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AI, automation and the Future of Work:The EU digital strategy, job polarisation and skill-biased technological change

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Abstract: According to OECD estimates, 14% of jobs are currently at risk of being automated while 32% will face substantial changes in the ways in which they are carried out. This essay aims at breaking down the technologies and trends which are characterising the rise of white-collar automation, taking into consideration the acceleration which will result from the geopolitical importance gained by these innovation as well as from market incentives. This essay will start by outlining theoretical framework behind the study of white-collar automation. It will consider different perspectives on this phenomenon, aiming at establishing a comprehensive framework to reason on its themes and principles. Then, the AI and RPA implementation will be analysed, with specific attention devoted to the impact of the EU Digital Decade strategy on this matter. Thirdly, the paper will analyse the possible projections concerning AI implementation in economics processes, and it will explain the impact they will have on both employment, skills composition of the workforce, and inequality. Finally, policy proposals which can effectively deal with this phenomenon will be briefly presented, outlining the issues and points in which future research is needed.

Keywords: Artificial Intelligence, RPA, Job Polarisation, Skill-biased Technological Change, Creative Destruction, EU Digital Strategy.

1. Background to White-Collar Automation

1.1 Technological background: AI and RPA

In the academic literature, artificial intelligence (AI) has been defined in different ways, often depending on the context in which the expression has been used. It is therefore useful to start off with a clarification of what it is here meant by AI. The term was coined by John McCarthy in 1956,[86]

[86] J. Roberts, "Thinking Intelligent Machines: The Search for Artificial Intelligence", *Distillations*, 2, 2018, p.14-23. Available:

and was then defined as "the science and engineering of making intelligent machines",[87] where "intelligence is the computational part of the ability to achieve goals in the world".[88] In other words, an AI can be defined as a machine which possess the ability to reach complex ends.[89] Due to the central role attributed to the AI's final goal, in the way here presented this technology can be regarded as an artificial goal-seeking entity. In fact, especially today, the development of artificially intelligent algorithms starts from three main considerations: (i) the nature of the environment in which the AI will be embedded; (ii) the ways in which it will be connected to the environment; (iii) a final goal.[90] Based on these considerations, the algorithm is then trained on large pool of high-quality, relevant data, learning how to predict, analyse, and intervene in complex systems[91] in a way which optimises the chances of achieving its goal.[92] To put it another way, through techniques such as machine learning, the AI develops a statistical model of the environment in which it is embedded and figures out the best way to fulfil its aim.

Another technology which is playing an increasingly important role in the current technological transformation is robotic process automation (RPA), a technology which automatically carries out a series of steps which make up a task. They cover everything from data-entry robots to verification and validation robots, to scheduled RPA,[93] and are characterised by the assurance to always complete the process and, at least in their most basic form, by the inability to adapt to different environments.[94] Contrarily AI, RPA requires a well-defined and well-documented sequence of steps in order to be implemented. While AI relies on a statistical model to achieve its final goal, RPA do not leave any space for error, and precisely follow the procedure as it was originally outlined. They do not have any ability to adapt to different environmental conditions, nor to deviate from the instructions they receive. Everything is well-defined and well-documented, yielding the mathematical certainty to complete a task.[9] This is a crucial difference between the two technologies, which makes them impact automation on different skill-levels.

Before moving on, three aspects must be underlined. First, AI technology enables machines to break human cognitive monopoly. In recent years, AI skills have increasingly improved and came to match

https://web.archive.org/web/20180819152455/https://www.sciencehistory.org/distillations/magazine/thinking-machines-the-search-for-artificial-intelligence (Accessed November 2021)

[87] J. McCarthy, *What is Artificial Intelligence?*, Stanford, 2007, p. 2. Available: http://jmc.stanford.edu/articles/whatisai.html (Accessed November 2021)

[88] R.S. Sutton, "John McCarthy's Definition of Intelligence", *Journal of Artificial General Intelligence*, p. 66-67, 11(2), 2020.

[89] M. Tegmark, *Vita 3.0. Essere umani nell'era dell'intelligenza artificiale*, Milano, Raffaello Cortina Editore, 2018, p. 75-82.

[90] S. Russell, *Human Compatible. AI and the problem of control*, New York, NY, Penguin, 2020, p. 42-43.

[91] First-hand interview with Paolo Climaco – AI researcher and PhD candidate at the University of Bönn.

[92] S. Russel, P. Norvig, *Artificial Intelligence, A Modern Approach, Second Edition*, Hoboken, NJ: Prentice Hall, Pearson, 2003, ch. 2.

[93] R. T. Yarlagadda, "The RPA and AI automation", *International Journal of Creative Research Thoughts,* p. 365-373, 6, September 2018.

[94] First-hand interview with Paolo Climaco – AI researcher and PhD candidate at the University of Bönn.

– or in some cases surpass – humans in tasks of acquiring, managing, and manipulating information.[95] AI is already better than humans at tasks which involve pattern-recognition, search and retrieve of information, and optimisation. Moreover, innovations in fields such as natural language processing are increasingly expanding the areas in which AI technology can be reliably implemented. This opens up to automation a class of workers which was shielded from it thanks to the human exclusivity of cognitive thinking and social actions. Second, however good, AI fails to be applied in those processes which imply the use of shared intelligence.[96] In fact, in the absence of an efficient recognition and awareness of the existence of other forms of intelligence, AI fails to develop a common sense or even a moral or ethical attitude.[97] It is precisely this aspect which makes processes such as reading and summarising a book not (yet) automatible. Third, RPA and AI enable companies to overcome the challenge of human intelligence scalability.[98] In fact, all those [repetitive] tasks which required the presence and knowledge of a person can now be automated, boosting efficiency, speed, accountability and reducing operational cost. RPAs can work 24/7, 365 days a year with little to no human effort, and only need access to electricity to keep running.[99] In other words, human workers now face a zero-wage competition from thinking computers.

1.2 Economics Background: Creative Destruction and the Great Decoupling

Since the first industrial revolution the process of technological innovation, as presented by Joseph Schumpeter, has been characterised by subsequent shocks to the economic equilibrium. What this means is that, whenever a game-changing technology was introduced, it created the conditions needed to induce a change in the economic status quo.[100] To put it simply, innovations induce an increase in the level of economic activity in terms of increased productivity, creating favourable climate conditions for economic growth. Credit expands, prices and incomes rise, and prosperity prevails – fuelled by borrowing – until the deflationary pressure from the rising debts brings the economic boom back to a new steady state.

Here, there are two important factors to underline. First, in this framework, technological innovation brings about a process of creative destruction.[101] Existing industrial structures are destroyed or invigorated as part of the dynamics of economic development. The consequence might be obvious: those industries which are able to change remain competitive in the economy, while those which are

[95] R. Baldwin, *The Globotics Upheaval: Globalisation, Robotics and the Future of Work*, London, Weidenfeld & Nicolson, 2019, p. 153-160.
[96] First-hand interview with Paolo Climaco – AI researcher and PhD candidate at the University of Bönn.
[97] For example, see: W. Knight, "This Program Can Give AI a Sense of Ethics—Sometimes", *Wired*, New York, NY, Condé Waste, 2021. Available: https://www.wired.com/story/program-give-ai-ethics-sometimes/ (Accessed December 2021).
[98] E. Siegel, "Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die", Washington, Wiley, 2016.
[99] R. T. Yarlagadda, *op. cit.*, p.370-371.
[100] I. Musi (a cura di), *Teorie dello Sviluppo Economico*, Torino, Petrini editore, 1985, p.100-106.
[101] J.A. Schumpeter, *Capitalism, Socialism and Democracy,* London, Routledge, 1994 [1942], pp. 82–83.

unable to do so do not and eventually die out. Let's look at an historical example to see how this looks in practice. In the 1970s-80s, the technological innovation of the computer-on-a-chip created the opportunity to drastically reduce costs of production, giving rise to the ICT revolution. Applying chips to machines meant that parts of the production could be automated and work with little to no human supervision. Moreover, the ICT revolution brought about the reduction of communication costs – and hence the cost of moving ideas and of managing economic life – which meant that most industrial production could be off-shored and manufactured in low-wage countries.[102] These two factors created a shift of the [western] workforce from industry to services, from things to thoughts, from working with the hands to working with the head. In Western Europe, the share of employment in service jobs grew from 46.9% in 1970 to 70.9% in 2000, while that in manufacturing fell from 44.6% to 24.5% in the same time span.[103] On the other hand, the two sectors' shares of value added at constant prices in Western Europe changed drastically. From 57.8% in 1970, the service sector came to contribute about 68% in 2000, while the share of manufacturing declined from 39.7% to 29.9% in the same period.[104] It was a restructuring of the economy around the innovations which disturbed the equilibrium in the first place, in this case, the ICT. This has important implications for the arguments hereby presented as technological innovation of RPA and AI technology have made redesigning industrial processes necessary for firms to stay competitive.

The second thing to be emphasised is that economic growth – fuelled by better machines, better workers, and higher aggregate efficiency – rely on innovations to improve these three factors.[105] A period of economic boom is accompanied by an increase in productivity brought about by innovation. This is especially true in the case of advancements in industry organisation, processes, and methods,[106] as well as the discovery of new raw or semi-processed materials – which can include new sources of energy.[107] New technologies and practices in all these areas dramatically increase productivity, reducing costs of production. In fact, from an historical analysis of these trends, it emerges that wages and productivity have all grown at similar rates starting from the first industrial revolution.[108] The same has been true for employment, which has followed a similar growth pattern to that of productivity and wages.[109] However, studies have shown that in the case of the third and

[102] R. Baldwin, *op.cit.*, p. 87-145.
[103] S. Houpt, P. Lains, L. Chön, "Sectoral Developments, 1945-2000", in *The Cambridge Economic History of Modern Europe: 1870 to the Present*, 333-359, ed. by S. Broadberry and K.H. O'Rourke, Cambridge, Cambridge University Press, 2010, p. 346.
[104] S. Houpt, P. Lains, L. Chön, *op. cit.*, p. 346-347.
[105] J. Rifkin, *The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy and the World*, New York, NY, Palgrave McMillan, 2011, p. 7-12.
[106] A great example of this is the revolutionary assembly line introduced by Ford.
[107] I. Musi (a cura di), *op.cit*, p.103.
[108] Economic Policy Institute, "The Productivity-Pay Gap," Economic Policy Institute, August 2021. [Online]. Available: https://www.epi.org/productivity-pay-gap/. (Accessed November 2021).
[109] Brynjolfsson, Erik; McAfee Andrew; Raman, Anand (2015). "The Great Decoupling". *Harvard Business Review*. Available: https://hbsp.harvard.edu/product/R1506D-PDF-ENG?recommendedBy=R1704G-PDF-ENG (Accessed November 2021)

especially in the fourth industrial revolution, we are starting to see a decoupling of the productivity and wage rate curves,[110] as well as a decoupling of employment and productivity growth.[111] In fact, between 1979 and 2020, while productivity rose 61.8%, hourly wage increased only 17.5% – meaning that the former grew approximately 3.5 times faster than the latter.[112] In much the same way, starting in the mid-90s, private employment also decoupled from productivity, stagnating at a relatively constant levels since then.[113] This means that even though the economy was expanding throughout the 1990s and 2000s – as a result of the technological innovation of the period – income and job prospects for the average worker did not follow the same trajectory. This is what Brynjolfsson and McAfee refer to as the great decoupling.[114]

It must be understood that the changes treated in this section have not resulted solely from technological innovation. Other factors, such as deregulation and other policy changes, have also influenced these processes. Nevertheless, a comprehensive analysis lies beyond the scope of this essay and is not to be conducted here. This section wants to give the reader an introduction to the general economic changes which have accompanied the technological transitions of the third industrial revolution – which, in the absence of effective policies, will most likely be carried on during the fourth industrial revolution.

2. RPA and AI Development and Implementation: forces and trends

In the post-Covid era, the economic and business environment changed drastically. In the past couple of years, more and more firms have accelerated a transition towards innovative and digitally oriented strategies in order to stay competitive in the market.[115] A McKensey Global Survey of executives, run in July 2020, showed that the rate of digital adoption in different areas of business interaction has drastically increased since the beginning of the pandemic. As a result, firms have experienced a net change in digital adoption which, under pre-pandemic reported pace of change, would have taken up to seven years to complete.[116] About 50% of respondents see the adoption of artificial intelligence

[110] Economic Policy Institute, *op. cit.*
[111] E. Brynjolfsson, A. McAfee, "Jobs, Productivity and the Great Decoupling", *The New York Times*, December 11, 2012. Available: https://www.nytimes.com/2012/12/12/opinion/global/jobs-productivity-and-the-great-decoupling.html (Accessed November 2021).
[112] Economic Policy Institute, *op. cit.*
[113] E. Brynjolfsson, A. McAfee, A Raman, "The Great Decoupling", *Harvard Business Review,* June-July, 2016, p. 1-11
Available: https://hbsp.harvard.edu/product/R1506D-PDF-ENG?recommendedBy=R1704G-PDF-ENG (Accessed November 2021).
[114] E. Brynjolfsson, A. McAfee, A Raman, *op.cit.*
[115] S. Blackburn, L. LaBerge, C. O'Toole, J. Schneider, *Digital Strategy in a Period of Crisis*, McKinsey, 2020. Available: https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/digital-strategy-in-a-time-of-crisis (Accessed November 2021).
[116] McKinsey, "How COVID-19 has pushed companies over the technology tipping point—and transformed business forever", *McKinsey Global Survey of executives*, McKinsey, October 5, 2020, p. 2. Available: https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever (Accessed November 2021).

and advanced technologies in decision-making and process automation to stick even after the recovery. This is because the pandemic has brought about a paradigm shift in the way in which companies see technological implementation. In fact, compared to the 50% in the 2017 McKesey Global Survey,[117] after the pandemic only 10% of executives see technology as a mere cost savings strategy.[118] They have shifted to see technology investments as granting a competitive advantage, in some cases leading to restructuring their businesses around digital technologies – AI and RPA play increasingly important roles in this process.

Automatic Processing evaluation is also expected to rise at a growth rate of 40% annually between 2018 and 2026.[119] Due to the RPA's low cost, high efficiency and positive impact on competitiveness, this exponential growth is not expected to stop anytime soon.[120] [121] AI, RPA and digital innovation is expected to increase productivity by 11-37% by 2035,[122] and, from a business point of view, it does not make sense for companies to miss out on this enhancement of their productive processes. These technologies enable them to automate low-value tasks, therefore freeing crucial resources for high-value ones.

Take Poppy, for instance, an AI powered RPA employed by Xchanging that helps insurance brokers at Lloyd's comply with post-2008 financial regulation – validating and reading London Premium Advice Notices (LPANs).[123] This is what can be called a knowledge assembly line job,[124] namely a routine knowledge work which can easily be automated – sometimes with the help of a little AI. Starting from standardised template containing premium data (created by a human), Poppy carries out the same tasks previously done by multiple people, doing so in a shorter about of time (hours instead of days). Employing of Poppy meant that less resources had to go towards the validation and

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[117] McKinsey, "How digital reinventors are pulling away from the pack", *McKinsey Global Survey on digital strategy*, McKinsey, October 27, 2017. Available: https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/how-digital-reinventors-are-pulling-away-from-the-pack (Accessed November 2021).
[118] McKinsey, "How COVID-19 has pushed companies over the technology tipping point—and transformed business forever", *McKinsey Global Survey of executives*, McKinsey, October 5, 2020, p. 8. Available: https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever (Accessed November 2021).
[119] Transparency Market Research, *Businesses In Robotic Automation Market Speed Up Implementation, Integrating Platforms With Machine Learning To Up The Ante For Incumbents*, Transparency Market Research, 2018. Available: https://www.transparencymarketresearch.com/pressrelease/it-robotic-automation-market.htm (Accessed November 2021).
[120] Transparency Market Research, *Robotic Process Automation (RPA) Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2017 - 2025*, Transparency Market Research, 2021. Available: https://www.transparencymarketresearch.com/robotic-process-automation-market.html (Accessed November 2021).
[121] R. Baldwin, *op. cit.*, p. 148-151
[122] J. Eager et al., *Opportunities of Artificial Intelligence*, Study for the committee on Industry, Research and Energy, Policy Department for Economic, Scientific and Quality of Life Policies, Luxembourg, European Parliament, 2020, p. 9. Available: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/652713/IPOL_STU(2020)652713_EN.pdf (Accessed November 2021).
[123] L. Wilcocks, M. Lacity, A. Craig, "Robotic Process Automation ai Wchanging", *Outsourcing Unit Working Research Paper Series*, 15/03, London School of Economics and Political Science, June 2015, p. 12.
[124] R. Baldwin, *op. cit.*, p. 103

creation of LPANs, and more could go to other higher-value tasks such as R&D. Moreover, it has the further advantages of being able to adapt to different workloads almost instantaneously,[125] to be more consistent, and to leave a digital trail which makes regulatory reporting faster and more accurate.[126]

From a technical point of view, the implementation of AI and RPA in SMEs is not a problem. The capital intensity of AI technology lies in the development rather than in the implementation process. Nowadays, specialised companies employ highly specialised personnel – i.e., human capital – and powerful computers which can process the data to train the system – i.e., physical capital. Nevertheless, once they have been developed sophisticated AI systems easily run on regular smartphones and can be used by virtually everybody.[127] This has two main implications. First, the relative absence high capital investments in AI implementation means that virtually every SME, with access to a computer can acquire and implement these systems in their production process. Second, it also means that the development of AI algorithms is mainly carried out in those companies which have both the human and the physical capital to do so. The latter aspect can have consequences on the concentration of [market] power regarding this technology, but, as a matter of relevance, these will not be discussed here.

In addition, over the past decades, AI has assumed a rising geopolitical relevance and has the potential to reshape the balances of power on the international stage. In 2017, Russian president Vladimir Putin expressed his view on the subject, stating that "*Artificial intelligence is the future, not only for Russia, but for all humankind. […] Whoever becomes the leader in this sphere will become the ruler of the world*".[128] Resulting from this epiphany, regional and national governments are also starting to develop strategies to foster AI development and implementation, which will have a substantial impact on future trends of AI implementation in the private sector. A clear example is that of China which recognised the central role of new technologies in geopolitics in 2013, and has put forward the Next Generation AI Development Plan in 2017, with the aim of making the country the global leader in AI.[129] In Europe this kind of initiative can be seen in the EU digital decade, which is the focus of the next section.

2.1 The EU Digital Decade: AI strategy

[125] L. Wilcocks, M. Lacity, A. Craig, *op. cit.*, p. 12-14.
[126] R. Baldwin, *op. cit.*, p. 149.
[127] First-hand interview with Paolo Climaco – AI researcher and PhD candidate at the University of Bönn.
[128] J. Vincent, "Putin says the nation that leads in AI 'will be the ruler of the world'", *The Verge*, September 4, 2017. Available: https://www.theverge.com/2017/9/4/16251226/russia-ai-putin-rule-the-world Accessed June 2021.
[129] P. Mozur, "Beijing Wants A.I. to Be Made in China by 2030", *The New York Times*, July 20, 2017. Available: https://www.nytimes.com/2017/07/20/business/china-artificial-intelligence.html (Accessed November 2021).

In March 2021 the European Commission presented its strategy for the digital transformation of the European Union. It evolves around four main pillars: skills, governments, infrastructure, and business – each of which has specific targets in different technologies.[130] Due to space constraints, these will not be analysed here. Rather, as a matter of relevancy, the focus will lie on the business pillar, and particularly on the AI and Data strategy which aims at "*combin[ing Europe's] technological and industrial strengths with a high-quality digital infrastructure and a regulatory framework based on its fundamental values, to become a global leader in innovation in the data economy and its applications*".[131]

As part of the tech up-take and of the digital transformation of businesses, the Commission's aim is to have at least 75% of companies in the EU using cloud, AI, and big data by 2030. In the *Draft Report on Artificial Intelligence in a Digital Age*, they recognise the strategic and economic importance of such technology. In fact, in point 49 of such report, they state: "*AI is a game changer for the competitiveness of EU industry as it increases productivity, accelerates innovation, makes manufacturing processes and end products safer as well as more sustainable, and could help to increase the resilience of European supply chains*".[132]

This kind of transformation of industries requires massive private and public investments. If, as it has stated, the EU is to become the global AI leader, then it will need to close the huge investment gap between itself, China, and the US. In 2018, EU public investments in AI strongly rose to 3.4 billion EUR. Nevertheless, this sum pales in front of the 31 billion EUR invested by the US and the 21 billion EUR invested by China in the same year. Moreover, a gap is also present in private investment, with 12.3 billion EUR in the US, 4.8 billion EUR in China, and 1.2 billion EUR in the EU.[133] Moreover, in 2018, the number of AI start-ups – a parameter regarded as a good indicator of the future dominance of AI markets – also shows a gap between the three countries. In fact, while the US retains its dominance in this category with 1,393 AI start-ups, the EU and China are much closer to each other – with the former having 402 and the latter 383. Nevertheless, here it must be underlined the fact that, contrarily to China, European start-ups most often face difficulties scaling-up, and, once they do, are very likely to be acquired by large tech corporations based in the US.[134] Improvements in this area mean fostering financial and regulatory certainty, especially through stricter intellectual property laws which grant a clearer and more predictable AI framework in the region. The EU plans to improve both these aspects.[135]

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[130] European Commission, *EU digital compass*, Brussels, 2020.
Available: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en (Accessed November 2021)

[131] European Commission, *White Paper on Artificial Intelligence: A European approach to excellence and trust*, European Commission, Brussels, 2020, p. 1.
Available: https://ec.europa.eu/info/sites/default/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf (Accessed November 2021)

[132] A. Voss (Repporteur), *Draft Report on artificial intelligence in a digital age (2020/2266(INI))*, Special Committee on Artificial Intelligence in a Digital Age, European Parliament, 2021, p. 15.

[133] *Ibidem*, p. 22.

[134] *Ibidem*, p. 16.

[135] *Ibidem*, p. 20-29.

Secondly, as they stated in the *White Paper on Artificial Intelligence*, the strategy for data is crucial to the AI one.[136] As explained in section one, high-quality, relevant data plays an important role in the training of the intelligent system. The algorithm's ability to analyse, predict and strategically intervene in complex systems ultimately depends on which data it is being fed. As AI products rapidly move from pattern recognition and insight generation to more sophisticated techniques which grant better decision-making ability, data will become ever more central in the development of this sector. Worldwide, the volume of data produced is expected to increase from 33 zettabytes in 2018 to 175 zettabytes in 2025[137] and The EU wants to strategically contain within its borders the data produced by its citizens.[138] This would enable for the creation of a common data market which can free the productive potential of the growing amount of European data, while also ensuring the respect of European values. To this aim, the Commission plans to invest heavily in "infrastructures, data-sharing tools, architectures and governance mechanisms for thriving data-sharing and Artificial Intelligence ecosystems" in the period 2021-2027,[139] therefore benefiting tall those industries which heavily rely on data use in their productive processes. It envisions a system in which common European platforms provide businesses and citizens with access to a diversified basket of cloud, data-sharing, and storage services to go along with AI applications.

Taken together, these factors show that AI implementation in the EU is not going to stop anytime soon. The overall increase in data – driven by the growth digital economy – as well as the improved access to it thanks to improvements in the digital infrastructure, depicts a scenario in which AI development – heavily depended on data – will continue to grow. Moreover, AI leadership is considered as a critical strategic goal for the European standing in the global economy and international system. It can therefore be expected that the use and development of artificial intelligence will take up more and more space in European societies, with all the implications which this implies.

3. Impact on the Labour Market

[136] European Commission, *White Paper on Artificial Intelligence - A European approach to excellence and trust*, European Commission, Brussels, 2020, p. 2.
[137] D. Reinsel, J. Gantz, J. Rydning, *The Digitization of the World From Edge to Core*, Framingham, MA, IDC, November 2018, p. 3.
Available: https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf (Accessed November 2021).
[138] European Commission, *European data strategy: Making the EU a role model for a society empowered by data*, Brussels, European Commission, 2020.
Available: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en (Accessed November 2021).
[139] European Commission, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of Regions: A European Strategy for Data*, Brussels, European Commission February 19th 2020, p. 17.
Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0066&from=EN (Accessed November 2021).

In order to analyse the future evolution of the workforce in response to the present-day technological revolution one might be tempted to look at the past. What happened, for instance, to blue collar workers after the first wave of automation in factories? Is it going to be the same this time? There are two main points of positions on this matter: (i) scholars who argue that automation will bring about new, better jobs as it happened after the Industrial Revolution and (ii) those who are more sceptic on the matter, underlying some crucial differences between now and then, and projecting a future in which people will not only be unemployed, they will be unemployable.

3.1 The net effect on the labour market

Let's start by assessing that technological innovation is implemented in the industrial processes precisely to replace costly human labour on some kind of job or task. We shifted from the muscular powered plough to the tractor, from human to robotic assembly lines, from physically handling of cash flows though bank tellers to ATMs because it was cheaper to conduct economic activity in these ways. These innovations rendered labour obsolete and displaced people from labour intensive activities.[140] In much the same way in which the tractor replaced the muscular power plough, AI and RPA are replacing intellectual [back-office] tasks and practices usually performed by humans.

It is worth emphasising the fact that, despite these changes, we are not running out of work. In fact, the cumulative fraction of adults in paid employment has steadily risen during the past century.[141] Historical accounts of technological innovation show the net effect on employment to be mostly positive, with some shock in the short term and a growth in the longer term, resembling the process of creative destruction outlined in section 1.2. Aside from the direct jobs created by tech companies – whose net market impact can be considered negligible[142] – job growth can be justified in different ways, all of which easily follow from some basic economic theory. First, the increase in productivity following AI/RPA implementation brings to lower prices, which in means that a rise in demand will follow, and more supply will need to be created.[143] Second, while prices of basic necessities fall as a result of productivity growth, people's relative income rises, bringing increased consumption for all kinds of goods and services.[144] Third, since higher productivity and lower production costs drive cheaper prices and increase consumption, not only will the company which implemented the AI need to increase its output to meet that demand, its suppliers will do too. This creates a sort of resounding

[140] R. Baldwin, *op. cit.*, p. 54 and 59-61

[141] It has to be pointed out that looking at the demographics of this growth it arises that this trend also reflects women's entry into the labour force.
Source: F.D. Blau, A.E. Winkler, *The Economics of Women, Men, and Work*, 8th ed. New York, Oxford University Press, 2018, Table 5.1.

[142] R. Baldwin, *op. cit.*, p. 163-166.

[143] This is best exemplified by the so-called "Uber Effect". See T. Berger, C. Chen, C.B. Frey, "Drivers of disruption? Estimating the Uber effect", *European Economic Review*, Volume 110, 2018, p. 197-210.

[144] This is often referred to as the "Walmart Effect" on consumers income. See F. Charles, *The Wal-Mart Effect: How the World's Most Powerful Company Really Works – and How it's Transforming the American Economy*, London, Penguin Books, 2007.

effect which increases the need for employment in those and related industries. Finally, new jobs emerge as a direct – frontier jobs – and indirect – wealth jobs and last mile jobs – consequence of innovation.[145] Even though there is "[n]*o economic law [which] dictates that the creation of new work must equal or exceed the elimination of old work, […] history shows that they tend to evolve together*".[146]

On the other hand, automation reduces the number of people employed in existing occupations. In fact, while it will not substitute whole routine knowledge occupations, AI and RPA will massively reduce the number of people working those jobs.[147] In much the same fashion as the introduction of the tractor did not eliminate the occupation of the farmer, service sector occupations will not disappear. They will undergo heavy changes because of the introduction of AI and RPA in the corporate and production processes. The tractor made each farmer increasingly more productive – and able to take on more tasks – in a way that society just needed fewer farmers to meet the markets' demand. As more and more white-collar tasks are automated, each person will be able to produce more, less people will need to be employed, and the headcount for each occupation in which automation is taking place will diminish. The remaining workers will take on a shrinking bundle of highly valued tasks[148] complementary to those conducted to the AI. They will heavily benefit from the automation of lower-value tasks in terms of resources being shifted towards them, of increased demand, and of increased productivity.

3.2 Labour market polarisation

At this point, two interconnected aspects must be underlined. In the age of white-collar automation, jobs will shift towards tasks which are complementary rather than substitutes to AI. Following the reasoning outlined in section 1.1, these tasks can be expected to be (i) non-routine – i.e., not well-documented, not well-defined tasks; and (ii) based on some kind of shared intelligence – i.e., tasks requiring expertise, judgement, and creativity. To put it simply, while non-routine jobs complement AI, routine workers are directly substituted by zero-wage RPA and AI systems. In fact, Acemoglu and Autor (2011) show that, because of their codefiable nature, the routine tasks, no matter if cognitive or manual, are already experiencing a considerable fall in demand.[149] Furthermore, Marcolin et al. (2016) demonstrated how routine intensity is highly correlated with skill level. In fact, high routine tasks – i.e., those most at risk of being completely automated – are heavily taken up by middle-

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[145] D. Autor, *Work of the Past, Work of the Future*, Richard T. Ely Lecture, Atlanta, January 4th 2019. Available: https://www.aeaweb.org/webcasts/2019/aea-distinguished-lecture-work-of-the-past-work-of-the-future (Accessed November 2021).

[146] D. Autor et al., *The Work of the Future: Building Better Jobs in an Age of Intelligent Machines*, Cambridge, MA, Massachusetts Institute of Technology, 2020, p. 11-12.

[147] R. Baldwin, *op. cit.*, p.152.

[148] D. Autor, *The work of the future: shaping technology and institutions*, Lugano, Università della Svizzera Italiana, 2019. Available: https://www.youtube.com/watch?v=0FbFjCmZQRM (Accessed November 2021).

[149] D. Acemoglu, D. Autor, "Skills, Tasks and Technologies: Implications for Employment and Earnings", in *Handbook of Labor Economics, Volume 4b*, Amsterdam, Elsevier B.V., 2011, p. 1075-1078.

skilled workers, which account for about 51.5% of the hours spent on these tasks.[150] At the same time, high-skilled workers account for about 63% of employment in non-routine tasks and jobs – namely those which complement AI systems.[151] Therefore, due to the fact that routine and non-routine tasks are asymmetrically distributed over different skill levels, the routine-bias of technological change also implies a skill-bias. As the demand for routine tasks decreases, that for middle-skilled workers will also decrease, while that for high and low-skilled workers increases along with that for non-routine jobs complementary AI. Together, these factors paint a picture of increasing labour market polarisation – i.e., "*the simultaneous growth of high-education/high-skilled/high-wage and low-education/low-skilled/low-wage jobs at the expense of middle-skilled jobs*".[152]

Let's look at one example. In the period between 1995 and 2015, unemployment rates for people without a higher secondary or tertiary education in the EU-15 went from 12% to 16%. In the same timeframe, people with a tertiary education experienced a decrease in unemployment from 6% to about 5%.[153] The skill distribution of this change shows what this section has argued until this point, namely that the change in unemployment for middle skilled workers was negative for the same period – cumulatively losing about 4.7% of its share between 2008 and 2015. The same analysis shows that, what has been lost in terms of employment share across the middle-skilled category, has gone to increase that of the high-skilled and low-skilled jobs – especially benefiting "professionals" (+5.2%) and "service and sales workers" (+3.5%) in the 2008-2015 period. In short, between 2008 and 2015 demand for high and low-skilled jobs has increased at the expense of middle skilled jobs.

3.3 Implication for inequalities

Due to the different characteristic of the different skill levels, this picture is quite worrying from the point of view of inequality. High-skilled jobs tend to be more highly paid and highly educated. They are usually based on tasks which require creativity as well as the ability to make judgements, making them highly secure and linked to the specific person doing a job. With experience, people in this category become more and more productive, leading to a raise in their wages. By contrast, low-skilled jobs are based on a generic skillset which does not change over time. This means that, by gaining experience, workers do not become more productive in their job, and their wages remain stagnant. Moreover, since they require only a generic skillset, job security in this category is pretty much absent. Finally, middle-skilled jobs are specific to a field and skillset which is accessible by uneducated

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150 L. Marcolin, S. Miroudot, M. Squicciarini, "Routine jobs, employment and technological innovation in global value chains", *OECD Science, Technology and Industry Working Papers*, Paris, OECD Publishing, 2016, p. 22-23.

151 D. Bernhard et al., "The impact of new technologies on the labour market and the social economy", *Science and Technology Options Assessment*, Brussels, European Parliamentary Research Services Scientific Foresight Unit, 2018, p. 20.

152 D. Autor et al., *The Work of the Future: Shaping Technology and Institution*, Cambridge, MA, Massachusetts Institute of Technology, 2019, p. 22.

153 *Ibidem*, p. 16.

workers but has the characteristic of improving with experience. This means that people in these jobs see a growth in their wage over their life cycle which represents their rising skill levels, leading to more job security in this category.[154] Given the tendency of the labour market to polarise through higher demand for high and low skilled jobs – which, in turn, is a result of the recent wave of automation –, there is the chance for inequality to crystallise in the future. In other words, as the demand for jobs enabling people to climb the social and economic ladder are less and less demanded as a result of automation, those at the bottom will not have effective means to improve their economic and social situation. This means stagnant wages and low job security. In the meantime, the other demanded category of workers, the high-skilled, will keep benefiting from the increases in productivity brought about by technological innovation. To sum it up in one sentence, in the absence of effective policies, this wave of automation is creating a bimodal job-growth[155] which cuts the jobs bridging between high and low pay – crystallising economic inequality.

4. Conclusion and policy proposals

This paper has argued that job polarisation is the result of the asymmetrical impact of automation on the labour market. It has shown that this is because of the routine-based nature of the skills which make up most middle-skilled jobs which makes AI and RPA their direct substitutes. As argued, the problem does not seem to be a scarcity of jobs. Rather, given the specific characteristics of middle-skilled jobs, the reduction in their demand reduces the opportunities to climb the economic and social ladder, with the potential to crystallise inequalities.

Secondly, the essay has showed that R&D and implementation of these technologies is not slowing down. This results from the combination of market incentives (in terms of competitiveness) the strategic importance of these technologies on the international stage. It has provided an example in this regard, outlining the EU digital strategy and its relevance in fostering public and private investments in AI research and implementation. This has been helpful to give the reader a sense of the urgency to address the problem.

Finally, it might be asked, how do we effectively deal with this problem? Let's start from the assessment that there would be no logic behind stopping technological progress to save people's employability. As shown in section three, technology has the potential to create jobs, and, mainly due to the positive impact on productivity, raise the overall prosperity of society. The issues which have to be dealt with arise from the (non)alignment of demand and supply for skills, as well as in the inequality of opportunities and resources which results from the structural changes to the labour market.

[154] A.S. Modestino, "The Importance of Middle-Skill Jobs", *Issues in Science and Technology*, 33, no. 1, 2016. Available: https://issues.org/the-importance-of-middle-skill-jobs/ (Accessed December 2021).

[155] M. Goos, A. Manning, A. Salomons, "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring", *The American Economic Review*, Vol. 104, No. 8, 2509-2526, August 2014, p. 2513-2515.

Concerning the first, policies that enable skills level to grow at a pace similar to technological change seem to be the best approach to maintaining a somewhat equal distribution of opportunities. These are identified in an educational system with different points of entry, and which targets specifically the adult population.[156] Without such policies, the risk is that of ending up in a situation where labour demand and supply are misaligned – with worrying effects not only on employment but on the overall employability of the workforce. In this regard, research on how AI skills will develop – i.e., which tasks are most likely to be automated –, which skills can best complement them, and which institutional and educational structure can best implement this is needed.

Secondly, this educational structure is to be accompanied by a revision of the fiscal and tax code in such a way that the returns from investments in human capital are at least equal to those in physical one.[157] This would incentivise companies to invest in reskilling – and therefore task creation – at least as much as they invest in machineries which displace workers. Finally, as machines become ever more intelligent, and take up more and more work, further research and experiments on the debated concept of universal basic income should be carried out. It would be a way to efficiently redistribute the prosperity gains without disincentivizing people to work – and without the administrative burden of more complex subsidies programs targeted to the poor.[158]

The AI revolution is challenging the economic paradigm in a somewhat similar fashion to previous revolutionary technologies. Historically, when undergoing these structural changes, markets have always benefited some while leaving others behind. This time, the burden of innovation is mainly falling on middle-skilled workers, with the potential to crystallise social and economic inequalities. In this regard, governments must act as to ensure that their workers remain employable, and that prosperity resulting from technological advancements in AI is effectively shared.

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[156] D. Autor et a., *The Work of the Future: Shaping Technology and Institution*, Cambridge, MA, Massachusetts Institute of Technology, 2019, p. 36-40.
[157] *Ibidem*, p. 41.
[158] M. Tegmark, *op. cit.*, p.168-171.