different types of data and its free flow across

borders[2]. The revised directive has a substantial impact on the development of AI applications given that it aims at reducing market entry barriers (e.g. the fees charged by public bodies for the re-use their data) and increasing the availability of data by making available new types of public data, such as those held by public undertakings in the utilities and transport sectors and research data resulting from public funding.

Other legislative proposals related to the implementation of the Digital Single Market (DSM) strategy can also have an impact on AI deployment in Europe. This is specifically the case of the Copyrights Directive[3] and ePrivacy Directive[4] legislative proposals, whose implementation can limit the use of AI in Europe. In particular, the existing proposal of the Copyrights Directive would limit and make more expensive for business and public-private collaborations Text and Data Mining (TDM) activities, which are a crucial building block for machine learning applications in general and deep learning applications in particular (Open letter to the EC, 2018). TDM techniques are vital for SMEs and start-ups because they allow them to access to large quantities of data to train AI algorithms, by applying, for instance, web crawling techniques.

Addressing liability issues and developing related legal rules is becoming more and more important as AI applications become part of our lives (e.g. as applications embedded into assisted driving and fully autonomous cars or unmanned ships). For SMEs and start-ups, legal certainty with respect to liabilities issues is instrumental for access to finance, because AI projects have to pass a due diligence process by private financers that includes a control on regulatory compliance with respect to contingent liabilities. However, establishing liability rules for existing and prospective AI algorithms is a difficult problem to address and solve. One has to take in due account the wide variety of stakeholders that are involved and the lack of interpretability of many kinds of AI learning systems. Another related and widely debated issue is whether or not AI systems can be deemed to be subjects of law (Čerkaa, 2017 and Nevejans, 2016).

The EC has recently conducted evaluations of the Product Liability Directive[5] and the Machinery Directive[6] that concluded that both regulations are "*fit for purpose and conducive to innovation*". However, some experts highlight that the legal framework related to AI-enabled decision-making might require the development of specific regulations, because of the difficulty of predicting exactly the future behaviours of many complex AI systems and the emerging behaviours of interacting AI systems. In particular, it is often difficult to recognise the biases embedded into systems that are developed by means of machine learning techniques and the resulting decision-making errors. To this

2 Proposal for a revision of the Directive 2003/98/EC on the reuse of public sector information

3 COM(2016) 593 final. Proposal underpinned by the need to upgrade existing copyright rules in the Internet era.

4 Proposal for reviewing the Directive 2002/58/EC to provide a high level of privacy protection for users of electronic communications services and a level playing field for all market players

5 Directive 85/374/EEC

6 Directive 2006/42/EC

end, new guidance on the interpretation of the Product Liability Directive will be issued by mid-2019, providing better legal certainty for consumers and producers.

Box 4: Estonia's attempt to define a general legal framework for AI-based technologies

Estonia has been one of the first countries in the world that officially undertook a discussion on the legal matters related to the use of AI-based technologies. Since the use of AI cuts across different sectors, Estonia is trying to develop a general AI legal framework that applies to AI-powered technologies. This framework specifically applies to AI general liability issues and different scenarios are under discussion. Through this approach Estonia seeks to establish a business friendly and clear-cut AI legal framework that would attract more investors to the country. Estonia has plans to use a blockchain technology to address liability, enforce the legal system, and establish trust between users and producers of AI-based products.

Source: European Commission, 2018c.

2. THE POLICY RESPONSE IN THE EU, MEMBER STATES AND OTHER INTERNATIONAL AI PLAYERS

KEY FINDINGS

Starting from 2017, AI research has benefited from strong political support which is based on the transformational power of these technologies for businesses and societies.

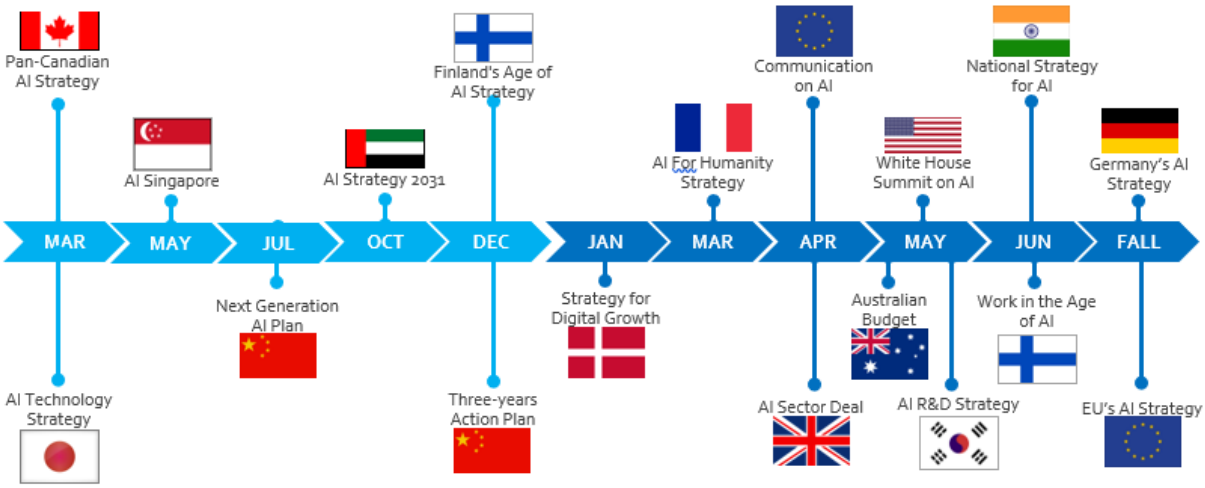
An AI race for leadership has just started and sees the US, China and Europe (mostly the UK) as the largest players. Israel and Canada, have smaller AI public funded programmes, but a vibrant AI landscape in specific technology niche.

The amount of resources required to stay abreast of the latest AI developments cannot be met by a single Member State, creating a clear rationale for EU intervention. China and US, which both aims at the global AI leadership, have started leveraging public and private investments exploiting large amounts of data and sophisticated computing capacity.

The characteristic feature of the approach presented in the EC Communication Artificial Intelligence for Europe in April 2018 is that it is based on addressing the risk-benefit duality of AI technologies. This implies developing an approach that does not merely focus on the potential impact of AI on competitiveness but also on the social and ethical implications of an increased deployment of AI systems.

Since the beginning of 2017, AI technologies have benefited from a large political support which is based on the high expectations of the transformative power of AI (Figure 4). Some countries have laid down AI specific and comprehensive AI strategies (e.g. China, the UK, France), some are integrating AI technologies within national technology or digital roadmaps (e.g. Denmark, Australia), while others have focused on developing a national AI R&D strategy (US). Regardless of the approach pursued, it emerges that countries are engaged in a sort of AI race that aims at achieving AI leadership.

Figure 4. Countries' support to AI (2017 and 2018)



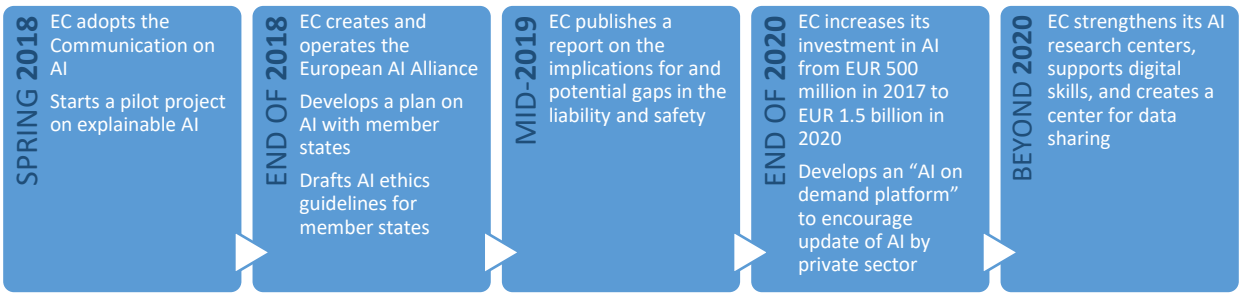
Source: Tim Dutton, 2018

2.1. The EU plan for AI

Despite being home to strong AI basic research, Europe has thus far been slow in responding to the many industrial and societal challenges that progress in AI are bringing about. A number of initiatives and measures have already been launched under Horizon 2020 - Work Programme 2018-2020 Information and Communication Technologies, which allocates EUR 1.5 billion to AI, and the work programme of Horizon Public-Private Partnerships on Big Data and Robotics that allocate additional EUR 2.5 billion to technologies relevant to AI.

Increasing global competition from the US and China, along with increased calls for action coming from industry, academia and European policy makers has prompted the EU to develop a framework to guide and coordinate future European investments and legislative proposals. In April 2018, the EC adopted a Communication on Artificial Intelligence for Europe which lays down a proposal for an EU AI strategy and investment plan to be developed and implemented under the next multi-annual financial framework 2021-2027 (Figure 5). Support for AI research and innovation will be provided by Horizon Europe, the next EU research and innovation framework programme with an overall budget of EUR 97.6 billion, under pillar II "Global Challenges and Industrial Competitiveness" (cluster digital and industry). Additional funding for AI will be available under the newly established Digital Europe Programme (DEP) which aims at reinforcing Europe's digital capabilities in four key areas including AI, cybersecurity, high performance computing and advanced digital skills. DEP sets aside EUR 2.5 billion to establish AI capacity and infrastructure in the EU that will be used to support the creation of AI testing and experimentation facilities along with open libraries and platforms for AI algorithms and data.

Figure 5: The timescale of the approach laid down in the EC Communication on AI



Source: EC Communication Artificial Intelligence for Europe, 2018

The AI plan proposed by the EC concerns three separate, but interconnected policy domains and deploys a diversified set of industrial policy measures. Through this approach the EC aims at creating a framework for coordinating and building upon national AI strategies and at becoming the world champion of an AI approach that truly benefit society as a whole.

Preparing EU industry to embrace and benefit from AI technologies. The primary focus of this policy area is to support AI fundamental research, develop AI specific industrial applications and upgrade AI research infrastructure. To do so the EC plans to substantially increase AI investment by leveraging EU

funds (EFSI-European Fund for Strategic Investments, Horizon Europe, VentureEU[7]) with national, regional and private sector resources. These measures aim at developing AI products and services in Europe and to avoid putting European consumer and industry in the condition of having to import these technologies from other countries. SMEs are a focal point in the approach proposed by the EC. In particular, the setting up of testing, and experimenting infrastructure and the development of an "AI-on-demand platform", will make available relevant AI resources for companies, including non-tech companies, willing to test AI technologies. It is also foreseen to build on the existing Digital Innovation Hubs to set up AI specialised hubs across Europe for the purpose of assisting companies to take advantages of the opportunities offered by AI systems. Efforts geared towards facilitating access to large data sets are also foreseen to boost the creation of diversified European AI ecosystems. To this end, the EC intends to build upon the successful experience of the Galileo and Copernicus programmes, which have established openly accessible space-generated data platforms. Examples of such efforts include an updated Directive on the Re-Use of Public Sector Information[8], Guidance on sharing private sector data; an updated Recommendation on Access to and Preservation of Scientific Data[9]; and a Communication on the digital transformation of health and care[10].

Preparing for socio-economic challenges. This policy domain is concerned with addressing socio-economic evolutions induced by AI progress and is set to prepare for changes in the labour market. It builds upon the New Skills Agenda for Europe, which encompasses ten actions to improve the quality and relevance of training and other ways of acquiring skills, make skills more visible and comparable, and improve information and understanding of trends and patterns in demands for skills and jobs. With respect to AI, upskilling and training for the acquisition of digital competence will be given major prominence in national and regional programmes (co-funded by the European Social Fund). Promoting diversity (e.g. women participation in AI related training) and interdisciplinarity is also a focal point in this policy area.

Ensuring that AI are developed within an appropriate ethical and legal framework. The Communication underlines the EU's imperative to protect personal data, safety and product liability. To do so, the EU has used its regulatory power to tackle issues related to citizen's privacy and product liability (see section 2.3) and to build trust in the online world (Cybersecurity Act[11]). Building upon the work of the European Group on Ethics in Science and Technology, the EC undertakes to draft AI ethics guidelines by the end of 2018, for whose preparation an ad hoc high-level expert group has been set

7 Pan-European venture capital Funds of Funds jointly established by the European Investment Fund and the European Commission to boost investments in innovative start-ups and scale ups.

8 Directive 2013/37/EU of the European Parliament and of the Council of 26 June 2013 amending Directive 2003/98/EC on the re-use of public sector information

9 Commission Recommendation (EU) 2018/790 of 25 April 2018 on access to and preservation of scientific information

10 EC Communication on enabling the digital transformation of health and care in the Digital Single Market; empowering citizens and building a healthier society COM(2018) 233 final. Brussels, 25.4.2018

11 COM(2017)477/947932

up (High-Level Group on Artificial Intelligence). This guidance will have a broader scope of existing AI ethics guidance (Box 6), and will embrace social inclusion, algorithm transparency, safety, fairness and the future of work. In parallel with this, the EC has recently set up a European AI Alliance as a multi-country and multi-stakeholder platform to interact with the members of the European High-Level Group on Artificial Intelligence and provide inputs for the design of the EU AI ethics guidelines. The EU also plans to promote the debate on AI and ethics in international groups and organisations.

Box 5: Supporting the development of AI applications in European industry and SMEs

AI permeates many of EIT (European Institute of Innovation and Technology) entrepreneurial, education, innovation and entrepreneurship activities. EIT work address different dimensions of the AI landscape.

1) ***Entrepreneurial Education***. At the EIT Digital Master School, two programmes are specifically related to AI: the Data Science programme (data science, innovation and entrepreneurship) and the Autonomous Systems programme (a combination of computer science and electronic engineering).

2) ***Innovation & Entrepreneurship***. AI is relevant to all EIT five action lines. A total of 19 Innovation Activities related to AI are supported in the EIT Digital Business Plan 2018 (out of a total of 54 Activities supported). This means that in 2018, 35% of EIT Innovation Activities are related to AI. A number of scale-ups that the EIT Digital Accelerator supports (or has supported) leverage AI technologies.

Source: based on documentation provided by EIT Digital

2.2. AI strategies and investment plans in Member States

The implementation of national policies and regional programmes is vital to complement European coordinated actions. After years of a slow trickle, the first months of 2018 saw an explosion of government-backed AI programmes announced all over Europe that were propelled by a general feeling that Europe is falling behind in the race for AI leadership. These plans were driven by a sense of urgency to establish a coherent framework for the deployment of AI in industries and in public services to further productivity gains, identify applications of AI that can deliver societal benefits and tap into the national talent pool of AI researchers to limit the migration of scientists from Europe to the US.

In January 2018, DG CONNECT (Directorate-General for Communications Networks, Content and Technology), in collaboration with EurAI, the European Artificial Intelligence Association, organised a workshop, with the purpose of gathering evidence about academic, industry, and governmental initiatives that are shaping the AI landscape across Europe (EC, 2018c). This was the first attempt by the EC to survey ongoing AI-related initiatives in Member States. It showed that policy responses in member States reflect the level of advancement and readiness of countries' AI research and industry ecosystems, and their specific comparative advantages (e.g. deep learning in the UK, robotics in Germany, AI in public services in Finland). Four countries (France, the UK, Finland and Germany) emerged as being more advanced in elaborating national policy responses to support AI deployment (Figure 6).

In March 2018, France unveiled its national strategy in the field of AI and pledged to invest EUR 1.5 billion until 2022 to support research and innovation in the field. The French strategy established a quite comprehensive set of policies that are targeted to address obstacles to the uptake of AI in French businesses, to boost investments in a limited number of sectors, where the societal impact of AI use is higher, mitigate the impact of AI in rising inequality. France already boasts one of the top European

research institute on AI, the Centre national de la recherche scientifique, and there is a proposal for setting up a joint research centre for AI in cooperation with Germany.

Figure 6: Member States' AI strategies at glance

Source: Author's elaboration from different sources (see Appendix 2)

AI and data economy are one of the four grand challenges identified by Britain's Industrial Strategy White Paper, (UK government, 2017). The AI sector deal aims at ensuring that the UK remains among the leaders in AI by providing the necessary investment and enabling conditions. It pursues the following objectives: i) make the UK a global centre for AI and data-driven innovation by investing in R&D, skills and regulatory innovation; ii) support sectors to boost their productivity through artificial intelligence and data analytics technologies; iii) lead the world in the safe and ethical use of AI; and help people develop the skills needed for the jobs of the future. The AI-specific sector deal outlines a package of approximately EUR 1.08 billion of public and private funding for AI. This support is to be further complemented by some of the EUR 1.9 billion that are to be made available under the cross-sectoral Industrial Strategy Challenge Fund for challenges having AI components. A peculiarity of the UK plan is that it based on a definition of roles and responsibilities between the public and the private sector and it is built upon co-financing.

Market studies identified Finland as one of the most promising market for the uptake of AI-based products and services. This is due to a combination of factors, including the advanced digitalisation of the Finnish society and public administration and the high level of education generally attained by Finland's population (McKinsey, 2017a). A vision for Finland in the short period is that of a society where AI are well integrated in every Finn's daily life and where these technologies are used ethically and openly. To achieve these objectives, specific measures are envisaged to ensure that Finland invests enough in the development and application of AI technologies, along to strengthen its capacity to adapt to the upcoming transformations.

Since 2006, the German government has been pursuing a 'High-Tech Strategy' to focus its efforts in research and innovation and industrial policy, but the strategy does not explicitly address AI. A masterplan for AI to channel investments in this area was first proposed by chancellor Angela Merkel in September 2017. It is expected that the government will follow up on that with an actual strategy to be formally adopted in fall 2018. One focus will likely be on helping SMEs use AI and for Germany to be a world leader in the area of AI. The strategy is also expected to address the issue of favourable conditions for AI scientists in Germany to stop the present brain drain to more vibrant AI ecosystems. Improving the environment for start-ups and linking research and business more closely will likely be another pillar of the strategy. The German Research Centre for AI (DFKI) is a major actor in the German AI landscape and has been assigned the mission of pursuing and providing funding for AI application oriented basic research.

Other Member States have also started a discussion about how to support AI technologies and mitigate societal risks. Estonia, focused on designing a regulatory framework that would create an AI-friendly regulatory environment in order to attract foreign investment in the country (see Box 3 in the previous chapter). In 2017, Denmark set up the Danish Centre for Applied Artificial Intelligence within the Alexandra Institute, a research and technology organisation focusing on ICT. The Centre is meant to be a key player of the emerging Danish AI ecosystem. Its purpose is to support the implementation of AI technologies in business, share data platform and expertise on specific AI technologies and foster collaboration between companies and between companies and research organisations. Italy's Digital Agency has published a white book that delivered guidelines and recommendations for a responsible use of AI in the public administration. To this end, the government has committed EUR 5 million for pilot projects of AI deployment in the delivery of public services (Agenzia per lo Sviluppo Digitale, 2018).

2.3. AI support policies in third countries

In the US, AI investments are driven by the private sector while AI governance issues are discussed within universities and think tanks. Towards the end of the Obama's presidency in 2016, the US developed two key documents that highlighted the key focus of a government strategy (The National Artificial Intelligence Research and Development Strategic Plan and Preparing for the Future of Artificial Intelligence). These reports were followed by a third report (Artificial Intelligence, Automation, and the Economy), which examined the impact of automation and identified what policies are needed to increase the benefits of AI while mitigating its social costs.

However, no specific funding was included and the Trump administration did not pursue that vision but rather followed a free market-oriented approach. At present, the US Government has no central AI policy and investment plan, but individual projects are funded by military and paramilitary departments like DARPA (Advanced Research Projects Agency) and IARPA (Intelligence Advanced Research Projects Activity). Discussions about AI deployment, automation, the future of work and privacy issues, are taking place within the private sector, academia and think tanks (e.g. the Future of Life Institute). The US AI landscape is diversified and based on strong digital eco-systems around the hubs of Silicon Valley, Seattle, Boston and New York, which bring together talent and research capabilities from leading universities, private investment and cross-science and industry collaboration. It can also rely on the US ICT tech giants, such as Microsoft, Google, Amazon, Facebook and IBM, have already transformed into world leading AI companies. However, contrary to common perception the role of public agencies in funding and developing AI technologies is prominent, especially with respect to the most innovative and apparently intractable AI technical challenges. In the US there are several separate agencies dealing directly or indirectly with AI technologies.

For instance, DARPA is now focusing on making AI more trustworthy (Explainable AI programme), with a view to apply more robust and reliable AI systems to their existing work with robotics and unmanned vehicles.

China follows a top-down government-driven approach which is based on a comprehensive national plan that has the ambition to make China the world leader in AI.

In 2017, the Chinese government published its Next Generation Artificial Intelligence Development Plan[12] to make China the global leader in the development of AI and to make the country a leading AI innovation hub by 2030. An AI Plan Promotion Office was established within the Ministry of Science and Technology for managing the implementation of the plan, which is to be phased out in three steps:

- by 2020 China needs to have a world-leading rate of general development and application while the AI industry has to keep growing;
- by 2025 AI will be a key driver of industrial and economic reform through the extensive deployment of AI indifferent industries, including healthcare and defence industry; and
- by 2030 China will be the world's leading artificial intelligence innovation hub.

After the release of the Next Generation Plan, the Chinese government published a Three-Year Action Plan to Promote the Development of New-Generation Artificial Intelligence Industry[13], which focuses on integrating AI across different manufacturing industries. The plan is articulated in four key areas: i) product developments in healthcare, transportation, agriculture, finance, logistics, education and culture; ii) development of intelligent sensors and neural network semiconductors; iii) development of smart manufacturing, in particular, key technical equipment and new manufacturing models incorporated with AI; and iv) establish a comprehensive AI support system, including setting up an industry training data pool and AI industry standards system (e.g. AI product assessment systems, AI patents and IPR protection platforms).

China has proposed the most comprehensive package of action to support its AI leadership objectives. Besides promoting the development of specific AI application within industry, the plan also seeks to recruit globally the best data scientist talents and to give China a prominent role in discussing the global governance of AI. China's largest strength stems from the size of its population and its citizens' willingness to make available their personal data to comply with state rules. The Chinese strategy is not replicable in Europe because of its marked top-down approach and the controls exerted over business and citizens.

Japan aims at integrating AI within sector roadmaps. In 2016, Japan launched a "Public-Private Dialogue towards Investment for the Future" and established the "Artificial Intelligence Technology Strategy Council". The Council subsequently formulated and "Artificial Intelligence Technology Strategy" (Strategic Council for AI Technology-Japan, 2017).

[12] https://chinacopyrightandmedia.wordpress.com/2017/07/20/a-next-generation-artificial-intelligence-development-plan/

[13] http://www.usito.org/news/three-year-action-plan-focuses-next-generation-artificial-intelligence

The plan is to be phased out in three separate steps starting from the development of data-driven AI in various domains of Japan's industrialisation road map (e.g. mobility, health, medical care, welfare). Similar to other countries, Japan AI strategy is to be implemented through a policy mix that includes support to R&D, nurturing human resources, improving the regulatory environment for data and experimentation and supporting start-ups. Japanese AI companies are hardware-oriented and their strength lays on the country longstanding knowledge in robotics but, unlike the US, the main rationale for developing robots is industrial and is not related to the military. The support to start-ups is key to build and reinforce Japan's capacity to compete in the AI software components industry, where the country lags behind in comparison with the US and China.

3. POLICY CHALLENGES BROUGHT ABOUT BY AI TECHNOLOGIES

KEY FINDINGS

There is not yet robust evidence of AI applications used for addressing significant and wide-ranging real-life problems or societal challenges. As a matter of fact, the pace and direction of technological progress in AI is difficult to predict, even in the short-term and it is rather difficult to separate the "marketing story" from the "implementation story".

In Europe, AI research efforts are abundant but scattered and skewed in academia and public research organisations, while technology transfer and commercialisation of AI applications in business take up more slowly than in the US. This implies that strong European AI ecosystems are yet to emerge. A competition for attracting talented data scientists has already started and the countries with the most vibrant AI landscape are better positioned. This virtuous cycle of capital and human resources accumulation in AI R&D and innovation activities reinforce the existing advantages.

Malevolent or ethically inattentive uses of AI may have dreadful effects for humanity. No governmental or international organisation has yet taken the leadership for developing a general guidance and framework for the development and deployment of AI in accordance with universal human values. Reflective work and actions in this direction have been mostly undertaken by groups of AI scientists, think tanks and industry, while some governments are trying to identify possibile solutions to some AI challenges individually.

The safe and ethical use of AI research is a global challenge and there is still a significant policy and regulatory gap to fill in this respect. The response to the legal, societal and ethical challenges posed by AI development has not been able to keep up with AI scientific progress. As a result of this, there are too many disparate initiatives that try to mitigate existing risks instead of anticipating them.

3.1. Global policy challenges

AI governance has thus far been confined to the initiatives of think tanks and AI researchers. There is a large consensus that AI is a disruptive set of technologies and that AI governance should be based on a set of universally applicable principles and guidelines regarding the responsible use of these technologies. With respect to the global threat that AI could potentially pose to humanity in the short period, three global policy challenges stand out. These are related to the need to:

- track existing and future applications of AI in cybersecurity and the military;
- address the risks of an uncontrolled international AI races; and
- keep AI research safe and beneficial to humanity.

At the G7 held in Italy on 19th - 20th October 2017, the G7 ICT and industry ministers acknowledged the potential benefits brought about by progress in AI technologies, but also warned about the need to understand the broader potential effects of AI on society and to develop these technologies with a human-centric approach in harmony with the existing laws, policies and values. During the 71st session of the United Nations General Assembly, on 29 September 2016, UNICRI (United Nations International Crime and Justice research Institute) announced the opening of the first Centre on AI and Robotics

within the United Nations system. The centre's mission is to enhance understanding of the risk-benefit duality of AI and robotics for the purpose of identifying global solutions to such problems.

In spite of the above-mentioned initiatives, there is still a significant policy gap in AI global governance that has been emphasized in various ways by initiatives driven by AI scientists or prominent business persons, such as Elon Musk (Tesla and Space X founder) and Bill Gates (Microsoft founder). At the same time, the Facebook-Cambridge Analytica affair made it evident that individual firms, including big tech ones, are often unable to address, in the absence of clear and comprehensive policies, the ethical and social threats that AI technologies may give rise to. Institutions and not-for profit organisations have been established to deal with AI ethics in research and society. These notably include the University of Oxford's Future of Humanity Institute (UK), the Future of Life Institute (US) and Open AI (US). The European scientists adhering to the CLAIRE initiative solicited EU institutions to develop an AI manifesto – similar to the "Russell-Einstein manifesto" developed in 1955 to denounce the threats for humanity posed by the nuclear arms race – to ensure that AI research is responsibly developed by anticipating and ethically guiding the consequences of deploying specialised, narrow AI systems while limiting the creation of general, human-level or even super-human AI.

Box 6: The AI Code of Conduct developed by UK House of Lords Special Committee

The committee suggested a cross-sector AI Code of conduct to be based on five key principles.

- AI should be developed for the common good and benefit of humanity.
- AI should operate on principles of intelligibility and fairness.
- AI should not be used to diminish the data rights or privacy of individuals, families or communities.
- All citizens should have the right to be educated to enable them to flourish mentally, emotionally and economically alongside AI.
- The autonomous power to hurt, destroy or deceive human beings should never be vested in AI.

Source: Artificial Intelligence Committee AI in the UK: ready, willing and able?

The larger diffusion of AI will be soon confronted with more ethical and moral issues that may jeopardise and hinder social acceptability of AI. As AI system use spreads over different sectors, critical decisions, such as identifying appropriate treatments for illness or granting a bank loan, will increasingly be based on data analytics. Because the existing ML models are opaque, non-intuitive, and difficult for people to understand, there are major research gaps to be fulfilled (Gunning, 2017). These include the need to:

- develop explainable, transparent, validated and trustworthy AI systems to address the unpredictable "black box" scenario, which is currently the norm in AI;
- add values, ethics, privacy and security in the core design of AI systems and applications; and
- ensure that AI are not used for malevolent purposes (e.g. promoting discrimination, dissemination of fake news and "deepfakes", attempts to use AI to establish hegemony, control of people, undermine democratic processes or even take down governments, to deceive and orient vulnerable categories of people by AI agents which are misidentified with human interlocutors, and so on).

Ensuring accountability and transparency in the use of data in AI systems has not been achieved yet.

There are technical reasons behind that, which are linked to the level of sophistication achieved by certain AI systems and limitations of the existing technologies. A new AI research area Explainable AI (XAI) is now developing to address the scientific and technological challenges raised by algorithm transparency, interpretability and accountability demands. However, when privacy and transparency are concerned, companies that benefited the most from the current free data availability tend to apply double standards. They fiercely advocate for open and free data access from individuals and governments but are extremely protective of their own data and algorithms.

As AI systems become more autonomous and have a larger control over their physical or digital environments, the chances of errors increase, along with the occurrence of unintended consequences. This refers to accidents in AI technologies that can be unintentionally harmful, which generally occur when the machine is not provided with appropriate objective functions and training data (e.g. leading to self-driving cars running into deadly car crash). In general, scientists are not in the position to control completely these aspects of the AI learning processes and to predict exactly every single behaviour of an AI learning system. However, they are currently working to minimize such accidents and improve robustness, risk-sensitivity, and safe exploration with the purpose of making AI use safer and more reliable (Amodei et al., 2016).

Finally, there are many open questions about human moral responsibilities. These refer to how responsibilities and liabilities are to be properly distributed among AI engineers, manufacturers, users and other stakeholders in the case of adverse events that are brought about by an AI system. It has been suggested that responsibilities might have to be shared between humans and machines (European Group on Ethics in Science and New Technologies, 2017). However, the idea of putting AI machines along with human beings in the category of responsible and accountable entities remains highly controversial.

AI applications are at an early stage of development and the future development of AI is highly uncertain. Despite AI are quickly becoming an integral part of our daily lives, there is general agreement that what we see today is just the tip of an iceberg of a would-be AI revolution. As a matter of fact, the pace and direction of technological progress in AI is difficult to predict, even in the short-term and it is rather difficult to separate the "marketing story" from the "implementation story". Presently, there is a considerable expectation on the potential of combining big data and AI for economic applications and for addressing societal challenges, but these expectations do not match well with the still too limited understanding on how to concretely apply AI-solutions in business (McKinsey, 2017; PwC, 2018a). Empirical data on the use of AI applications in business show that AI are still disproportionally applied to chatbots, while too few AI solutions are applied to solving real-problems (Asgard and Roland Berger, 2018). Existing technologies used for speech and image recognition still have many limitations in their effective use and there are ample margins for improvements. Empirical studies measuring aggregate productivity growth in relation to progress made in transformative technologies, such as AI, show that, while the value of developing these technologies has been generously reflected in the market value of the leading firms, the promised productivity gains have not yet materialised (Brynjolfsson et al., 2017). Businesses in different sectors have recently become more sceptical about the large productivity which are supposed to be connected with the deployment of the state-of-the-art AI technologies. Some industry representatives are also concerned that an excessive emphasis on AI could divert investments from other equally important process and product innovations (Financial Time, 2018).

Against this backdrop, AI experts are also concerned that there might be too much hype, as well as inaccurate reporting about AI. This could both rise unrealistic expectations about the possibility of applying AI in the short term to solve a number of societal challenges while nurturing fears about science fiction scenarios where AI overtake humanity. Realizing the societal benefits of AI is not automatic and will depend upon a combination of factors, including the improvement of the existing AI systems to integrate concerns related to safety and ethics. The future evolution of AI systems is thus linked to the process of development and generalisation of AI technologies for concrete applications (McKinsey Global Institute, 2017 and Strategic Council for AI Technology, 2017) and the capacity of society to adapt and restructure to participate in and benefit from the transformational processes triggered by an uptake of AI across sectors and citizens' life (Brynjolfsson et al., 2017).

3.2. Policy challenges for Europe

AI research resources are abundant in Europe but scattered. Collectively, Europe has a strong tradition of excellence in all areas of AI but does not have yet AI ecosystems that are comparable to those established in the US. Fragmentation is highly visible in AI research activities and in national AI development strategies that aim at gaining individually AI market leadership. The EC Communication "Artificial intelligence for Europe", constitutes the first steps on which the Commission envisages to build a strong European AI community. It is widely acknowledged in European industry, science and institutions that it is only by joining forces that Europe can remain competitive.

The UK is currently the only leading country for AI that has succeeded, thanks to a favourable AI ecosystem, to stand in international competition for AI funding, research, and talents. Brexit is going to have a heavy impact on the EU AI landscape that will be deprived of its most vibrant player. At the same time, Brexit is likely to affect UK's ability to attract and retain strong computer science academics, especially from other EU countries. In this scenario, maintaining a collaboration between the UK and the EU is vital to remain competitive with US and China.

Competition for digital talent is getting tougher. The development of AI applications requires a wide variety of scientific and engineering competences and skills to cope with the increased complexity of state-of-art algorithms and the related design, implementation, testing and revision challenges. Data workers of the future will need to improve their knowledge of mathematics and statistics, along with the ability to identify and collect data sets for machine learning, to track the sources of data biases, and to foster fairness, non-discrimination and diversity. Since AI solutions are by nature multidisciplinary the combination of technological, cognitive and new creative and interpersonal skills is also gaining more prominence (McKinsey, 2017b).

As fierce demand for skilled AI researchers is already heavily outstripping supply[14], the further uptake of AI is likely to intensify global competition for talented data engineers and data scientists and European companies are already looking outside Europe for getting enough people with the right skills mix. European universities are having several difficulties in keeping talented computer scientists.

14 According to an IDC high-growth scenario in 2020 there will be over 2.8 million unfilled data worker positions. IDC et al., European Data Market, SMART 2013/0063, D9 – Final Report, 1 February 2017, http://datalandscape.eu/study-reports

Top British AI researchers are being lured from academia by US tech firms with the prospect of much higher salaries. This brain drain is hampering research and disrupting computer science teaching in leading universities, but it is also bringing academic and basic AI research in private laboratories. Such a level of competition for data scientists is disproportionately affect European SMEs by limiting their growth perspectives.

In an attempt to stop the brain drain, European leading computer scientists have put forward a proposal for establishing a large pan-European AI research institute. The initiative, which was named ELLIS- Initiative to establish a European Lab for Learning & Intelligent Systems, was followed by another initiative called CLAIRE - Confederation of Laboratories for Artificial Intelligence Research in Europe- that is set to nurture the creation of a unified community of AI European researchers that puts human values, such as fairness, truthfulness and privacy, upfront. Learning partially from the successful experience of CERN, CLAIRE proposal is based on a polycentric model that foresees the creation of several AI Centre of Excellences along with AI collaborative networks (CLAIRE, 2018).

AI will transform labour, with far-reaching implications for education, long-life learning and social welfare. Concerns that technological innovation may lead to increased unemployment and greater inequality between and within countries are not new and AI is no exception to this. The largest public fear is that AI technologies can soon replace a wide variety of human jobs, resulting in mass scale unemployment, ever increasing inequality and social unrest. In the past, countries have addressed technology-led transformations by deploying a mix of policies that were geared towards mitigating the adverse effects on the most vulnerable people and fostering reskilling and skills upgrade. (UN DESA, 2017). At present, AI systems can replace humans in undertaking narrowly defined tasks, including both physical and intellectual routine tasks, at a much lower cost per unit. In the future, automation is not likely to be directed at entirely replacing occupations requiring capabilities such as human adaptiveness to changing problem-solving environments, social intelligence, and cooperative decision-making, unless general intelligence AI systems, contrary to most educated expectations, will be soon developed (Tegmax, 2017 and Eurofound 2017).

Statistics on the impact of AI on the labour market needs to be taken with cautions. A Gartner report published in 2017 estimates that AI will create 500,000 additional jobs for medium and high skilled workers over the next three years. A McKinsey report predicts that half of today's workplace activities could be automated by 2055, or even 20 years earlier, in the most extreme scenario (McKinsey, 2017c). As a matter of fact, these impacts are difficult to estimate and will actually depend on effective progress in AI application for real-life problems and on the combination of AI with other breakthrough technologies.

Regardless of the actual number of jobs destructed and created, a key issue in more automated workplaces will be the amplification of power asymmetries and inequalities. If, as foreseen by a McKinsey Report (McKinsey, 2017b), half of the productivity gains in the future will likely come from job losses, while the other half will be attributed to product and process innovation, automation is likely to lead societies towards a significant transfer of national income from wages to capital. Given that these predictions reinforce existing trends that already see an uneven distribution of productivity gains, a big area of concern for European policy makers is to understand how the gains of improved AI technologies could be shared within and between countries. Adaptation of welfare and education systems might be necessary to protect the people whose skills become obsolete.

Finally, transformation induced by the diffusion of AI technologies, along with other digital technologies, will have far-reaching implications for training and education and a major shift in the type of skills needed is expected to occur in the medium term.

The diffusion of AI applications stems from progress on general digitalisation and a better understanding of how applications of AI can be effectively used in public administrations and in supporting public decision-making.

The uptake of AI is enabled and leveraged by the ongoing digital transformation within the private and public sectors. The state of digitisation across the EU varies considerably across sectors and countries. According to the EU Digital Monitor Report 2017, Denmark, Finland, Sweden and the Netherlands have the most advanced digital economies followed by Luxembourg, Belgium, the UK and Ireland. Romania, Bulgaria, Greece and Italy have the lowest scores on the Digital Economy and Society Index[15]. However, the general perception is that European industries are not taking full advantage of digital technologies and of the opportunities that these technologies offer.

A similar analysis applies to public administrations. Public sector digitisation (e.g. creating a digital public administration) in key to create a market for these technologies that can be applied to generate public savings through a more efficient use of public resources (e.g. using AI to assist public servants in finding patterns, matching data, and automating manual processes). As an example, in Finland the development of AI applications is linked to the objective of providing the best public services in the world (Finland's Ministry of Economic Affairs and Employment, 2017). The Italian government has launched a consultation with experts from multiple disciplines to assess to what extents and under which conditions AI technologies can be applied in public administration to support the provision of public services, along with overall progress in e-government (Agenzia per lo Sviluppo Digitale, 2018).

However, the use of AI in public administration and public decision making is no risk free and has several implications. Firstly, it has a non-negligible impact on the relationship between a state and its citizens. Secondly, the use of AI algorithms risks to deliver oversimplified solutions and undesired social outcomes. This is because algorithms do not nuance and are not good in dealing with trade off and with being inclusive by balancing diversified interests.

Finally, governments risk being overconfident about AI being the easy and quick fix of complex societal challenges that require longer process and arbitration capacities. Actually, there is not yet sufficient empirical evidence on the use of AI systems to support such a statement. Market studies highlight that AI are currently mostly employed in marketing and retail sectors, especially in relation to customer profiling and service and product offers' customisation. In this context, the policy response risks to be too much driven by the latest technology trends (e.g. AI, blockchain), while there could be several cases in which other technologies, or alternative non-tech solutions, could deliver similar outcomes at lower social costs.

15 This is a composite index that summarises relevant indicators on Europe's digital performance and tracks the progress of EU Member States in digital competitiveness.

4. RECOMMENDATIONS

In order to maximise AI benefits, while addressing risks related to the diffusion of AI technologies in products and services, and promoting an informed and open debate about AI, the EP could consider the following actions.

Promote genuine progress in AI global governance and discussions about the societal risks of these technologies. Gathering upon its founding social and ethical values, the EP could launch a process that would start a discussion about a common, internationally recognised ethical and legal framework for the design, production and use of AI. This framework should provide a roadmap for promoting and protecting human values and welfare by the responsible uses of these technologies. Suitable policies for protecting human dignity, autonomy and responsibility from threats posed by autonomous decision-making and action by AI and robotic systems should also be actively promoted at the global level. This should also include an evidence-based discussion about the risks of adopting such technologies in terms of their impacts on individual rights and freedom (e.g. what are the implications of the systematic profiling of citizens? To what extent and how the use of these pieces of information should be limited?).

Ensure that the development of AI based products and services developed in Europe integrate core European values by mean of a general ethical framework. So far, the European Union and Member State legislations had to respond to ethical and social risks of AI innovations imported from the US (e.g. protection of citizens' privacy from abusive behaviours). The development of European AI product and services will give to the AI applications developed in Europe a distinctive character and comparative advantage. In general, ethical issues raised by AI technologies and systems should be more extensively analysed and appropriate ethical policies should be developed accordingly. This implies creating a coherent and trusted regulatory framework. This can be achieved by regulating broad AI principles rather than specific algorithms, which is deemed to be more effective and cost-efficient. This general ethical framework should be inspired by the principle of human-centric AI (i.e. AI tightly developed under human oversight and control), embed the principles of fairness and justice in algorithms, applied in all phases of AI systems' design, implementation and testing, while following through bias complaints and other undesired effects reporting.

Prioritise AI applications that effectively address societal challenges. The use of AI in critical industrial applications is a relatively untested field**.** The literature shows that the potential of AI, as compared to other technologies, might be presently over estimated and might be driven by unrealistic expectations about what these technologies can effectively achieve in terms of generating economic and social value. The business community has also recently started to take a more cautious approach. While substantial investment in AI research should be tested against alternatives, the combination of AI with other technologies and megatrends should be better explored and based upon empirical evidence. The EP should ensure that funds allocated to AI prioritises applications in which AI supports human efforts with respect to taking better, informed and unbiased decisions to address societal challenges. Investment in applications with large multiplier effects that leverage on the potential benefits of AI for business and society should be carefully identified and prioritised.

Ensure consistency in regulations and policies that are linked to AI, such as those affecting the access, use and storage of data. This goes in the direction of removing barriers to the cross-border access, use and storage of data. Since many new AI applications are developed by start-ups, regulatory impact assessments should also consider to what extent new or revised regulations disproportionally affect these companies. The possibility of introducing regulatory sandboxes should be carefully considered to test the use of AI in heavily regulated sectors, such as finance and healthcare.

These could be introduced at the European level to facilitate collaborative projects and avoid a further fragmentation of the Digital Single Market.

Ensure that EU support for AI leverages and complements actions undertaken in Member States. As the European countries develop their national policy responses to promote the uptake of AI and mitigate its risks, European institutions should play a key role in coordinating such efforts, filling in policy gaps that cannot be addressed solely at the national level and support the widespread development of competitive AI ecosystems throughout Europe. This also requires seizing synergies between the EU framework research programme, the newly established Digital European Programme and the ESI Funds.

Finally, engage with Member States to prepare business and society for the upcoming transformations. Although statistics on the impact of AI on the labour market need to be taken with caution, policy makers have to be aware of the possible different outlooks and become prepared to address short-term or even long-term effects of technological unemployment which AI developments may significantly contribute to bring about. Adaptation of welfare and education systems will be necessary to protect the people whose skills become obsolete and to mitigate the amplification of power asymmetries and inequalities generated by increased automation.

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ANNEX 1 – LIST OF PEOPLE INTERVIEWED

Stakeholder category	Name	Organisation	Position
Industry	Jochen Mistiaen	Digital Europe	Senior Policy Manager
Industry	Ana Garcia Robles	European Big Data Value Association	BDVA Secretary General
Industry	Koen Simoens	EU Tech Alliance/ Sentiance	VP Delivery & Data Security
Industry	Fabrizio Porrino	EU Tech Alliance/ SVP Global FacilityLive	In charge of public affairs-scaling up
Industry	Lenard Koschwitz	Allied For Startup	Director
Research	Marco Gori	Siena University	Professor of computer science
Research	Bertie Muller	University of South Wales	Chair UK Society for the Study of AI and Simulation of Behaviour
Research	Lucy Suchman	Lancaster University	Professor of Anthropology of Science and Technology
Public institutions	Willem Jonker	EIT Digital	CEO EIT Digital
Public institutions	Jussi Nissilä	Finland's AI Programme Innovations and Enterprise Financing Department	General Secretary of National AI Programme
Public institutions	Marten Kaevats	The Government Office of Estonia	National digital advisor to Estonian government

ANNEX 2 – AI NATIONAL STRATEGIES AND DEVELOPMENT PLANS IN MEMBER STATES

Table 3 The French policy mix to support the uptake of AI

PRIORITY AREAS	PLANNED MEASURES
Data policy	• Establishment of data commons and a data governance model based on reciprocity, cooperation and sharing. • Establish clear conditions for making data of public interest more accessible. • Support the right to data portability.
Sector targeting (health, transport, the environment and defence and security)	• Identify targets that matter to address specific challenges (e.g. zero-emission urban mobility). • Test sector-specific platforms (e.g. data gathering, accessibility to computing infrastructure). • Implement innovation sandboxes to run experiments in "real-life" conditions.
Research and development	• Create interdisciplinary AI institutes in selected public higher education and research establishments. • Allocate appropriate resources to research, including supercomputer designed especially for AI applications in partnership with manufacturers. • Make careers in public research more attractive (e.g. increase salaries for AI experts).
Professional transition	• Create a public laboratory on the transformation of work to anticipate changes. • Develop complementarity between humans and machines (i.e. legislative project on working conditions in the automated era). • Identify and test new funding methods for vocational training.
Making AI more environmentally friendly	• Establish a research centre focusing on AI and the ecological transition. In order to identify ways to leverage AI applications to support such transition. • Make AI become less energy-intensive by supporting the ecological transition of the European cloud industry. • Increase accessibility of ecologically relevant data.
Social acceptability (AI transparency, reliability and accountability)	• Establish group of experts to verify algorithms and databases and improve understanding in civil society (e.g. interpretable user interfaces, understanding the mechanisms at work in order to produce satisfactory explanations) • Raise awareness in AI communities about the ethical issues at stake. • Create a consultative ethics committee for digital technologies and AI, which would organize public debate in this field. • Guarantee the principle of human responsibility, particularly when AI tools are used in public services.

PRIORITY AREAS	PLANNED MEASURES
AI for Inclusivity and diversity	• Improve gender balance in the AI industry starting from the education sector • Identify mediation tools to improve accessibility of increasingly dematerialised public services • Support AI-based social innovations (e.g. dependency, health, social action and solidarity).

Source: Cédric Villani, 2018

Table 4. The UK policy mix to support the uptake of AI

POLICY AREAS	PLANNED INVESTMENTS/ACTIONS (GOVERNMENTAL ACTIONS ONLY)
Data Policy	• Provide legal certainty over the sharing and use of data in accordance with the UK's strengthened Data Protection Bill. • Develop fair, equitable and secure data sharing frameworks.
Research and Development	• About EUR 343 million are allocated to fund research related to 'data science and AI' complementing the new centres for doctoral training. • Invest up to EUR 22.8 million in the application of AI in the services sector through the Next Generation Services Industrial Strategy Challenge. This will include a network of Innovation Research Centres and collaborative R&D to develop new applications of AI and data-driven technologies in sectors such as law and insurance. • Invest EUR 106 million from the Industrial Strategy Challenge Fund into the robotics and AI in extreme environments programme. • Increase in the rate of the R&D Expenditure Credit from 11% to 12% from January 2018.
Commercialisation of AI	• Establish a new EUR 2.8 billion Investment Fund incubated in the British Business Bank. By co-investing with the private sector, a total of EUR 8.5 billion bn of investment is expected to be supported. • Expand significantly the support available to innovative knowledge-intensive businesses through reforming the Enterprise Investment Scheme (EIS) and Venture Capital Trusts (VCTs). • Invest EUR 24 million in regional tech companies and start-ups. • Work with Digital catapult across the UK.
Public procurement	• Create a EUR 22.8 million GovTech Fund to support tech businesses to provide the government with innovative solutions for more efficient public services. • Raise overall UK R&D intensity by raising total R&D spending across public and private sectors to 2.4% by 2027, and 3% over the longer term.

POLICY AREAS	PLANNED INVESTMENTS/ACTIONS (GOVERNMENTAL ACTIONS ONLY)
Social acceptability (AI transparency, reliability and accountability)	• A Centre for Data Ethics and Innovation will be tasked with ensuring safe, ethical and ground-breaking innovation in AI and data-driven technologies.
Infrastructure	• Invest over EUR 1.1 billion to develop 5G mobile networks and extend full fibre broadband to build the next generation digital infrastructure.
Education/skills	• Nearly EUR 48 million funding for the Alan Turing Institute. • Build towards an additional 200 doctoral studentships in AI and related disciplines a year by 2020 to 2021. • Doubled Exceptional Talent visas to 2,000 a year and change immigration rules to enable world-leading scientists and researchers arriving under this scheme to apply for settlement after 3 years. • Work with the AI Council to promote the importance of a diverse research base and workforce in AI.
AI governance	• An Office for AI has been established to implement the AI Sector Deal and the government's overarching strategy for AI, while an AI Council is set to become the central forum where industry, academia and government leaders come together to identify opportunities and issues and actions to address them.

Source: UK government, 2018.

Table 5. Finland's policy mix to support the uptake of AI

POLICY AREAS	PROPOSED ACTIONS TO BE ADOPTED BY END OF 2018
AI uptake in enterprises	• Establish enterprise-driven ecosystems to help in the application of artificial intelligence through artificial Intelligence, data economy and platform economy programmes (Tekes). • Incentives to utilise artificial intelligence solutions (e.g. Tekes innovation voucher). • Artificial intelligence encoding course offered by Finnish universities.
Data policy	• Extend s use and sharing of data • Establish a "regulatory sandbox" experimentation environment.
Infrastructure	• Setting up of AI accelerator facilities to provide some companies with computational capacity, the newest artificial intelligence tools and open environment (e.g. open data, open interfaces, open source code, trials, challenge competitions).
Skills and talent	• Establish an international hub for AI in Finland • Expand AI literacy in Finnish population • Attract talents from abroad

POLICY AREAS	PROPOSED ACTIONS TO BE ADOPTED BY END OF 2018
Research and development	• Target innovation funding with a EUR 100 million permanent increase to: the application of AI in different sectors, and to the building enterprise-driven ecosystems and strategic projects. • In the long term, renew the enterprise subsidy system to support the renewal of business and investments in competence and expertise. • Ensure sufficient national co-funding for EU-funded Horizon 2020 projects.
AI uptake in public administration	• Start with the Finnish Immigration Service's solution for immigrants (multilanguage assistance). • Improve interoperability of data and systems.

Source: Finland's Ministry of Economic Affairs and Employment, 2017

As a general-purpose technology Artificial Intelligence (AI) is expected to bring about far reaching effects on business and society. Worldwide, governments have launched ambitious programmes to support the development of AI-based technologies and achieve technology leadership. Against this background, this study was commissioned by the Policy Department for Economic, Scientific and Quality of Life upon request of the ITRE Committee to feed into the general debate on how Europe could seize the opportunity of progress made in AI.

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