BRIEFING

European Parliament

Economic impacts of artificial intelligence (AI)

SUMMARY

Artificial intelligence plays an increasingly important role in our lives and economy and is already having an impact on our world in many different ways. Worldwide competition to reap its benefits is fierce, and global leaders – the US and Asia – have emerged on the scene.

AI is seen by many as an engine of productivity and economic growth. It can increase the efficiency with which things are done and vastly improve the decision-making process by analysing large amounts of data. It can also spawn the creation of new products and services, markets and industries, thereby boosting consumer demand and generating new revenue streams.

However, AI may also have a highly disruptive effect on the economy and society. Some warn that it could lead to the creation of super firms – hubs of wealth and knowledge – that could have detrimental effects on the wider economy. It may also widen the gap between developed and developing countries, and boost the need for workers with certain skills while rendering others redundant; this latter trend could have far-reaching consequences for the labour market. Experts also warn of its potential to increase inequality, push down wages and shrink the tax base.

While these concerns remain valid, there is no consensus on whether and to what extent the related risks will materialise. They are not a given, and carefully designed policy would be able to foster the development of AI while keeping the negative effects in check. The EU has a potential to improve its standing in global competition and direct AI onto a path that benefits its economy and citizens. In order to achieve this, it first needs to agree a common strategy that would utilise its strengths and enable the pooling of Member States' resources in the most effective way.

In this Briefing

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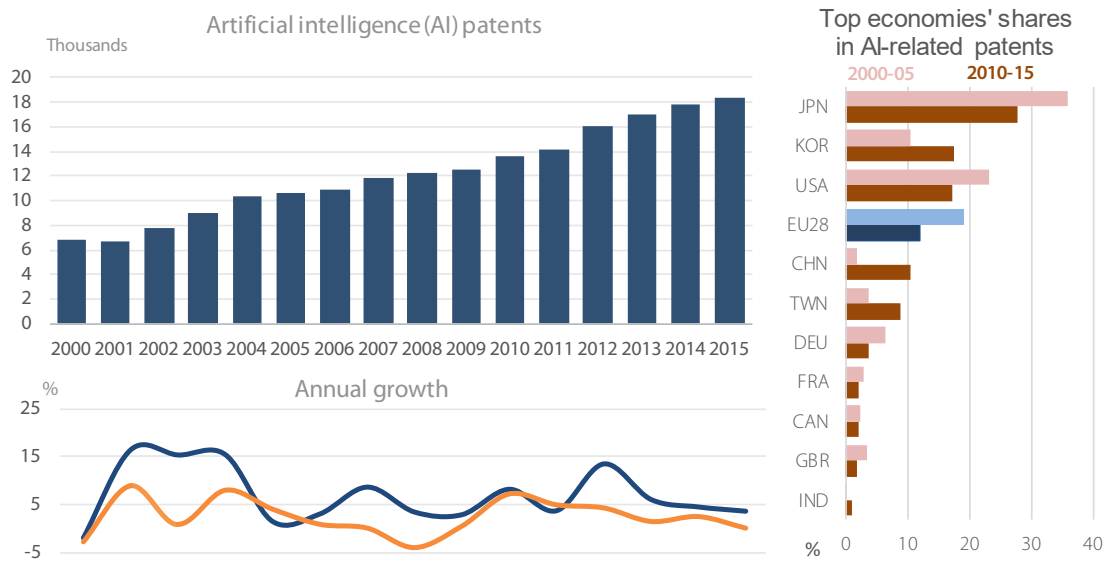
Context

Artificial intelligence (AI) is a term used to describe machines performing human-like cognitive processes such as learning, understanding, reasoning and interacting. It can take many forms, including technical infrastructure (i.e. algorithms), a part of a (production) process, or an end-user product. AI looks increasingly likely to deeply transform the way in which modern societies live and work. Already today, smartphone smart assistants, such as Siri, perform a variety of tasks for users; furthermore, all Tesla cars are connected and things that any one of them learns are shared across the entire fleet. AI also matches prices and cars when one orders an Uber ride, and curates what social media offer to a user based on their past behaviour. With the rise of AI come the important questions of how much it will affect businesses, consumers and the economy in more general terms. Employees are increasingly interested in knowing what AI means for their job and income, while businesses are also keen to find ways in which they can capitalise on the opportunities presented by this powerful phenomenon. There is a global accord that AI technologies have the potential to revolutionise production and contribute to addressing major global challenges, a view shared by organisations such as the OECD and the European Commission.

Rapidly increasing computing power and connectedness have made it possible to compile and share large volumes of valuable data, which is now more accessible than ever before. This has created momentum for AI technologies. Importantly, AI patents have been on the rise worldwide (see Figure 1), with a 6 % average yearly growth rate between 2010 and 2015, which is higher than the annual growth rate observed for other patents.

Figure 1 – AI patents worldwide, 2000-2015



Source: OECD, Science, Technology and Industry Scoreboard, 2017.

The countries at the forefront of research during this period were Japan, South Korea and the United States, which together accounted for almost two-thirds of AI-related patent applications. South Korea, China and Chinese Taipei have recorded a remarkable increase in the number of AI patents compared to their past results. EU Member States contributed 12 % of the total AI-related inventions over 2010-2015, a decrease from the 19 % recorded in the previous decade.

A 2019 report on AI by the World Intellectual Property Organization (WIPO) shows that there has been a boom in the number of scientific papers in the field since the start of the century, followed by an upsurge in patent applications between 2013 and 2016. This could indicate a switch from theoretical research to the practical application of AI technologies in commercial products and

services. The WIPO reckons that the large number of patents in machine learning shows that this is currently the main application field of AI, while deep learning (used, for example, in speech recognition) and neural networks are the fastest-growing technologies. The OECD also attributes recent progress in AI to the development of deep learning using artificial neural networks.

The WIPO report reveals that the largest number of AI-related patents is in areas such as telecommunications, transport, life- and medical sciences, and personal devices that compute human–computer interaction. Smart cities, agriculture, e-government, banking and finance are the most dynamically growing areas of application. The WIPO report also highlights the dynamic growth in the number of AI patents registered by China, pointing out that since 2014, it has recorded the highest number of first-patent filings. According to the WIPO, China, the US and Japan together account for 78 % of total AI-related-filings, while between 2000 and 2015 almost one in five AI patent families featured a European country.[1]

Some argue that in the AI race, the EU has a structural disadvantage: a lack of scale manifested by a lack of a huge homogenous pool of data, which is an essential precondition for a thriving AI ecosystem. In the EU, the level of AI uptake by companies is low, and AI-related investment and patent numbers are lagging behind the US and Asia. However, the EU has the potential to leverage its high value-added manufacturing and industry base and use its well-qualified workforce to improve its global position. It can also use its regulatory prowess and clout to become a global leader in AI governance, and use tools, such as standards, to its advantage. Some see developed EU countries, particularly northern European ones, as the inevitable winners in the global AI revolution. Taking into account the fierce global competition in AI, the European Commission maintains that a solid coordinated framework is necessary to advance European efforts in this undoubtedly promising sector, an urgency recognised by many EU Member States. It also considers AI one of the most strategic technologies of the 21st century.

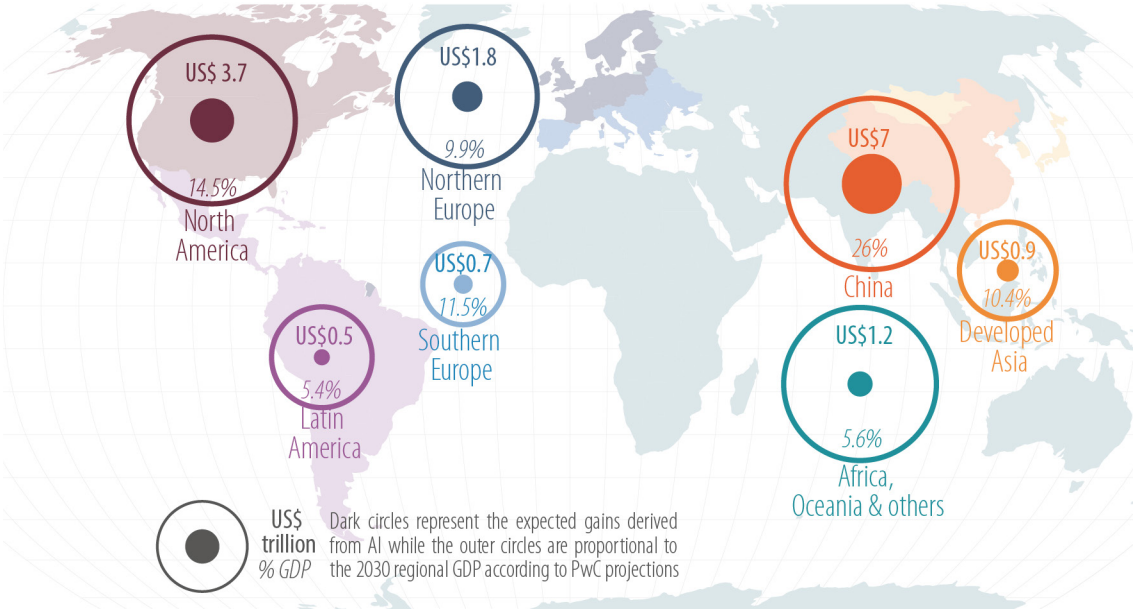
Economic potential of AI

The majority of studies emphasise that AI will have a significant economic impact. Research launched by consulting company Accenture covering 12 developed economies, which together generate more than 0.5 % of the world's economic output, forecasts that by 2035, AI could double annual global economic growth rates. AI will drive this growth in three important ways. First, it will lead to a strong increase in labour productivity (by up to 40 %) due to innovative technologies enabling more efficient workforce-related time management. Secondly, AI will create a new virtual workforce – described as 'intelligent automation' in the report – capable of solving problems and self-learning. Third, the economy will also benefit from the diffusion of innovation, which will affect different sectors and create new revenue streams.

A study by PricewaterhouseCoopers (PwC) estimates that global GDP may increase by up to 14 % (the equivalent of US$15.7 trillion) by 2030 as a result of the accelerating development and take-up of AI. The report anticipates the next wave of digital revolution to be unleashed with the help of the data generated from the Internet of Things (IoT), which is likely to be many times greater than the data generated by the current 'Internet of People'. It will boost standardisation and consequently automation, as well as enhancing the personalisation of products and services. PwC sees two main channels through which AI will impact on the global economy. The first involves AI leading to productivity gains in the near term, based on automation of routine tasks, which is likely to affect capital-intensive sectors such as manufacturing and transport. This will include extended use of technologies such as robots and autonomous vehicles. Productivity will also improve due to businesses complementing and assisting their existing workforce with AI technologies. It will require investing in software, systems and machines based on assisted, autonomous and augmented intelligence; this would not only enable the workforce to perform its tasks better and more efficiently but would also free up time allowing it to focus on more stimulating and higher value-added activities. Automation would partially remove the need for labour input, leading to productivity gains overall.

Eventually, the second channel – the availability of personalised and higher-quality AI-enhanced products and services – will become even more important, as this availability is likely to boost consumer demand that would, in turn, generate more data. Or, as PwC puts it: 'in turn, increased consumption creates a virtuous cycle of more data touchpoints and hence more data, better insights, better products and hence more consumption'. Although the benefits will be felt globally, North America and China are expected to gain the most from AI technology (see Figure 2). The former will likely introduce many productive technologies relatively soon, and the gains will be accelerated by advanced readiness for AI (of both businesses and consumers), rapid accumulation of data and increased customer insight.

Figure 2 – Expected gains from AI in the different regions of the world by 2030



Source: The macroeconomic impact of artificial intelligence, PwC, 2018.

It is likely to take more time for China to feel the full effect of AI, but this effect will eventually occur in the country's huge manufacturing sector and then move up the value chain into more sophisticated and high-tech-driven manufacturing and commerce. Europe will also experience significant economic gains from AI, while developing countries are likely to record more modest increases due to lower rates of adoption of AI technologies.[2]

The McKinsey Global Institute expects that around 70 % of companies would adopt at least one type of AI technology by 2030, while less than half of large companies would deploy the full range. McKinsey estimates that AI may deliver an additional economic output of around US$13 trillion by 2030, increasing global GDP by about 1.2 % annually. This will mainly come from substitution of labour by automation and increased innovation in products and services. On the other hand, AI is likely to create a shock in labour markets and associated costs needed to manage labour-market transitions; this shock would be incurred as an effect of negative externalities such as loss of domestic consumption due to unemployment.

A 2016 study by Analysis Group (funded by Facebook), considers that AI will have both direct and indirect positive effects on jobs, productivity and GDP. Direct effects will be generated by increased revenues and employment in firms and sectors that develop or manufacture AI technologies, which may also create entirely new economic activities. Indirect ones will come from a broader increase of productivity in sectors using AI to optimise business processes and decision-making, as well as increase their knowledge and access to information. Altogether they envisage much more modest gains (US$1.49-2.95 trillion) over the next decade.

Other sources argue that AI will have limited impact on growth, as exemplified by sectors enjoying the highest productivity growth rates, yet witnessing a decline in their overall share in the economy. Despite progress brought by AI, some areas of the economy would remain essential yet hard to improve, retaining human labour that would be well remunerated. Ultimately, this would constrain new technologies from having an impact on the overall economy. AI may even partly discourage future innovation by accelerating imitation, which would limit the return on innovation.

AI and the future of productivity

According to a well-known productivity paradox, we are experiencing low productivity in an age of accelerating technological progress. One possible explanation for this is that the diffusion of those capabilities of AI that can spur productivity remains limited. Even with their broad uptake, their full effect may only materialise with ensuing waves of complementary innovations. On the contrary, some experts say that the ICT revolution has reached maturity and that research productivity is declining sharply, having diminishing impacts on the economy. Taking into account the low rate of increase in physical and human capital, which can have a stronger effect on overall productivity compared with innovation, they foresee only a gradual evolution of productivity due to AI. According to opposing views, AI will significantly improve human capital by offering novel ways of teaching and training the workforce.

Some consider that in reality, technological progress has a much greater impact on productivity than shown by many estimates, as a result of mis-measurement. The OECD expects that through detection of patterns in enormous volumes of data, AI will significantly improve decision-making, cut costs and optimise the use of production factors and consumption of resources in every sector of the economy. Overall, it seems likely that, while AI has significant potential to boost productivity, the final effects will depend on the rate of AI diffusion across the economy and on investment in new technologies and relevant skills in the workforce.

Impact on manufacturing

AI is one of the cornerstones of the growing digitalisation of industry ('Industry 4.0'). Technologies underpinning this process – such as IoT, 5G, cloud computing, big data analytics, smart sensors, augmented reality, 3D printing and robotics – are likely to transform manufacturing into a single cyber-physical system in which digital technology, internet and production are merged in one. In the smart factories of the future, production processes would be connected and AI solutions would be fundamental in linking the machines, interfaces, and components (using, for example, visual recognition). Large amounts of data would be collected and fed into AI appliances, which would in turn optimise the manufacturing process. The OECD reckons this use of AI can be 'applied to most industrial activities from optimising multi-machine systems to enhancing industrial research'. Deployment of AI in production is likely to increase over time, due to the development of automated learning processes. Fundamentally, it is likely to boost the competitiveness of the manufacturing sector through efficiency and productivity gains enabled by data analysis, and supply chains would be based on these gains. AI would also boost automation, ensure stronger quality control of products and processes, and preventive diagnostics of machinery status, while also ensuring timely maintenance, near-zero downtime, fewer errors and defective products. Manufacturers would be able to access new markets, since their products would be more customised, varied and of higher quality. Although the building blocks already exist, Industry 4.0 may not be realised before the middle of the next decade, as it demands a combination of various technologies, which, according to some, will take 20-30 years to mainstream. The OECD forecasts that in the long-term, AI may lead to scientific breakthroughs that could even create entirely new, unforeseen industries.

Effects on firms, industries and countries

McKinsey argues that AI and automation may on one hand facilitate the rise of massively scaled organisations, and on the other will enable small players and even individuals to undertake project work that is now mostly performed by bigger companies. This could spawn the emergence of very small and very large firms, the end result being a barbell-shaped economy in which mid-sized

companies lose out. Other likely effects are increased competition, firms entering new areas outside their previous core business, and a deepening divide between technological leaders and laggards in every sector. 'Early adopters', that is, companies that fully absorb AI tools over the next five to seven years, will most probably benefit disproportionately. At the other end of the spectrum would be the slow adopters or non-adopters, which are likely to experience some economic decline. The market share is likely to shift from the laggards to the front-runners, which would be able to gradually attract more and more of the profit pool of their industry. This would lead to a 'winner-takes all' phenomenon, similar to what is currently observed on tech markets. Advances in AI and technology could enable front-runners to make a decisive break from the pack and become 'superstars' enjoying the highest productivity levels. This can have significant consequences. For example, the OECD has raised the question as to why apparently non-rival technologies are not diffused to all firms. It may well be that the widening productivity gap between firms can be attributed to the highly uneven process of technological diffusion, which favours global frontier firms over laggards. This may occur because global frontier firms can better protect their advantages; this could eventually even contribute to a slowdown in aggregate productivity growth in the economy. These widening productivity and innovation gaps are surely going to attract a lively policy debate on the unequal distribution of the benefits of AI.

In this context, it is useful to look at the industries that are moving to the forefront of AI deployment. McKinsey sees AI as already having a significant impact and great commercial potential in sectors such as marketing and sales, supply chain management, logistics and manufacturing. A 2018 survey by the Boston Consulting Group points to the transport, logistics, automotive and technology sectors as already being at the forefront of AI adoption. It also reveals that process industries (such as chemicals) are lagging behind. PwC expects that thanks to AI all sectors of the economy will see a gain of at least 10 % by 2030. The report says that the services industry is to gain the most (21 %), with retail and wholesale trade as well as accommodation and food services also expected to see a large boost (15 %).

Current AI adoption levels across the world vary, making it possible that the gap between advanced and lagging countries will widen. AI front-runners, located mostly in developed countries, are likely to increase their lead over their counterparts in developing countries. This potential effect is likely to be compounded by the fact that high wages in developed economies create a stronger incentive to substitute labour with AI than in lower-wage economies. Moreover, AI may make it economical for some manufacturers to bring back production from poorer countries.[3]

AI impact on labour markets and redistributive effects of AI

If indeed technologies, such as AI, robotics and automation, are widely deployed across the economy, there will be job creation (as a result of demand in sectors that arise or flourish due to this deployment), as well as job destruction (replacement of humans by technology). As a 2018 meta-study of results shows, there is no consensus among experts, with predictions ranging 'from optimistic to devastating, differing by tens of millions of jobs even when comparing similar time frames'.[4] A forecast by think-tank Bruegel warns that as many as 54 % of jobs in the EU face the probability or risk of computerisation within 20 years. The effect is likely to be more nuanced, and there seems to be a consensus among researchers that there will be significant workforce shifts across sectors of the economy, accompanied by changes in the nature and content of jobs, which would require reskilling.[5] Furthermore, job polarisation is probable: lower-paid jobs that typically require routine manual and cognitive skills stand the highest risk of being replaced by AI and automation, while well-paid skilled jobs that typically require non-routine cognitive skills will be in higher demand. Studying the patterns of previous industrial revolutions indicates that job destruction will be stronger in the short and possibly medium term, while job creation will prevail in the longer term. Nonetheless, labour relations may alter, with more frequent job changes and a rise in precarious work, self-employment and contract work, which would possibly weaken workers' rights as well as the role of trade unions.

The disruptive effects of AI may also influence wages, income distribution and economic inequality. Rising demand for high-skilled workers capable of using AI could push their wages up, while many others may face a wage squeeze or unemployment. This could affect even mid-skilled workers, whose wages may be pushed down by the fact that high-skill workers are not only more productive than them thanks to the use of AI, but are also able to complete more tasks. The changes in demand for labour could therefore worsen overall income distribution by affecting overall wages. Much will depend on the pace, with faster change likely to create more undesirable effects due to market imperfections. Theoretically, the more AI solutions replace routine labour, the more productivity and overall income growth will rise and the more sharply inequality will increase. This may lead to a 'paradox of plenty': society would be far richer overall, but for many individuals, communities and regions, technological change would only reinforce inequalities. There are indeed fears that the current trends of shifting the distribution of national income away from labour, which leads to deeper inequality and the concentration of wealth in 'superstar' companies and sectors, will indeed only be exacerbated by AI.

On the other hand, many economists are positive, saying that it will be hardest for AI to replace the 'sensor-motor skills' required in non-standard and non-routine jobs, such as that of security staff, cleaners, gardeners and chefs. Others add that automation always has an ambiguous impact on inequality: low-skill automation always increases wage inequality, and high-skill automation always reduces it. In conclusion, it is therefore uncertain that at least over the short to medium term, the rise in inequality due to AI automation will be significant.

Taxing robots

Bill Gates is one of many who argue that robots that take somebody's job should pay taxes, so as to prevent new technologies from diminishing the public money that supports society. In 2017, the European Parliament rejected the idea of imposing a robot tax on owners to fund support for retraining of workers put out of their jobs by robots. However, if automation leads to significant falls in income tax receipts and increases the pressure on government finances (e.g. through increased welfare and retraining expenditure), such a tax may be unavoidable in the future. In 2018, South Korea, the most robotised country in the world, lowered the tax deduction on business investments in automation, a move that seems to acknowledge some experts' concerns about excessive incentivising of automation. The debate on this topic is picking up, but if a robot tax were to be introduced, some fundamental questions regarding a clear and agreed definition and the possible forms of taxation need to be answered. One possibility is to come up with an international solution that would allow such a tax to be effective in the global economy. This solution might lie along an uneasy path of imposing taxes on the digital economy – an issue that is hotly debated both internationally and at EU level.

Source: OECD, 2017.

Selected policy implications

AI has significant potential to boost economic growth and productivity, but at the same time it creates equally serious risks of job market polarisation, rising inequality, structural unemployment and emergence of new undesirable industrial structures.

EU policy needs to create the conditions necessary for nurturing the potential of AI, while considering carefully how to address the risks it involves. A recent economic paper shows that if labour income does not benefit from the economic gains generated by AI, consumption may stagnate and restrict growth, thereby having an adverse effect on the economy. Questions about distributing the gains from AI are therefore fundamental in managing its outcomes. Tax policies could help to rebalance the shift from labour to capital, and shelter vulnerable groups from socio-economic exclusion.

The European Political Strategy Centre describes the internal and external challenges the EU is facing. The former include low investment and a slow uptake of AI technologies by companies and the public sector, and the necessity to establish a regulatory framework that does not stifle technological progress, while at the same time adhering to key fundamental EU principles. The latter include fierce global competition, with other jurisdictions benefitting from structural advantages. The centre suggests that the EU should address these by developing an investment-conducive framework and becoming a leader in setting global AI quality standards. A precondition to

successfully harness the potential of AI is to develop relevant skills in education and work as well as funding research and pooling resources to deliver true EU added value. Importantly, the EU has the necessary tools, such as a powerful competition policy, to address market distortions and power asymmetries. Issues, such as responsibility and liability, security and safety of AI-driven decision-making, raise many questions that need to be addressed in the near future. While public authorities are starting to focus on AI and national AI strategies are being developed, the need for a common EU-level path becomes more urgent than ever.

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ENDNOTES

1 The report elaborates further: 'The European Patent route is mainly used by European applicants to seek protection in several countries directly from first patent filing, but also by U.S. patent applicants, whereas the PCT route is used mainly by applicants in the U.S., Japan and China (...) 15.1 percent of all the AI patent families identified in this report include a European application.' EU countries also file for PCT patents.

2 The PwC paper groups the following states as 'northern Europe': Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Sweden, the United Kingdom, Switzerland and Norway. 'Southern Europe' includes Cyprus, Greece, Hungary, Italy, Malta, Portugal, Slovakia, Slovenia, Spain, Bulgaria, Croatia, Romania, Albania, Belarus, Ukraine, the rest of the EFTA countries and the rest of eastern Europe.

3 McKinsey estimates that leading AI countries could capture an additional 20-25 % in net economic benefits compared with today, while developing countries could capture only about 5-15 %. China is an important exception.

4 There are numerous factors at play that render the making of forecasts of the final effect a challenging task. For example, AI diffusion may be slow, which will limit its impact on employment. On the other hand, AI can result in product innovations that foster growth in demand, thereby creating new jobs.

5 In 31 OECD countries, 14 % of jobs are at high risk of automation, while a further 32 % will change significantly.

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