EPSC Strategic Notes

European Commission

Issue 29
27 March 2018

European Political Strategy Centre

The Age of Artificial Intelligence

Towards a European Strategy for Human-Centric Machines

In the words of the late Stephen Hawking, 'AI [Artificial Intelligence] could be the biggest event in the history of our civilisation. Or the worst. We just don't know.' As the world stands at the cusp of this transformative technology, much is at stake. Deployed wisely, AI holds the promise of addressing some of the world's most intractable challenges, from climate change and poverty to disease. Used in bad faith, it can lead the world on a downward spiral of totalitarianism and war, endangering – according to Hawking – the very survival of humankind itself.

Finding a policy response to what is undoubtedly 'the next big thing' is both urgent and challenging. **Europe needs an ambitious and rapid deployment strategy, covering both business and public administration**. This must go hand in hand with a world-class research and science strategy, as well as an international drive to claim its stake in what is for now a heated race between the United States and China for global dominance. In addition to creating an enabling environment for AI, Europe must use its widely recognised values and principles to build global regulatory norms and frameworks that ensure a human-centric and ethical development of this technology.

Build the environment

Three ingredients have led to the rapid advancement of AI: stronger computational power; more sophisticated algorithms; and higher availability of vast amounts of data. Decisive and concurring action is needed in all three areas to create an enabling AI framework for Europe, while also investing in the accompanying skills and ensuring appropriate safeguards.

Identify Europe's competitive advantage in AI

Given that machine intelligence and learning is driven by access to large volumes of data, Europe's practice of data minimisation and high data privacy standards can be seen as a disadvantage against the likes of China, where personal data flows more freely. But in the long run, digital 'prosperity' will inevitably have to go hand in hand with citizens' well-being. This is where Europe can create a competitive edge for itself.

Strengthen Europe's AI talent base

Not only is it likely that AI will lead to many modern-day tasks and jobs being automated, but Europe also faces a major shortage in AI talent. This calls for an urgent and comprehensive upgrade of Europe's skills base towards interactive, cognitive and non-routine occupations, as well as efficient social safety nets. Skills development must be inclusive and help build resilience to potential downsides of AI.

Prompt a human-centric approach

An augmented society is one where power asymmetries and inequalities are magnified. This is of concern as AI-powered technologies are progressively shaping the infrastructure that underpins many economic and societal activities. Early actions can ensure a human-centric orientation of AI. But this requires high and transparent quality standards – also at global level – and continuous monitoring of AI's societal impacts. Traditional institutional tools, such as competition policy, will also need updating, alongside new measures.

EPSC Strategic Notes are analytical papers on topics chosen by the President of the European Commission. They are produced by the European Political Strategy Centre (EPSC), the European Commission's in-house think tank.

The economics of Artificial Intelligence

Paraphrasing Nils J. Nilsson, the term **'Artificial Intelligence'** (AI) can be used to indicate any technology (software, algorithm, a set of processes, a robot, etc.) that is able to **function appropriately with foresight of its environment**.[1] This represents a step change from the common assumption that machines are 'dumb' and can only act on human command. Today, large volumes of data allow machines to quite literally learn and thereby become intelligent, conferring superior analytical capabilities that at times surpass human ones. This learning also enables machines to make intelligent inferences about the future.

Much like electricity or the steam engine, Artificial Intelligence is a general-purpose technology that will profoundly change all aspects of life. **It is difficult to imagine any segment of society that will not be transformed by AI in years to come**.[2] Already, AI has come to play a major role in everyday life. Technologies based on machine learning, such as text and speech recognition or translation, are increasingly adopted both in the private and public sectors. Algorithmic computation provides product suggestions for those surfing the web, or tailored news to those browsing feeds on their social media accounts. The number of potential AI applications is unlimited: a producer of packaged salads could, for example, forecast the next popular vegetable before growing season even starts by unleashing sophisticated algorithms to collect information from restaurant menus across a country and anticipate changes in consumer demand.[3]

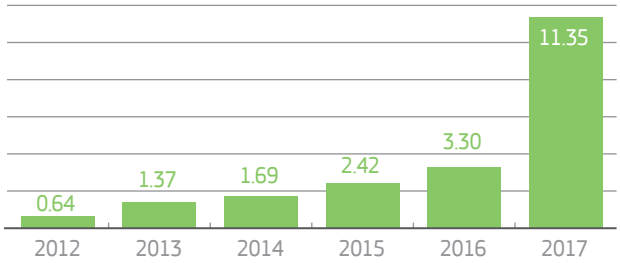
And bigger changes are on the horizon: the arrival of self-driving cars, automated drones for package delivery, health analytics and precision medicine, cybersecurity applications and cryptocurrencies, automated fraud detection, factory automated production processes, conversational interfaces, etc. Estimates suggest that, already this year, 20% of all global business content will be authored by machines and that, by 2020, AI bots will power 85% of all customer service interactions.[4] Thanks to the emergence of high computational power and the availability of massive amounts of data, all these examples of 'narrow' or 'task-specific' AI applications can push humankind beyond its limits and achieve outstanding goals. Google DeepMind's deep learning technology AlphaGo certainly did so in 2016, when it won against Lee Sedol, world champion of Go, the board game with the highest number of potential move combinations.

The economic impact of AI will be significant and heralds many opportunities for those countries and firms which embrace it. It is estimated that the global adoption of cognitive systems and AI across a wide area of sectors will drive worldwide business revenues from 6.4 billion euro in 2016 to more than 37.8 billion euro in 2020.[5] More broadly, AI could contribute 12.8 trillion euro to the global economy by 2030, representing an increase of 14% on today's global GDP.[6] It is anticipated that 7.4 trillion euro could come from consumer demand for new products, while 5.4 trillion euro could be generated from higher market productivity. Indeed, AI could boost productivity by up to 40% by 2035.[7] Increased productivity will come from industries adopting new automation techniques and replacing routine tasks by machines that are able to perform them more efficiently and around the clock. With the increase in computing power and the availability of vast amounts of data, machine learning technologies will significantly improve the efficiency of the manufacturing production process.[8]

The global AI developing ecosystem is already in a frenzy. Overall venture capital funding for start-ups specialising in AI applications grew by a compound annual growth rate of 85% between 2012 and 2017. **Funding more than tripled between 2016 and 2017 alone, to reach over 11 billion euro**,[9] reflecting a considerable change in funding priorities by private investors (Figure 1). Corporate giants are racing to buy up AI-focused companies. Over 250 companies using AI algorithms were acquired since 2012, 37 of which in the first quarter of 2017 alone.[10]

Figure 1: Global AI financing expanding fast

Billion euro



Source: Venture Scanner, Artificial Intelligence Startup Highlights, Q4 2017

Economic benefits will accrue across sectors, as well as on the demand side, as citizens benefit from personalised health diagnostics, driver assistance increases road safety, and students get access to tailor-made learning offers. AI has the potential to achieve outstanding goals for humanity, like **winning the battle against cancer**[11] or **minimising the impact of disasters**.[12] Both the private and public sectors can become significantly more efficient and responsive to specific needs and demands of individuals.

Not only a rosy picture

The significance of AI's positive impact is mirrored by its **likely destabilising effects on some aspects of economic and social life**. Labour markets can be heavily impacted if a significant chunk of the workforce is made redundant by new technologies while unable to profit from the new opportunities created by digital markets. Individuals worry about losing control of their personal information and feel increasingly vulnerable to online abuse. Online platforms – private businesses largely based on algorithmic functions – have come to play a quasi-public role, essentially regulating what individuals read, see, hear or say, while harvesting data to refine their understanding of people's behaviour and preferences.[13]

While AI is still an emerging field, the widely acknowledged transformative nature of the technology requires public authorities to be vigilant. On the one hand, AI needs support to flourish: a favourable regulatory environment and significant efforts to ensure availability of the necessary inputs, such as access to computational power, data, skills and financial markets. On the other hand, policymakers have the duty to identify new threats and take action to tackle them. They should not aim to control the evolution of technology, but **steer its direction and aim to set global standards and best practices**, making sure that all technologies based on Artificial Intelligence increase value for society and that this value is shared as widely as possible.

The global race is on

Governments around the world are deploying extensive AI strategic plans with comprehensive policy programmes, research activities and extensive financial support for private investment. **From China[14] to Singapore,[15] Japan[16] or South Korea,[17] Asian governments are taking the lead in AI**. With its strategy, China aims to become the world's leader in AI by 2030 (Table 1). On 14 December 2017 the Chinese government announced a detailed three-year plan with concrete goals to be achieved by 2020, such as mass-production of neural-network processing chips and increasing the manufacturing sector's energy efficiency by 10%.[18]

In the meantime, **Canada**[19] and the **United States**[20] are also developing their own strategies. While Canada seeks to increase scientific excellence in AI and develop a framework on ethics, policy and the legal implications of AI, the United States focuses on the need for basic and long-term research on AI but considers the government's role as a regulator to be minimal. In Europe, only the **United Kingdom** and **Finland** have adopted an AI strategy. The French government has entrusted a task force (the 'Mission Villani') to propose an AI strategy for **France**. The strategy will contain measures to foster AI development (such as the creation of a favourable regulatory framework) and measures to guarantee protection of individual rights.[21]

Table 1. Main goals of China's Artificial Intelligence development plan

2020	2025	2030
• Develop the next generation of AI technologies on big data, swarm intelligence, hybrid enhanced intelligence and autonomous intelligence systems	• Make AI the primary driver for China's industrial advances and economic transformation	• Become the world's premier AI innovation centre
• Gather the world's leading AI talents together	• Use AI in a wide range of fields – manufacturing, medicine, national defence	• Develop major breakthroughs in research and development
• Establish initial frameworks for AI laws, regulations, ethics and policy	• Become a leading player in AI research and development	• Expand the use of AI through social governance and national defence
	• Finalise AI laws, regulations, ethical norms, policies and safety mechanisms	• Create leading AI innovation and personnel training bases

Source: 'Sizing the prize – What' s the real value of AI for your business and how can you capitalise', PwC, 2017

Where does Europe stand?

Broadly speaking **Europe faces two major challenges, an internal and an external one**.

The **internal challenge** relates to the uptake of AI technologies by companies and the public sector, and to putting in place a regulatory framework that is flexible enough to adapt to future technological progress, while respecting key fundamental principles. Such principles include social and institutional considerations – for example the defence of democracy, protection of vulnerable persons (i.e. children), and data privacy – as well as economic ones, such as fostering innovation and competition.

Companies across the continent are slow to adopt digital technologies in general. Only 4% of world data is stored in the EU and a mere 25% of large EU enterprises and 10% of EU SMEs used big data analytics in 2017.[22] Data scientists account for far less than 1% of total employment in most EU Member States.[23] While large corporations are able to adopt AI technologies in order to improve their own systems (voice, face recognition, personal assistants, bot-to-bot communication), **smaller companies face significant constraints**, including the lack of qualified staff, higher cost of investment, difficulty in assessing economic returns, or simply doubts about the possible integration of AI in the company.

Furthermore, Europe has the potential to leverage the backbone of its economy – its high value-added manufacturing and industry base, which currently accounts for roughly 23% of GDP – to get ahead in the Internet of Things (IoT) and in Artificial Intelligence. However, today, much of this sector still largely operates in an analogue world. Missing the digitalisation boat (again) would not only put EU companies at significant disadvantage vis-à-vis their competitors. It would also over time significantly impact the wider economy, be it in terms of growth, tax revenues or employment.

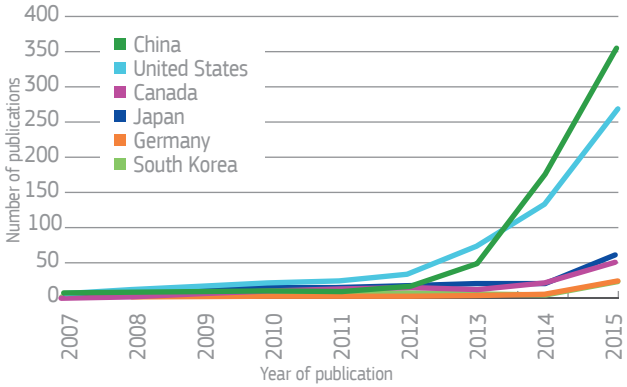
By creating an interconnected system of machines and adopting AI-powered technologies, European companies would obtain an **'AI-multiplier' effect**. They would not only become more efficient, they would also be able to capture and analyse massive amounts of machine generated data as a by-product of operations. A 'smart factory',[24] for example, would generate data from automated manufacturing processes, warehouse operations, inventory tracking, quality control, maintenance, etc.

Europe's external challenge is the uneven pace at which AI is being developed around the world, with other jurisdictions enjoying structural advantages. Places like Silicon Valley, for example, have a unique economic framework geared to support disruptive innovations with strong commercial applications. It is also a place where the quintessential ingredient for AI, *data,* is more easily available. This is also the case in China, where the regulatory environment offers little in terms of privacy or control of personal data, and where major public and private investments continue to flow into AI development. This underscores the key role of cultural factors, giving China a strong advantage: 93% of Chinese customers are willing to share location data with their car manufacturer, compared to 65% of Germans and 72% of Americans, suggesting that China is more likely to become the hotbed of the 'car data revolution.'[25] While China continues to be an opportunity for European companies wanting to invest and expand abroad, it will also increasingly become a major competitor if **Chinese firms can implement more advanced AI technologies and work with larger volumes of granular data**.

China's efforts on the corporate side are mirrored in academia where Chinese researchers are currently publishing more journal articles on deep learning than their US or European counterparts (Figure 2). While Europe's science and research base is comparatively strong, it suffers from a long-standing inability to turn promising inventions into genuine innovations, resulting in a scarcity of globally successful, sizable digital companies.[26]

Europe also lags behind the US and China on patent submissions[27] and investments. Between 2002 and 2015, while the number of ICT patents submitted in India more than doubled and increased by as much as 50% in China, average submissions in the EU28 actually decreased over the same period.[28]

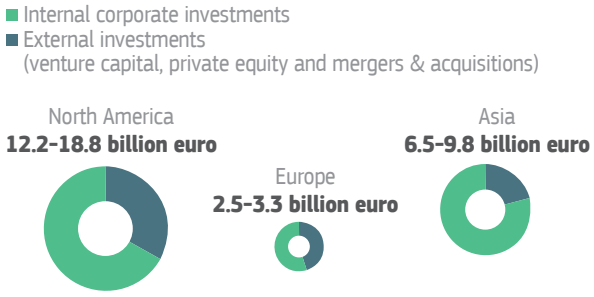
Figure 2: China leads the way on deep learning research



Source: White House, National Artificial Intelligence Research and Development Strategic Plan

In 2016, external investors poured between 900 million and 1.3 billion euro into European firms. But they invested between 1.2 and 2 billion euro in Asian companies, and 4 to 6.4 billion euro in North American ones. And, although some big European companies are investing in AI (ABB, Bosch, BMW, Siemens), internal corporate investments in AI were also much lower in Europe in 2016 (Figure 3).[30]

Figure 3: AI investments are lower in Europe



Source: McKinsey, 2017

Even if some European AI companies are performing well and succeeding in developing new AI technologies (DeepMind, Skype, etc.), **they tend to be acquired by non-European companies at a later stage of development**. The European continent at times functions as a *de facto* 'incubator' for others, unable to build up sizable, internationally-operating tech companies of its own. That hasn't stopped tech companies – particularly US ones – from setting up new AI hubs in European countries to tap into the strong research base and highly qualified professionals.[29]

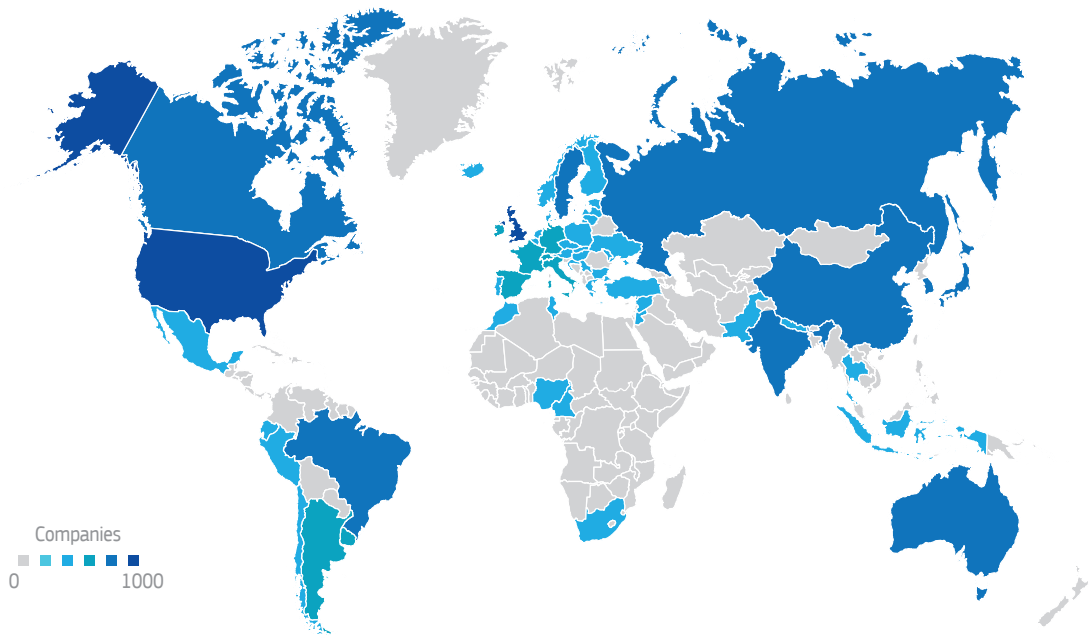
Europe should respond to its internal and external AI challenges by pursuing two goals: First, creating an enabling framework favouring investment in AI, and second, setting global AI quality standards.

Europe should emerge as a quality brand for AI

A lax approach to citizens' digital rights may give short-term economic advantages. The easier it is to collect and process data, the lower the cost for companies to develop AI-powered solutions.[31] Yet, **pursuing a 'Chinese' model is neither possible nor desirable**. Successive waves of technological advancement have essentially revolved around the empowerment of individuals. **In the long run, there will not be digital 'prosperity' for countries that do not address issues related to the effect of technology on citizens' well-being**. If not addressed early-on in the development of technology, the tension between users and misuse of technology might escalate at a later stage, when it can be more difficult to handle.

Conversely, Europe has an opportunity to set global standards to reach the highest level of welfare for citizens, gaining trust and thereby **setting the ground for a stable and broad level of acceptance of the new technology**, not only in Europe but, over time, also in other parts of the world. In the short term this can imply additional hurdles for companies willing to invest in Europe. However, in the long run it is likely that higher standards will prevail, so the companies that gain early trust among users could have a competitive advantage.

Figure 4: US has clear lead in terms of numbers of AI companies



Source: White House, National Artificial Intelligence Research and Development Strategic Plan

Steering AI to augment rather than substitute humans

Artificial Intelligence will not lead to the end of jobs. But this does not mean that no one will lose their job to machines. Rather, the expectations around jobs will be transformed. For example, Microsoft is deploying a technology to refine radiologists' capacity to identify the boundaries of tumour cells and monitor their progress. However, this does not mean radiologists will be replaced by machines in any foreseeable future.[32] There will be a place for humans in an AI-augmented society, but the focus must be on facilitating the transition and on providing support and security to those who are more likely to bear its costs. In the past, technological change has often meant resistance to change, which has only compounded job losses, without the upside of job gains that early technology leadership might have afforded.

Public policy should encourage the development of Artificial Intelligence aimed at establishing a symbiosis between human and machines. Artificial Intelligence should be conceived as a complement to humans, not a substitute. **The goal should be a society where people feel *empowered*, not *threatened* by AI**. That is why skills-oriented actions, including retraining, as well as robust safety nets that accompany citizens during times of transition are of utmost importance.

The General Data Protection Regulation – leading the world towards a better AI?

Due to enter into force in May 2018, the General Data Protection Regulation (GDPR) introduces a number of guarantees, protecting individuals and strengthening the role of consent for the processing of personal data. It endorses a principle of data minimisation, limiting the use of data to the purpose for which they have been collected. It promotes transparency of data processing and establishes a right of explanation for the subjects of a decision based on automated process.[33]

These principles may at first seem to limit the scope for AI development in Europe. Yet, the GDPR also creates opportunities: companies will be incentivised to find innovative solutions in order to be able to process data while remaining within the legal remit of the GDPR. Data could be kept 'close' to the data subject with local processing on their devices, as envisaged in the 'GoFair' project.[34] A UK start-up called Anon AI is winning the trust of investors on its promises to use Artificial Intelligence to 'share data securely using a workflow tool that automatically anonymises and adapts changing datasets'. More generally, the principle of accountability enshrined in the GDPR is set to foster the accuracy of data; it implies increasing trust in the source of the data and the reliability of results. Studies show that mature information governance is a determinant of business success and **data protection can been seen as an enabler, not a barrier, to innovation**.[35] Google Flu Trends' 'epic failure'[36] shows that massive amounts of data do not guarantee accurate outcomes; **data quality, as fostered by the GDPR, is crucial too**.

By respecting the legitimate right to privacy of users, AI technologies would be more readily accepted by society at large, and can rapidly emerge as global standards, granting Europe a first-mover advantage. As recently confirmed by Facebook's Chief Operating Officer Sheryl Sandberg,[37] big multinational companies are likely to adopt GDPR-compliant business models worldwide, rather than inefficiently operating multiple models in different regions. People around the world are becoming more, rather than less, concerned about the potential misuse of their data. A recent study finds hat 84% of US consumers are concerned about the security of their personally identifiable information and 70% of them stated that their concern is greater today than a few years ago.[38]

Much, however, will depend on implementation by Member States. With just a short time to go before the entry into force of the GDPR, only Austria and Germany have adopted the necessary measures to make their national systems compatible, including setting up national data protection authorities and designating accreditation bodies. Diversity in enforcement by Member States or even regions risks erasing one of the most important benefits of the GDPR for citizens and business: the creation of a uniform and predictable approach to data protection across Europe.

The inherent AI bias

While augmenting humans' capabilities, **AI can also exacerbate existing power asymmetries and biases.** The *AI Now 2017* report for instance highlights how AI technologies enhance employers' ability to oversee, monitor and assess the work of employees. Sophisticated automated software can be used to grasp sentiment in the text of e-mails and attach a 'productivity risk' to employees who are deemed to be likely to leave the company, for example.[39]

Prudence is called for because Artificial Intelligence increasingly powers the technologies that are rapidly becoming the **essential analytical, communicational, and even legal, infrastructure for our societies**. Algorithms are affecting the hiring processes of companies, communication between smartphone applications, and what content users see on Google, Twitter or Facebook.

Yet **these technologies invariably reflect the background and bias of the source that programmed them.** As such, the composition of the Artificial Intelligence development ecosystem is heavily skewed towards a population group with specific characteristics: developers are mostly white males, well-off, well-educated, with a strong inclination for high-tech.[40]

A non-diverse environment cannot design the new paradigm on which society will run without inevitably replicating its own bias. In the early 1970s, male developers introduced the first airbags and tested them with male-sized test dummies; the result was a 47% higher chance of serious injuries for seat-belted women drivers than for belted male drivers. It took the US national transport safety authority and automakers more than thirty years to introduce tests with women and child dummies. **When it comes to digital technologies, we do not have that much time**. Digital markets evolve very rapidly. A typical traditional Fortune-500 company would take twenty years to get to a market valuation of one billion of dollars. Google, Uber and Snapchat got there in slightly more than eight, four and two years respectively.[41]

It seems **unlikely that market forces alone would be able to generate the necessary response to effectively handle the issue of bias**. Features like extremely strong network and scale economies imply that competition often happens *for* the market rather than *in* the market. Established online platforms that are subject to very low competitive pressure both inside the market or from potential new entrants are unlikely to pay a price in terms of loss of users if they increase participation costs, change their privacy settings, or even if their reputation is compromised. In such a context, companies have too few incentives to swiftly correct the implicit bias of their algorithms.[42]

Even assuming that all bias could be corrected at the development stage by well-intentioned tech companies and programmers, AI technologies generate even deeper concerns. Accurate algorithms are of little use if the source of the bias is not only in the composition of the data sample or of the developing ecosystem, but rather is a by-product of the way people think or, more broadly, the structure of the society they live in. Google's sentiment analysis attaches a neutral value to words such as 'straight' but a negative value to 'homosexual', because it draws from the environment in which those words are placed, and it seems it is more likely that negative connotations are attached to minorities on online chats.[43] Microsoft's Tay chatbox 'became' racist a few hours after its launch, because it *learned* to do so from interacting with other users on Twitter.[44]

AI can indeed bring the consequences of power asymmetries to an extreme, with discrimination as a key risk. While discrimination as such is not always bad (cinemas 'discriminate' students offering them discounted tickets, for example), discrimination enabled by massive amounts of data and sophisticated algorithms can challenge the very fundamentals of our societies.

Predictive analysis could enable the circumvention of laws that prevent discrimination on the basis of race or sexual orientation, for example, or even impose higher insurance premiums on people with a higher likelihood of falling ill. It is therefore of utmost importance that the task of defining the fundamentals of the new 'digital society' is not left in the hands of developers alone. Instead, it has to be, at least partly, a function of public policy. And policymakers should set the necessary framework conditions before AI advances much further.

A 'Hippocratic Oath' for AI?

A Hippocratic Oath has traditionally been sworn by physicians, requiring them to uphold specific ethical standards, such as non-maleficence. In recent times, there have been calls to formulate a Hippocratic Oath for developers and technologists, in particular those working on AI. As the remit of technology now covers areas that go to the very heart of human well-being, many feel that a more robust ethical compass is needed to guide development and ensure accountability. Even industry leaders have made this demand.[45]

What EU policy responses are needed?

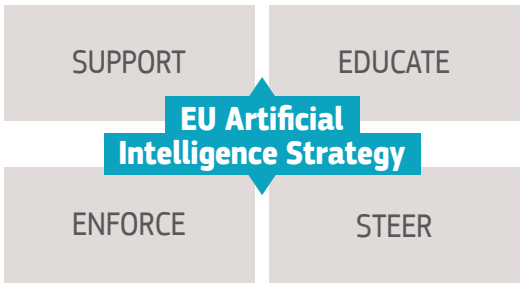
Three ingredients have led to the rapid advancement of AI in recent years: high network **computational power**; extremely sophisticated **algorithms**; and the availability of vast amounts of **data** from a number of different sources (social media, operational data, commercial and public data, etc.).[46]

To create an enabling AI framework for Europe, the focus should be on decisive and concurring action in all three of these areas, while also investing in the necessary **accompanying skills**. And, because AI-powered technologies are progressively shaping the very infrastructure that underpins economic and societal activities, regulatory authorities should ensure **proper safeguards**. These should aim to limit bias and prevent AI from cementing and entrenching current asymmetries, or from creating new ones in the distribution of value within society.

As such, a **European Strategy for Artificial Intelligence** should be based on a four-pronged approach (Figure 5):

- ***Support.*** Build an environment that is favourable to the development and uptake of AI technologies
- ***Educate.*** Focus on individuals to build AI skills and educate users
- ***Enforce.*** Deploy and adapt traditional policy tools to tackle economic and societal challenges posed by AI
- ***Steer.*** Ensure a human-centric approach that guarantees the highest level of welfare for citizens

Figure 5: A European Strategy for Artificial Intelligence



Source: European Political Strategy Centre

1) Support: Boost AI development and uptake in Europe

AI needs full support by EU decision-makers to flourish. Europe needs to catch up on the deployment and uptake of AI technologies. Demand and supply can be stimulated through multiple dimensions, namely by:

- ***Boosting access to data in order to feed AI systems.*** Regulatory solutions should be designed so as to favour the collection, use and sharing of data across the continent, while maintaining the highest standards of protection of personal data as mandated by the General Data Protection Regulation (GDPR).

  The European Commission's 'Building a European Data Economy' initiative aims to pull down barriers to access and the sharing of data across the continent.[47] It includes a proposal for a regulation to allow the **free flow of non-personal data**[48] which is now being discussed by the Council and the European Parliament. Members of the European Parliament and EU Member States should be keenly aware that the future of AI – and with it their vaunted pursuit of Industry 4.0 – depends in large part on support for this initiative.

  The creation of a '5th freedom' for the movement of non-personal data within the Single Market is critical in this regard, especially for EU Member States such as France and Germany, both of which have high ambitions with regards to Artificial Intelligence[49] and digitisation of industry.[50] Initiatives in the European Commission's pipeline, such as the forthcoming revision of the Public Sector Information Directive that will prompt public authorities to open their data for public use, can also prove extremely useful for start-up ecosystems and established companies in developing AI-based applications.

  In compliance with competition laws, the European Commission could also facilitate the sharing of data assets between European companies, for example through the creation of **data commons platforms**. Given the non-rival nature of data (multiple uses of data do not deplete its value), companies and researchers would be incentivised to contribute and tap into those platforms, with great potential for value creation. They could also address information asymmetries that particularly affect small and medium enterprises, which are often unaware of the potential of the data they hold or could have access to. Data commons could also stimulate market competition by providing companies with the means to challenge multinationals' power in data markets. Promising in that respect is the European

Commission's planned initiative on 'Industrial Data Spaces'[51] – modelled after the 'German Industrial Data Space' – as a platform favouring secure data exchange in business ecosystems on the basis of standards and by using collaborative governance models.[52]

- ***Enabling infrastructure investment and designing a favourable regulatory framework for AI inputs.*** New regulation should unlock investment and access to the key infrastructures needed for developing AI solutions, namely telecom infrastructure and high-performance computing (HPC) facilities. A number of initiatives of the European Commission's Digital Single Market Strategy have exactly that purpose. The new proposed Telecoms code lays down measures to incentivise investment in fast and ultra-fast broadband connections as well as a rapid uptake of advanced wireless 5G technologies.[53] Fifteen EU Member States have signed an agreement in support of the European Commission's plans to establish a multi-government cooperation framework for acquiring and deploying an integrated next-generation supercomputing infrastructure.[54] These measures now require urgent political prioritisation because without competitive high-performance computing capabilities and high-speed connectivity, Europe will quite literally not have the necessary speeds and bandwidths to build and support the business models of the future.[55]

- ***Promoting the development of AI hubs and excellence in AI research.*** Innovation ecosystems bring together researchers and scientists with businesses and private investors, stimulating growth through the aggregation of complementary skills and resources, such as start-up incubators, *fablabs,* co-working spaces and three-dimensional printing. The European Commission is investing 100 million euro per year from 2016 to 2020 to create digital innovation hubs across the EU in several business fields.[56] In order to boost the development of AI in Europe, a significant part of that funding should be geared to support AI innovation within these digital hubs. Germany's Max Planck Society, for example, is creating the world's leading hub for AI around Stuttgart and Tübingen, bringing together academic institutions (two technical universities) and industry (six leading companies) to boost research in Artificial Intelligence. Recently, Amazon decided to open an AI research centre in this region to benefit from the existing ecosystem.[57]

Europe does not lack centres of research excellence in Artificial Intelligence, as it in fact accounts for the largest share of top AI research institutions worldwide.[58] However, universities are often left in a vacuum, lacking connections with other research institutions, without significant backing from public funding, and in unsystematic relationships with companies. European universities' AI labs do not have the resources to scale up and become interconnected powerhouses capable of working on ambitious large-scale research projects or commercial applications.

To address this, the European Commission should foster the creation of a **permanent network of AI research institutions** and back the scaling-up of AI labs with appropriate public and private funding, as is done elsewhere. The US government, for instance, has invested 800 million euro in unclassified AI research and development in 2015. The government of South Korea is investing jointly with Korean companies some 730 million euro to support the creation of a public-private AI research centres.[59] Top European AI research needs to have the means to compete with these initiatives – and do so quickly before others pull ahead in markets in which first-mover advantage is real. Policy action needs to foster a conducive ecosystem, centred around a strong and mutually beneficial relationship between EU universities and AI companies.

Funding should also be used to **incentivise the creation of richer, more diverse development and research environments for AI**, **to minimise the risk of biased outcomes**. This could be done through scholarships for researchers from different disciplines and of different gender or ethnicity.

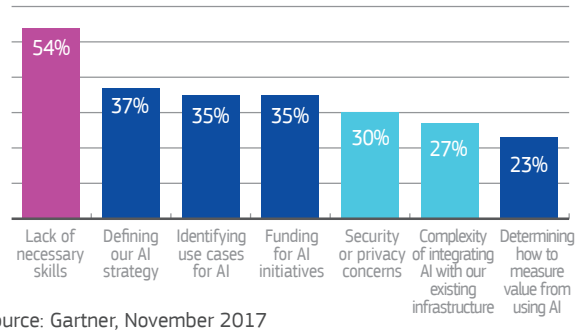
- ***Supporting the creation of a European Artificial Intelligence Platform.*** Such a pan-European platform could play a role as advisory body, bringing together different stakeholders (representatives from top universities and research institutions; EU, national and regional public authorities; enterprises, investors and local communities) from multiple sectors (ICT, services, manufacturing, financial, etc.) to identify bottlenecks in the AI ecosystem and advise on possible public policy measures to enable faster growth in the development of AI technologies in Europe. The stakeholder platform would have an instrumental role in spelling out the obstacles, be they financial, institutional or regulatory, that slow down adoption of AI technologies, especially by SMEs and the public sector.

2) Educate: Focus on individuals to build AI skills and educate users

- ***Foster AI-specific expertise but also a more digitally-savvy workforce.*** One of the biggest roadblocks to AI adoption is the lack of skilled workers (Figure 6).[60] The recent surge of merger and acquisition activity in the tech space can largely be explained by the general difficulties experienced by companies in finding the necessary AI expertise: **the acquisition of promising start-ups by multinationals is now often primarily about access to talent**. It is estimated that fewer than 10,000 people worldwide have the necessary skills to undertake serious Artificial Intelligence research.[61] Despite the evident demand for technology skills, a significant proportion of the EU population – 37% of the European labour force[62] – still does not even have basic digital skills. The European Commission forecasts a gap of 750,000 vacancies by 2020 between demand and supply of ICT experts.[63] Addressing the shortage in AI, machine learning and data experts should therefore be a top priority in an effective AI strategy. But upgrading IT skills and data literacy in traditional jobs in traditional sectors is also a must, if policymakers want a labour market where AI augments rather than replaces jobs.

Figure 6: Lack of staff skills is number one challenge in adoption of AI

Answers to the question: 'What is the biggest roadblock to AI adoption?' (Share of respondents, %)



Source: Gartner, November 2017

- ***Building on European initiatives to create the next-generation AI talent.*** The European Commission's strategy to address this issue centres on the 2016 'New Skills Agenda,' which includes, among others, a Skills Guarantee that targets adults to help overcome digital illiteracy. In addition, the Digital Skills and Job Coalition is a platform for coordinated action at all levels – business, government, public institutions, educational and training institutions – for upskilling, re-training, and promoting digital education, targeting in particular the young, the unemployed and helping SMEs to reskill their workforce.

  These efforts need to be complemented with **additional actions aimed specifically at fostering the creation of AI expertise**, upskilling from quantitative, math-literate professionals to data experts and data scientists. **A Talent Plan for Artificial Intelligence** could be steered by the European Commission to mobilise AI talent, ideas, technologies, investments and business across Europe and beyond. The plan could also envisage partnerships with universities and technological institutes across Europe in order to create opportunities for AI researchers. This is particularly important as research and academic expertise are areas where Europe has a globally competitive edge that needs to be fostered and strengthened.

- ***Creating resilience and independence, especially among digital natives.*** An inclusive AI strategy needs a bottom-up approach that provides members of society with the necessary tools to safely navigate the new digital paradigm. The customisation enabled by AI and the large amounts of data on which it thrives empower individuals because they can get access to a supply of goods and services that respond exactly to what they want. However, it also pushes individuals to the limits of their 'bounded rationality', making them vulnerable to exploitation by developers, to psychological dependency and online harassment. Algorithms can be tweaked to stimulate addictions to social media, for example, by increasing the number of 'likes' and similar feedback loops received by teenagers when they are most in need of social support and affirmation.[64]

  The potential risks or downsides of AI cannot only be tackled through top-down regulatory action. The major force of change and resilience has to come from individuals themselves. Public authorities can assist these efforts by **developing a digital and media literacy strategy**. Platforms may also need to be prompted to 'nudge' vulnerable users away from self-harming behaviour.[65]

3) Enforce: Modernise traditional institutional and policy tools

- ***The end of exceptionalism?*** Policymakers, especially in Europe, seem to have been caught off guard by the transformative nature of digital technologies. AI-powered technology companies such as online platforms have traditionally been granted an exceptional status, shielding them from assuming responsibility for the consequences of activities they enable through their services. This is partly because so few foresaw that yesterday's start-ups could become very powerful businesses in such a short period of time. A notable example is article 14 of the e-Commerce

Directive[66] which exempts online intermediaries from liabilities related to content they *unawarely* host on their platforms. That status was originally granted in order to promote growth in the sector, which held – and still holds – the promise of bringing huge benefits to society. However, it is time to acknowledge that those technologies have now become so ubiquitous that, on many counts, they serve a quasi-public purpose. It would be naïve to expect that mismatches between the objectives of these privately-run businesses and the public interest would not lead to serious consequences for society. While questioning the neutrality principle enshrined in the e-Commerce Directive would seem premature at this stage, all these elements suggest that public authorities need urgently to adapt traditional institutional and policy tools to the digital age.

- ***Address market distortions and power asymmetries***. The digital age has on occasion created asymmetries between providers and users. On balance, traditional policy tools developed in the analogue age appear fit for dealing with such instances, but they need to be adapted to the new digital environment in order to be effective. That, for instance, has been the logic underlying a number of initiatives launched by the European Commission in recent years, including the General Data Protection Regulation, but also parts of the Digital Single Market Strategy, such as the e-Privacy Regulation, consumer protection for digital goods and services, and the ban of geo-blocking.[67]

- ***Among the most effective traditional tools is competition policy***. A proper enforcement of merger control, antitrust and state aid rules can prevent market distortions and the creation of bottlenecks in the digital value chain. By forcing companies to compete on the basis of merit, competition policy contributes to ensuring that market rewards are distributed to players that innovate and offer the best quality to their customers. It also empowers users. Competition reduces the ability of suppliers to glean value from customers through algorithmic-empowered discrimination. For example, strong competition in the insurance market lowers premiums for users, limiting the ability of insurers to extract value from their clients through the use of predictive analysis. Adapting competition policy, however, requires catching up with a fast-evolving business environment. Antitrust enforcement, for instance, needs to accelerate while antitrust tools must be refined in order to stop AI from being used by companies to break the law, for example by coordinating prices. Likewise, merger control should take into account the implications of a reduction in market competition, which might allow merged companies to use AI technologies to discriminate against their users or elicit them to hand over more personal data to access their services. Importantly, **merger control should be fine-tuned to capture acquisitions which may have a significant impact on competition in the future but that today skip the scrutiny of authorities because they are below notification turnover thresholds**.

- ***Encouraging the public sector to lead by example.*** Europe's public sector, including the European Commission itself, can play an important role in demonstrating leadership and incentivising businesses to follow suit. This would require access to modern computing facilities and revising human resources policies in order to attract and retain people with AI, machine learning and data analytics skills. It would also suppose a thorough restructuring of internal processes and hierarchical structures, which experience suggests has a higher chance of success if led by external actors - so called 'digital architects' - or internal ad-hoc task forces with a mandate for innovation and disruption. AI-powered decisions taken by 'augmented public officials', be they high-court judges, police officials or European Commission employees, should not stem from 'black boxes'. They must be available for public auditing, testing and review, as well as subject to accountability standards.[68]

4) Steer: Guarantee a human-centric approach to AI

In order to succeed in the AI race while preserving its own cultural preferences, Europe needs to address potential social risks and **establish an EU AI quality branding** distinguishing it from the lax approach exhibited by other jurisdictions. This could be achieved through a well-defined **action plan**, led by the European Commission, **to steer AI towards compatibility with EU principles**. Such a plan should focus on building the necessary expertise at EU level to monitor the evolution of AI technologies in Europe, as well as on gaining the legitimacy to establish quality standards and the authority to enforce them (Figure 7).

Figure 7: An EU action plan for a human-centric Artificial Intelligence

Source: European Political Strategy Centre

The central elements of this action plan should include:

- ***Monitoring and periodically reporting on the general evolution of AI technology.*** Sophisticated statistical indicators should be developed at EU level to quantify the uptake of AI technology in all its forms, not only robotics, but also the use of automated services based on machine learning. Based on this, areas of concern or improvement could be identified, prompting a discussion around the most effective public policy measures to address them.

- ***Introducing social-system analysis.***[69] Researchers and experts from different disciplines, government and business representatives should assess the social and economic impact of the introduction of new AI technologies, for different communities, through different dimensions of analysis, be they economic, social, historical, ethical, or anthropologic. The potential effect of biased algorithms and the implications of discriminatory practices, should be assessed and the results of the assessment should inform public opinion ,as well as the definition of potentially corrective regulatory measures.

Setting Universal Ethical Standards

The global engineering association IEEE has since 2016 launched an initiative to recommend policy guidelines to foster an ethically aligned design of Artificial Intelligence. An explicit goal of IEEE is to have an inclusive approach to cultures, for example drawing insights from Buddhism or Confucianism to address the risk of designing an ethical code resting only on Western values and principles.[70]

- ***Defining AI quality standards***, including the necessary levels of transparency for algorithmic processes, as well as obligations for private and public entities using AI-powered technologies to ensure the absence of bias. Principles such as the need for AI to be **'lawful by design'** should be promoted, so that the respect of laws is embedded in AI technologies such as algorithms when they are designed by developers.[71] 'Lawful by design' algorithms would overcome an intrinsic problem of machine learning and neural networks technologies, particularly where these are able to 'learn' and evolve by themselves and often escape the control of their initial creators. Standards should also embed a **'human in the loop'** principle in new AI technologies so that they are conceived to augment human abilities – not to fully substitute them but rather to complement them. A 'human in the loop' principle would include periodic tests and retraining to ensure that humans would still be able to perform the task in question in case of a technology breakdown.

- ***Enforcement.*** The EU should be empowered with the necessary tools to effectively enforce the quality standards it defines on AI. Mechanisms should be developed to determine when technologies deviate from those standards and to verify that requirements are met at the moment of deployment and launch. There should be a public reporting of identified violations of quality standards. Where appropriate, identified potential infringements of applicable regulations – such as privacy, consumer protection, or competition laws – should be redirected to the relevant enforcing authority.

Military applications of Artificial Intelligence

Advances in the fields of Artificial Intelligence are changing the face of defence and warfare. Robots with autonomous weapons capabilities have been deployed in the Korean Demilitarized Zone, for example, and the US and China are currently in the lead in developing these weapon systems. But many see the prospect of autonomous lethal weapons or killer robots with great concern.

In August 2017, Elon Musk and Alphabet's Mustafa Suleyman led an initiative of 116 world's leading robotics and artificial pioneers to call for a ban of the development and use of killer robots. Stuart Russell, founder and Vice-President of Bayesian Logic, commented: 'Unless people want to see new weapons of mass destruction – in the form of vast swarms of lethal microdrones – spreading around the world, it's imperative to step up and support the United Nations' efforts to create a treaty banning lethal autonomous weapons'. A similar initiative is the Campaign to Stop Killer Robots (https://www.stopkillerrobots.org), which is supported by a number of non-profit organisations. However, on balance, these efforts to are too marginal given the formidable threat that AI-powered weapons systems pose.

That is why it is urgent for the European Union to take the lead in an international multilateral discussion around the use of Artificial Intelligence for military purposes, and to promote global solutions, including blanket bans. For a vivid illustration of the potentially destructive power of lethal drones, watch this video http://autonomousweapons.org/slaughterbots/.

- ***Leading global multilateral initiatives***. Finally, the EU should take on a leading role in fostering a consistent approach to the definition of fundamental principles in AI development at global level by prompting and engaging in a multilateral dialogue with other jurisdictions. For example, it should herald the drafting of an **AI Charter**, which would include principles such as limiting the development and sale of AI technologies for use by oppressive regimes or for potential violation of human rights, and a ban of the use of AI for the deployment of automated lethal weapons.

Conclusions

The European Union needs a fully-fledged and ambitious Artificial Intelligence strategy. This is necessary because machine learning is particularly important for Europe given its strong industrial base. Losing the global race for AI leadership would likely have a detrimental effect on European manufacturing, and thus on jobs, growth and innovation. At the same time, ethical concerns weigh high and quite naturally fall within the remit of Europe as the EU can rightfully consider itself the only global jurisdiction that enjoys the trust and regulatory prowess to help steer technology into human-centric and consumer-empowered directions.

The stakes are high, but so are the opportunities if Europe manages this next wave of technological advancement which will quite literally merge the physical with the digital world.

Notes

1. Nilsson, N. J., 'The quest for artificial intelligence', in Cambridge University Press, 2009.
2. Ng, L. S. A., 'Why AI is the new electricity', in Nikkei Asian Review Online, 27 October 2016.
3. Bitvore Corporation, Applications of Material Intelligence. See https://bitvore.com/competitive-intelligence-gathering/.
4. Gartner, 'Top 10 Strategic Predictions for 2017 and Beyond. The Storm Winds of Digital Disruption', October 2016.
5. International Data Corporation (IDC), 'Worldwide Semiannual Cognitive /Artificial Intelligence Systems Spending Guide', October 2016.
6. PwC, 'Sizing the prize – What's the real value of AI for your business and how can you capitalise?', June 2017.
7. Accenture, 'Why Artificial Intelligence is the Future of Growth', June 2016.
8. European Political Strategy Centre, 'Enter the data economy', 11 January 2017.
9. Venture Scanner, 'Artificial Intelligence Startup Highlights', Q4 2017.
10. CB Insights, 'The Race for AI: Google, Baidu, Intel, Apple in a Rush to Grab Artificial Intelligence Startups', July 2017.
11. MIT, 'Using Artificial Intelligence to improve early breast cancer', October 2017.
12. Artificial Intelligence for Digital Response. See http://aidr.qcri.org/.
13. BBC News, 'What a Facebook experiment did to news in Cambodia', 31 Octoer 2017, explains the power of social media as publishers and businesses, using the example of Facebook's 'Explore' experience, whereby six countries had their posts restricted to the Explore Feed unless they paid a fee to appear in the general timeline.
14. The State Council of The People' s Republic of China, 'Guidelines on Artificial Intelligence Development', July 2017.
15. Government of Singapore, Prime Minister's Office, Singapore AI Strategy (AI.SG), National Research Foundation 'Artificial Intelligence R&D Programme', October 2017.
16. Government of Japan, 'AI Research Centre'.
17. Zastrow, M. (2016). South Korea's Nobel Dream. Nature, 534(7605), 19-22.
18. MIT Technology Review, 'China has a new three year plan to rule AI', 15 December 2017.
19. Government of Canada, Canadian Institute for Advanced Research, 'Pan-Canadian Artificial Strategy', March 2017.
20. Executive Office of the President, National Science and Technology Council Committee on Technology, 'Preparing for the Future of Artificial Intelligence', October 2016.
21. Republique Française, '#FranceIA: the national artificial intelligence strategy is underway'', 26 January 2017.
22. European Commission, 'Europe's Digital Progress Report', 2017.
23. Organisation for Economic Cooperation and Development, Data-Driven Innovation, 'Big Data for Growth and Well-Being, October 2015.
24. Deloitte, 'The smart factory: responsive, adaptive, connected manufacturing', August 2017.
25. McKinsey&Company: 'Car data: paving the way to value-creating mobility - Perspectives on a new automotive business model', March 2016.
26. McKinsey Global Institute, briefing note prepared for the EU Leaders Tallinn Digital Summit, '10 imperatives for Europe in the age of AI and automation', September 2017.

27. The Economist, Wuzhen Institute, 'China may match or beat America in Artificial Intelligence', July 2017. See https://www.economist.com/news/business/21725018-its-deep-pool-data-may-let-it-lead-artificial-intelligence-china-may-match-or-beat-america.
28. Organisation for Economic Cooperation and Development (OECD), Science, Technology and Industry Scoreboard 2017, 'The Digital Transformation', 2017.
29. Wired, 'Europe is leading the way in Artificial Intelligence and Machine Learning'. See http://www.wired.co.uk/article/deep-tech-europe-hubs.
30. McKinsey Global Institute, '10 imperatives for Europe in the age of AI and automation', September 2017 , and 'Europe's economy: Three pathways to rebuilding trust and sustaining momentum', January 2018.
31. Shanghai News, 'Shanghai will be at the heart of China's artificial intelligence'. See further: http://www.shanghai.gov.cn/shanghai/node27118/node27818/u22ai87316.html.
32. Reiner, B. & Siegel, E., 'Radiology reporting: returning to our image-centric roots', in American Journal of Roentgenology, 187(5), 1151-1155, 2006.
33. European Commission, 'Stronger protection, new opportunities – Commission guidance on the direct application of the GDPR Regulation as of 25 May 2018', January 2018.
34. GOFAIR Initiative, 'A bottom-up international approach', see https://www.go-fair.org/.
35. Information Commissioner's Office (UK ICO), 'Big data, artificial intelligence, machine learning and data protection', September 2017.
36. Wired, 'What we can learn from the epic failure of Google flu trends'. See https://www.wired.com/2015/10/can-learn-epic-failure-google-flu-trends/.
37. Techcrunch, 'Facebook to roll out global privacy settings hub – thanks to GDPR'. See https://techcrunch.com/2018/01/24/facebook-to-roll-out-global-privacy-settings-hub-thanks-to-gdpr/.
38. Pew Research Center, 'Americans and Cybersecurity'. See http://www.pewinternet.org/2017/01/26/americans-and-cybersecurity/.
39. AI Now Institute, 'AI Now Report', November 2017.
40. Atlassian, 'State of Diversity Report 2017', March 2017.
41. World Economic Forum, 'White Paper – Digital Transformation of Industries', January 2016.
42. For example, see Techcrunch on Facebook's failure to enforce anti-discriminatory policy https://techcrunch.com/2017/11/22/facebooks-ad-system-shown-failing-to-enforce-its-own-anti-discriminatory-policy/?utm_medium=TCnewsletter.
43. The Inquirer, 'Google's AI is already associating ethnic minorities with negative sentiment'. See https://www.theinquirer.net/inquirer/news/3019938/googles-ai-is-already-associating-ethnic-minorities-with-negative-sentiment.
44. The Verge, 'Twitter taught Microsoft's AI chatbot to be a racist asshole in less than a day'. See https://www.theverge.com/2016/3/24/11297050/tay-microsoft-chatbot-racist.
45. Smith, B., 'The Future Computed: Artificial Intelligence and its role in society', 2018, https://blogs.microsoft.com/blog/2018/01/17/future-computed-artificial-intelligence-role-society/
46. AI Now Institute, 'AI Now Report', November 2017.
47. 'European Commission, Communication on Building a European Data Economy, January 2017.
48. 'European Commission, 'Regulation on the Free Flow of non-personal Data', September 2017.
49. Inria Saclay– Île-de-France Research Centre, 'Marc Schoenauer to work with Cédric Villani to define an AI strategy for France'. See https://www.inria.fr/en/centre/saclay/news/marc-schoenauer-to-work-with-cedric-villani-to-define-an-ai-strategy-for-france.
50. Federal Government of Germany, Federal Ministry for Economic Affairs and Energy, the Federal Ministry of the Interior and the Federal Ministry of Transport and Digital Infrastructure Ministry for Economic Affairs and Energy of Germany, 'Digital Agenda'.
51. European Commission, 'Legislative priorities for 2018-2019', 14 December 2017.
52. Industrial Data Space Association. See http://www.industrialdataspace.org/en/
53. European Commission, 'Directive establishing the European Electronic Communications', September 2016.
54. European Commission, 'EU Ministers commit to digitising Europe with high-performance computing power', March 2017.
55. European Political Strategy Centre, 'Connected-Continent for a Future-Proof Europe', July 2016.
56. European Commission, Smart Specialisation Platform. See http://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool.
57. Financial Times, 'Germany's Cyber Valley aims to become the leading Artificial Intelligence hub'. See https://www.ft.com/content/1d0b2770-7226-11e7-93ff-99f383b09ff9 & Ted Crunch 'Amazon to open visually focused Artificial Intelligence research hub in Germany'. See https://techcrunch.com/2017/10/23/amazon-to-open-visually-focused-ai-research-hub-in-germany/.
58. Of the top 100 AI research institutions, Europe has 32, the US has 30 and China has15. For a full list see Atomico' State of European Tech 2017.
59. McKinsey Discussion Paper, 'Artificial Intelligence, the Next Digital Frontier?', 2017.
60. Venture Beat, 'The biggest roadblock to Artificial Intelligence adoption is a lack of skilled workers'. See https://venturebeat.com/2017/11/04/the-biggest-roadblock-in-ai-adoption-is-a-lack-of-skilled-workers.
61. The New York Times, 'Tech giants are paying huge salaries for scarce AI talent'. See https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html.
62. European Commission, Europe's Digital Progress Report 2017, 'Human Capital: Digital Inclusion and Skills', 2017.
63. European Commission, 'A New Skills Agenda for Europe', June 2016.
64. The Guardian, 'Our minds can be hijacked'. See https://www.theguardian.com/technology/2017/oct/05/smartphone-addiction-silicon-valley-dystopia.
65. The Telegraph, 'Facebook should identify children at risk of mental health problems, Jeremy Hunt says'. See https://www.telegraph.co.uk/news/2018/02/12/facebook-should-identify-children-risk-mental-health-problems/.
66. Directive 2000/31/EC of the European Parliament and of the Council of 8 June 2000 on certain legal aspects of information society services, in particular electronic commerce, in the Internal Market ('Directive on electronic commerce').
67. European Commission, 'Shaping the Digital Single Market', March 2015.
68. Crawford, K. and R. Calo, 'There is a blind spot in AI research', in Nature, 20 October 2016, doi: 10.1038/538311a.
69. AI Now Institute, 'AI Now Report', November 2017.
70. IEEE Standards Association, 'The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems'. See https://standards.ieee.org/develop/indconn/ec/autonomous_systems.html.
71. An illustrative example could be that algorithms should be prevented from fostering collusion by helping companies to converge on same (non-competitive) price levels.

PDF: ISBN 978-92-79-81355-9 • doi:10.2872/481078 • ISSN 2467-4222 • Catalogue number: ES-AA-18-001-EN-N
HTML: ISBN 978-92-79-81356-6 • doi:10.2872/143581 • ISSN 2467-4222 • Catalogue number: ES-AA-18-001-EN-Q