UCL Institute of Education

The challenge of the Fourth Industrial Revolution and Artificial Intelligence: Towards a Framework of Understanding

Discussion Paper 1

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Part 1. Introduction

Up until January 2020 and the arrival of COVID-19, the world saw itself on the cusp of what has been termed the Fourth Industrial Revolution (4IR) and the emergence of an Artificial Intelligence (AI) saturated era. While previous industrial and technological revolutions have generated waves of optimism as regards their perceived economic and social benefits, the new technological age suggests a particular combination of promise and threat with the added ingredient of 'inevitability'; an argument that pervasive and disruptive change is coming whether we like it or not.

Even though the new technologies are in their infancy there is huge speculation about the potential power of AI to develop forms of machine-based intelligence, with some writers stressing the emergence of new forms of human-AI intelligence and working relationships (Daughery and Wilson, 2018), while other writers speculate this development may require minimal human intervention and even the possibility of a transhuman future (Galeon, 2018). The rapid development of AI, let along the possibility of a transhuman future, would suggest that the combined developments - material, digital and biological - that comprise the 4IR may have a different and more unpredictable logic compared with previous waves of technological change.

COVID-19 is currently profoundly transforming the global economic, social and political landscape. We are in the midst of a global recession as a result of country-by-country imposed 'lockdown'. Moreover, there are speculations across the political and research spectrum that some businesses and by extension forms of employment may never return. This introduces a very different context for our discussion of AI, as well as more direct implications for the use of AI in relation to tracking the virus. Much of the pre-COVID-19 AI literature that we draw on took economic growth for granted and speculated about the way in which AI could be deployed to enhance growth and improve the quality of life. That set of economic assumptions no longer exists. Instead the big question or 'really wicked problem' that is focusing the minds of government, transnational agencies, employers and researchers is – what will the post-COVID-19 economy and society look like? A subsidiary

question is – what role will AI play in contributing to the development of the post-COVID-19 settlement?

This paper addresses these questions and the issues that flow from them in the following way. It starts by discussing the 4IR/AI 'promise/threat nexus' pre-COVID-19 – exploring the potential for an AI-era to benefit humankind while, at the same time, 'calling out' current and foreseeable regressive uses of AI-related technologies and the dystopian futures they can generate. In developing a balanced view about the promise/threat of rapid technological change, the paper aims to address the thesis of 'technological inevitability'. This questions how far the path of AI development is technologically predestined in the sense that, having been created by humans, its trajectory of development will be in accordance with an AI-specific logic or whether that logic will be subject to wider forms of human steering and control.

We argue here that a 'balanced' analytical approach involves contextualisation by examining technological change in the context of wider economic, social and political developments. Contextualisation is important in order to avoid technological determinism with exaggerations of technological idealism or pessimism. As part of this, a political economy perspective begins with the benefit of hindsight involving a brief historical overview of the contours of Third Industrial Revolution of the 1980s and 90s in order to understand what happened to the various predictions of the time and the forces that eventually shaped and continue to influence the outcomes of this recent industrial/technological phase. At the same time, this introductory piece delves into the world of AI and ML in order to arrive at a provisional understanding of current definitions and debates that surround these core technological forces.

We then explain why the 4IR is seen as inevitable by its proponents, paying particular attention to the strongest form of that argument presented by writers associated with the 'right' and 'left' versions of Accelerationism. We further contextualise these arguments by discussing the literature on Varieties of Capitalism which highlights the potentially different approaches that could be adopted towards the 4IR in different types of capitalist society.

Finally, we conclude this contextualisation section by noting the emergence of a Green Alternative perspective on the 4IR.

The paper then changes the focus by exploring a number of issues that are integral to, but that have received little attention in the debates about the 4IR. The first one is the relationship between Human and Artificial Intelligence in order to pave the way for a discussion of the concept of the 'Extended Mind'. The second concerns why this concept offers a way to engage with, but to go beyond, the more technologically deterministic view of human and machine intelligence associated with Accelerationism and the Singularity. This is followed by the discussion of the concept of specialisation which has, historically since the First Industrial Revolution, underpinned debates about human intelligence. We then add another dimension to our conception of an Extended Mind by arguing that it offers a new way of thinking about the concept of *specialisation*, before introducing the concept of the General Intellect and the Organic Intellect.

As a result of a historical multi-level societal approach, the paper concludes by provisionally explores several possible 'technological futures' that arise from current visioning within academia and the wider economic and political world. As part of this wider analysis we make a case for a 'technological resocialisation/reshaping perspective' that involves a critique of different variants of technological determinism and the limiting idea that all humans can do is to adapt to a single and inevitable technological future.

Towards the end of the paper, the technological resocialisation/reshaping perspective is provisionally applied across the fundamental spheres of human activity - work and its future; living in an AI-saturated world and learning in the 21st Century. Learning is understood not only as a means of adapting to rapid technological change, but also the development of capacities to exercise judgement and control so that the dominant role of 4IR/AI/ML is shaped in aid of humanity and the confrontation of its existential challenges. The learning challenge of the resocialisation/reshaping perspective is not only societal and involving the wider population, but has implications for 'specialist intellectuals' who are intimately involved in the world of AI/ML. Put another way, the resocialisation/reshaping of

technologies cannot take place without experts who are willing and able to undertake this kind of work.

Part 2. The Fourth Industrial Revolution and Artificial Intelligence – threats and promises

Technological revolutions, particularly in their early phases, have produced bouts of intense optimism as technological innovation becomes associated with breakthroughs and paths of progress for humanity. Examples within recent memory include the technological advances of the 1960s - jet engines and rocketry - that culminated in the 'race for space' between the US and USSR. In what were very different economic/political systems there was a shared feeling that technological innovation would allow humans to explore new frontiers and which in the US found a popular cultural form in the iconic TV series and films - Star Trek. This technological optimism was also found in other spheres of society – a faith in the potential of planning, the role of the state and large-scale organisation – forming part of the 'Keynsian Dream' of the 1950s/60s that stretched into the early 1970s.

Technological optimism', however, did not die with the decline of the Keynsian era. It was replaced by new more market-based anticipations of what, in retrospect, has been referred to as the Third Industrial Revolution (3IR) of the 1980s/1990s. The technological developments associated with the 3IR, for example, the development of Information Technology (IT), IT-mediated knowledge transfer and the Internet, are more commonly associated with a number of concepts that have emerged over the last 30 years a number from the Social Sciences - Post-Fordism, the Knowledge Economy, and the Network Society - which have animated discussions globally in research, policy and popular literature about the development of capitalist economies and societies. In their purest version, each concept has been associated with some notion of progress – the deployment of Information Technology (IT) to replace soul-destroying methods of production (i.e. Fordism and Taylorism); the increased role of knowledge in all aspects of the economy and hence the creation of more rewarding forms of work, and the potential of the Internet to facilitate open global communication and to access communities to hitherto unavailable forms of knowledge.

When stressing these progressive developments the advocates of each concept tended, however, to pay less attention to the potential downside of their predictions or insights about the forms of economic, social and technological change they were celebrating. For example, that IT could be deployed to intensify work though new systems of monitoring performance and coordinate global economic outsourcing. What turned out to be naïve optimism was rooted in technological determinism; what we define as the tendency to over-estimate the effects of the technological change on economies, work and life more generally and to under-estimate the framing effect of the wider economy and politics on the development and deployment of those technologies. We explain briefly in this paper that the fate of the 3IR coincided with and was shaped by the wider forces of neoliberalism that expanded over the decades since the late 1970s in which the knowledge economy tended to intermingle the growth of high-skill work, low-level service work and squeeze out intermediate skill work; a process often referred to as the 'hourglass economy'. This kind of historical reflection tends to result in a more sober assessment based on evidence of a complex mix of progression and regression in relation to technological innovation.

Part 3. The Fourth Industrial Revolution in perspective

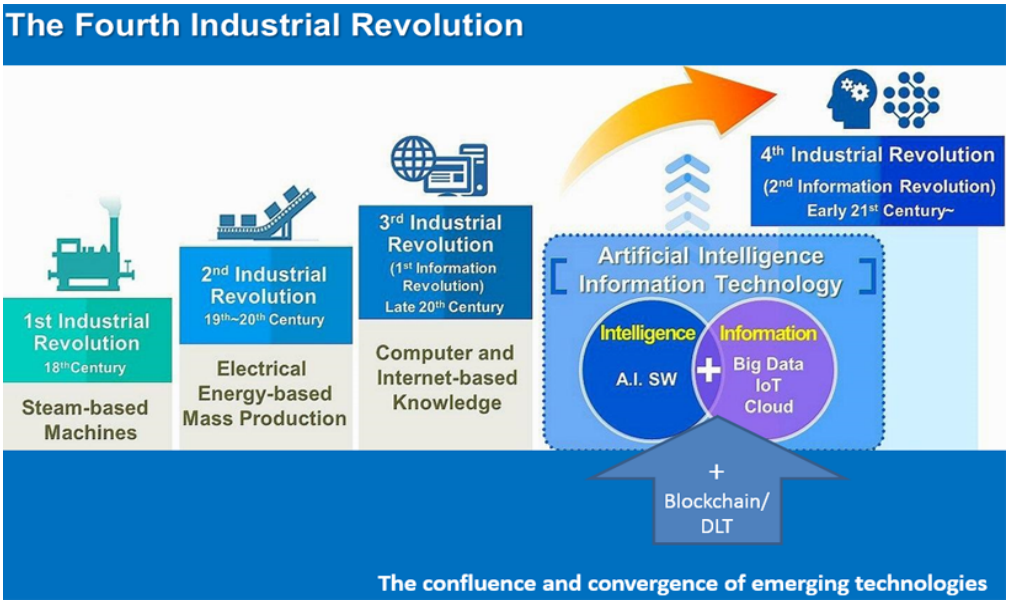
The latest addition to stimulate discussions in the global policy, research and popular literature is the *4th Industrial Revolution* (4IR). 4IR is an 'umbrella' concept (Hirsch and Levin, 1999) that packages together a number of technological developments, including recent and anticipated advances in artificial intelligence (AI) and machine learning (ML), robotics, 3-D printing and the Internet of Things (IoT), to forecast the future direction of economic, social and technological development in the 21st Century (Davies, 2016; Schwab, 2018). In this part of the paper we employ a historical perspective that views technological change in wider economic and political contexts, within which we can identify the transnational organisations that developed 4IR and the underlying assumptions.

What is the Fourth Industrial Revolution?

Part of the reason that 4IR has become a commonplace term and a feature of the popular policy and research vocabulary across the globe, is a result of its promotion by the World

Economic Forum (WEF https://www.weforum.org/focus/fourth-industrial-revolution). The WEF – a not-for-profit organization – is chaired by Founder and Executive Chairman Professor Klaus Schwab and guided by a Board of Trustees comprising global leaders from business, politics, academia and civil society. It defines its mission as 'committed to improving the state of the world by engaging business, political, academic, and other leaders of society to shape global, regional, and industry agendas' (WEF(a), p. 6). In the context of its mission statement, one of the WEF's concerns is to serve as a global platform for interaction, insight and impact on the scientific and technological changes that are changing the way we live, work and relate to one another. To advance and popularise this concern, Schwab wrote in 2017 the first book to be published with the title *The 4th Industrial Revolution*. Drawing lightly on the well-established tradition of the historical chronology of the invention of technological tools and techniques (see *inter alia*. Bunch and Hellemans 1993; Singer *et al*. 1978), Schwab presents a compelling narrative about technological change. He argues it is possible to identify four distinctive phases of technological change or in his more flamboyant term 'revolutions' (see Figure 1). The First Industrial Revolution was characterised by the use of water and steam power to mechanize production; the Second by the use of electric power to create mass production and the Third by the use of electronics and information technology to automate production. The Fourth is, however, according to Schwab (2016, p. 1-2) very different because it is 'characterised by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres, collectively referred to as cyber-physical systems'. This fusion or blurring is occurring as a result of technological breakthroughs, such as artificial intelligence, nanotechnology, biotechnology and robotics, becoming firstly, commercialised via additive manufacture/3D printing and autonomous transport and secondly, interconnected through the Internet of Things underpinned by fifth-generation wireless technologies (5G).

Figure 1. The Fourth Industrial Revolution in historical perspective



Source:
http://www.huawei.com/en/about-huawei/publications/winwin-magazine/29/accelerating-success-in-the-4th-industrial-revolution Accessed 27 May, 2018.

Further substance to this forecasting about the combined implications of these technological developments can be found in the work of writers, such as Brynjolfsson & McAfee, 2014; Ford, 2015; Mason, 2015; and Rifkin, 2014. They have argued these developments have been, and will continue to have, a disruptive influence on work and life in the second half of the 21st Century and beyond. What distinguishes the 4IR from its predecessor concepts is that it, firstly, emanates from 'consultancies, think tanks and modellers, mainly drawn from economics or working with economists' (Morgan, 2019, p. 393), and this constituency of interests has enabled the concept, as we shall see, to rapidly become a part of a global futuristic lexicon. Secondly, the concept, unlike its predecessors, denotes an inevitable future than can be viewed, simultaneously, as having utopian, for example, life-transforming developments in environmental sustainability, and dystopian, for example, massive loss of employment, dimensions. A similar argument is made by Kai-Fu (2018) about the way in which China views the potential benefits of the 4IR.

Currently, the vivid account of the trajectory of technological change provided by Schwab appears to have captured the imagination of governments, think tanks and, especially, professional service firms who offer their consulting services to help private and public

sector organisations address different aspects of the 4IR. The influence on the latter is apparent from a cursory glance at the number of reports or blogs citing Schwab's four-stage trajectory (see *inter alia*. Deloitte, 2018; Forbes (2018); McKinsey, 2017(a)(b); 2018; PEW 2017; Price Waterhouse Coopers, 2019) and from the visual representation – Figure 1. *The Fourth Industrial Revolution* – created by William Genovese on behalf of the Chinese telecommunication company Huawei.

While highly seductive, the 4IR conception has nevertheless drawn criticism – that it is an 'ideological construct' because it uncritically accepts the inevitability of capitalist market relations (Avis, 2018) and that a close historical analysis suggests that industrial revolutions are not so revolutionary since they are built on previous technological advances (e.g. Unwin, 2019). In keeping with these criticisms of the underlying assumptions of the 4IR concept we briefly introduce different strands of thinking about technological change that suggest that the character and future direction of the 4IR may be less inevitable and singular and more contested and pluralistic.

Technological inevitability, 'accelerationism' and the job replacement debate

What distinguishes the concept of the 4IR from its predecessor concepts is both technological and ideological. The historically unique factor is not only the inevitability of digital, physical and biological fusion to which Schwab refers but, more specifically, the rapid development of Machine Learning (ML). A fundamental feature of ML concerns the capacity of algorithms to facilitate a machine to learn by trawling and interpreting data that has been procured and interfaced with that algorithm, by humans.

An alternative interpretation, which will be referred to here as 'Accelerationism', of the capacity of machines to learn also exists. This interpretation has latched onto the 'autonomous' feature that ML and other forms of AI is forecast to bring about, namely an increased velocity and scope of change that could potentially move beyond human control and have unknown consequences.

The ideological dimension of this historically unique era is articulated through predictions of an 'inevitable future' – the aforementioned Inevitability and Accelerationist perspectives.

As mentioned earlier, they both generate utopian and dystopian imaginings of a coming 4IR world through differing economic and political imaginings. On the one hand, technological accelerationism could usher in a post-capitalist era of boundless plenty, leisure time and the technologies to tackle humanity's greatest challenges (e.g. Bastani, 2015, Srnicek and Williams, 2015, Mason, 2015). Or, as is equally if not more likely given the dominance of AI in market-driven economies, 4IR/AI-inspired change could lead to mass unemployment, increased social division and poverty, technological authoritarianism that heralds a new dark age (Brindle, 2018).

Amidst these differing versions of Accelerationism we can identify two interconnected dimensions of futures thinking concerned with the 4IR - a world without or with new forms of work, and the fusion of human and AI intelligence or the supremacy of AI over Human Intelligence (HI).

The Inevitability perspective predicts, on the one hand, a world without work based on the assumption that increasingly intelligent machines will replace human labour; a vision summed up in the clarion call – 'the robots are coming' (Ford, 2015). There is general agreement that the development of AI in market-based economies will, in the near future, lead to the replacement of a wide range of jobs by machines, many of which will are low-level and routine forms of employment (Ford, 2015; Frey *et al*., 2014). This replacement process, which has occurred historically in industrial revolutions, has already begun in areas such a banking and warehousing and is predicted to happen in, for example, transportation as a result of the arrival of self-drive vehicles. The replacement debate in relation to 4IR/AI concerns not job replacement as such, but its scale; the types of occupations involved and whether rapid technological development is also accompanied by the emergence of new types of employment.

This, however, is not simply an exploration of the pace of technological development based on abstract calculations of the effects of ML, but the conceptualisation of the projected development of ML in economic, political and work-related contexts. The economic context will include tendencies towards increased divisions in workplaces in market-led conditions in which some jobs are replaced but not others (e.g. a low-paid workforce in the Amazon

warehouse and more highly paid white-collar workers involve in more complex work) (Harris, 2019). The wider political context will concern, for example, strategies/decisions by nation states and transnational organisations such as the EU to develop particular types of technologies notably in relation to climate change and sustainability (EU, 2019). At the same time, changes are taking place in work organisation as a result of the 3IR, digitisation, recent scientific advances and non-technological factors with the 4IR/AI developments yet to make a significant impact. These include, for example, the emergence of more diverse forms of para/assistive roles in the health and social care sector due to scientific discoveries; ageing populations and resource constraint. Here, AI-related technologies are presently seen mainly in their assistive or augmentation roles, but with knock-on effects on the nature of health-related employment linked to future imaginings of health care and the role of the professional (Yu *et al*., 2018). In addition, as part of the new jobs thesis, there is a world where new human-AI configurations emerge that result in occupational transformation, for example, job loss, job redesign, and occupational creation as a result of AI developments (Daugherty and Wilson, 2018).

Industrial hybridisation and varieties of capitalism

While attempting here to describe and understand these different versions and visions of the inevitability and accelerationist perspectives, a contextualised analytical approach leads to a more nuanced view of futures. Our starting premise is that when we look more closely at the relationship between the different industrial revolutions, we can see that they co-exist alongside, rather than replace one another, creating a variety of economic and technological admixtures. This technological and economic hybridity is also the result of the complex relationship between technological development and technological implementation resulting in the uneven spread of technological innovation in different societies (Guile *et al.* 2018).

The wider economic and political context also holds another variation that could influence technological development; that of different models of capitalism. While over recent decades neoliberal capitalism has been a fundamental expansionary force, nevertheless different 'types' or 'varieties' of capitalism have evolved that have been framed by various national and regional relationships between markets and the state (Hall and Soskice, 2001).

Here we suggest that different models of technological development can be associated with varieties of capitalism.

The current dominant global model is Anglo-Saxon Capitalism that has emerged over the past 40 years arisen through the spread of neoliberalism (Srinivasan, 2006). Its leading edge is now driven by US Silicon Valley giant 'Platform' Capitalist companies (e.g. Facebook, Google, Amazon, Apple, Microsoft, Uber, AirBnB) (Srnicek, 2018). The Anglo-Saxon model of tech, that is deeply intertwined with the world of finance and advertising, is primarily concerned with promoting material consumption and through this focus it has developed new and exploitative relationships with a digital-using public through the harvesting and rendering of personal data; what Zuboff refers to as 'Surveillance Capitalism' (2019). By way of contrast, 'Co-ordinated Capitalism', in which the national state plays a major role, can be associated with a strategic model of production, notably the case of German *Industrie 4.0* (German Federal Ministry for Economic Affairs and Energy, 2020). Here the emphasis is on creating the 'smart factory' and AI-informed value chains to strengthen the German economy in the 4IR/AI era.

Chinese State Capitalism can be seen to have created a third technological model. Chinese Tech, that systemically excludes Silicon Valley platform companies by creating its own parallel 'digital ecosystem', appears to be a complex mix of both Platform Capitalist and Co-ordinated Capitalist models with a focus on production, consumption and civil/military integration guided by powerful long-term AI/ML state and communist party-led strategies (Webster *et al*. 2017; Kania, 2018).

If 4IR/AI/ML is viewed in a variety of industrial, economic and political contexts, the future of rapid technological change looks a great deal more multifaceted and capable of taking differing directions, and less inevitable and singular than the writers associated with those two perspectives tend to imply. So far this 'limited divergence' has been guided mainly by varied market/state relationships within nation states, with a question as whether it 4IR/AI is capable of undergoing more radical divergences influenced by social, sustainability and global health factors.

The wider political context will concern, for example, strategies/decisions by nation states and transnational organisations such as the EU to develop particular types of technologies notably in relation to climate change and sustainability (EU, 2019). A technological contingent approach linked to a variety of economic, work and political contexts, in contrast to the certainties of the 'technological/market nexus' leads to quite different conclusions regarding replacement/augmentation. Our suggestion here is that the more diverse the context based on an enhanced role for state and civil society, the more likely will be an augmentation rather than replacement trend.

Different directions for 4IR/AI - Green Alternatives

A third contextual influence, and a growing one, is the influence of 'Green Thinking' in response to the climate emergency, global pollution and resource depletion. A recent notable addition has been provided by John Mathews (2017) in his book *Global Green Shift*. Drawing on neo-Schumpeterian school of waves of industrial development, Mathew's conceptualisation differs in two significant respects from Schwab's account of industrial revolutions. The first way is that Mathews expands Schwab's four revolutions into five waves and then adds a sixth. He argues this wave is being 'driven by renewable energies and the application of IT to energy and transport…and it will create the dominant technological wave of the twenty-first century' by greening capitalism (Mathews, 2017: 44). Secondly, he asserts that the greening of the global economy is more likely to be shaped by China and India and the development of a 'circular economy' that aims to recycle resources than the massive investment being in AI made by the Silicon Valley giants, such as Amazon, Facebook and Google.

Seen in terms of the varieties of capitalism argument, Mathews is suggesting that Co-ordinated rather than Anglo-Saxon Capitalism is more likely undertake the greening process. The future direction of 4IR may also be influenced other ecological positions; notably the concept of the Green New Deal and Green Industrial Revolution – a comprehensive political/industrial strategy being promoted by left of centre forces on both sides of the Atlantic (Pettifor, 2019; Rifkin, 2019). If we follow the logic of Mason's argument (2015), then the enhanced role that these strategies envisage for the state and civil society may

mean that the greening of 4IR begins to move beyond marketised relations and into a post-capitalist world.

Summary

We have seen so far in the paper that, pre-COVID-19, most established forms of technological analysis from transnational organisations such as the WEF, the World Bank and UNESCO, have avoided adopting the historical and system-wide perspective on technological relationships and their potential effects that we are advocating. Instead there has been a tendency to see 4IR/AI as a nexus of market-driven behaviours and technological inevitability or necessary acceleration, leading to policy and practice emphases on 'human adaptiveness' to a technologically-imagined future. This approach, while important, tends to downplay the possible different directions of technological, economic and social development. It also offers little help in addressing the post-COVID-19 big question – how to rebuild the global economy and what role might AI play? We return to this later. Before doing so, the paper explores the concepts of, and relationship between, Human and Artificial Intelligence to pave the way for our discussion of, firstly, the concept of the Extended Mind as a way to understand the relationship between human and artificial intelligence. Secondly, why this concept offers a way to engage with but go beyond the more technologically deterministic view of human and machine intelligence associated with Accelerationism and the Singularity.

Part 4. AI and Human Intelligence

Perspectives on Human and Artificial Intelligence

The relationship between human and artificial intelligence has since the publication of Dreyfuss and Dreyfuss's (1986) seminal book *Mind Over Machine* been the subject of rising discussion in Philosophy, Psychology, Sociology of Science and Feminist Theory (see *inter alia*. Barad, 2015; Haugland, 1989; Harraway, 1991; Latour, 1993; Clark 2003; 2008; Harari, 2017). Written in response to the widespread euphoria engulfing the first generation of computer technology, Dreyfuss and Dreyfuss sought to undercut that euphoria and also re-

affirm humanity's distinctiveness. In the case of the former, they pointed out that the human-technology relationship had always been characterised by 'wishful thinking' as regards the development of 'autonomous machines, freed from their reliance on fallible, contentions humanity' (Dreyfuss and Dreyfuss, 1986, p. ix). In the case of the latter, they firstly, argued 'Human understanding was a skill akin to knowing how to find one's way about the world' and this ultimately involved the application of 'intuition'. Secondly, expounded this thesis in their widely celebrated discussion of the transition from novice to expert in relation to their five-stage model of skill acquisition, which defined the determining characteristic of expert decision-making as 'intuitive' rather than 'analytical' (Drefuss and Dreyfuss, 1986: 50).

In parallel with debates about current AI and its uses, a much more speculative debate has been taking place regarding Artificial General Intelligence (AGI). Before discussing AGI it may be helpful to discuss briefly its predecessor concept – Narrow AI (NAI). Currently, NAI has been defined as the development of 'computer systems currently able to perform specific tasks normally requiring aspects of human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages through processes of flexible adaptation and machine learning' (NESTA, 2020). The recognition of NAI and its particular strengths and limitations has important implications for current decision-making by governments, private companies and civil society.

The benefits of NAI in the world of production, science and public services more generally, however, have generally been taken for granted since they have become a ubiquitous feature of late 20th and 21st Century life, for example the Internet, mobile technology and so forth. These developments tend to be understood by specialist communities such as clinicians, engineers and agronomists, but not more widely recognised by society at large. The most popularly known and discussed uses of NAI concern its negative impacts. Current and near future projections of its uses in society have focused on visual recognition technologies; issues of privacy and personal freedom; information manipulation/fake news, targeting of particular demographics and attacks on democracy; the use of algorithms in relation to welfare payments or sifting job applications and concerns about prejudice and

fairness; and the use of algorithms by giant tech companies to harvest and render personal data, suggesting the emergence of a new type of 'surveillance capitalism' (Zuboff, 2019).

The very strengths and limitations NAI remind us that humans potentially remain in control because we are able to determine the algorithms and the mediating technologies that underpin AI and ML. The question is not just how we regulate and ameliorate the negative effects of AI, but the ways in which NAI can be 'shaped' for common good. This is not just about essential technical expertise to reshape AI/ML, but also a wider economic, political and social awareness that will be required to drive the willingness to undertake the 're-purposing' of emergent technologies in their 'assistive' and 'augmentative' roles.

In contrast, AGI the holy grail of the AI world, is understood as an AI capable of understanding the world and accomplishing any goal at least as well as humans (Tegmark, 2017) while also being capable of exponential rates of improving its own intelligence. This has given rise to a less nuanced, more deterministic and even deeply troubling line of thinking. In particular, there is a medium- to far-future debate that has inspired a particular form of futurology – predictions about the envisioned moment of 'singularity' that refers to the intimate merger between the technology-creating species and the technological evolutionary process it spawned, and even speculate that role of AI intelligence will surpass human intelligence at some point in the future – a point referred to as 'singularity' (Kursweil, 2006; Pandya, 2019). The singularity debate highlights the tendency to extrapolate rates of technological acceleration without any reference to wider economic, social, political and ecological contexts. However, the most regressive strand of this technologically determinist version of AGI thinking, is dominated by predictions of the techno-capitalism, loss of human control and a neo-fascist thinking, understood as the Dark Enlightenment (Land, 2016).

Like the workless world debate, this form of futurology too also contains differing imaginings. On the one hand, there are forebodings about the destiny of the human race with the threat of extinction at the hand of machines that can reproduce themselves (e.g. Verner, 1993; Joy, 2000; Hawking, 2014). Unsurprisingly, the technological singularity thesis has its critics who broadly assert that there are many obstacles in the path of an 'explosion'

of artificial intelligence. Their arguments include the fact that currently there is no known technological path to AGI, due notably to the absence of recursively Self-Improving Software (RSI) (Yampolskiy, 2015) and, allied to this, that approaching singularity will involve a scale of human and physical resources that will, at some point, become depleted (Nordhaus, 2015). Put another way, the case for the coming singularity is being made without any meaningful reference to the wider economic, political and social contexts in which technological developments are taking place.

Linked to our concerns about the future directions of the 4IR and the way in which COVID-19 will undoubtedly cast a heavy shadow on those directions, we are more interested in thinking about the movement beyond the Dreyfuss and Dreyfuss's argument since, arguably, humans are developing an intuitive understanding of using code as a resource to facilitate professional judgement as was the case with earlier generations of technology (see Zuboff 1988 for a discussion of this issue with respect to physical and symbolic data). Moreover, moving beyond speculations about singularity we are interested in focusing on the nature of Human Intelligence (HI) in an AI-era and through this the possibilities of new forms of HI/AI fusion.

Our starting point is a more grounded conversation that does strays into the AGI world among a cross-section of social, scientific and technological futurologist concerns (Future of Life Institute http://futueoflife.org); what Tegmark (2017) refers to as, 'Life 3.0' or what it will mean to be *human* in the AI age. Acknowledging that the question of how to define life is notoriously controversial, he presents a three-stage framework with roles for biology, culture and technology to depict the distinguishing features of evolutionary development - Life 1.0 as the biological stage which evolves its 'hardware' and 'software', in other words, rudimentary mental functioning and basic tools, such as anvils, knives, ploughs etc. Life 2.0 is viewed as the cultural stage of more sophisticated mental processing and material and symbolic tools, such as automobiles, books, music; and, Life 3.0 as the technological stage which designs its hardware and software. Life 3.0, in other words, marks the development of human-level AGI to control biological, cultural and technological developments on the planet.

Despite having some misgivings about Tegmark's evolutionary framework as a result of its compression of thousands of years of complex human development into three stages of life, his argument raises an extremely important issue. Does the current state of play of AI, let alone the prospect of AGI, imply the creation of a HI-AI ecology and, if so, what form would it take? This provocative thought presages a rethinking of concepts historically associated with *homo sapiens* – mind, learning and knowledge – in both a speculative and evolutionary sense.

The Human/AI Ecology and the Extended Mind

Our starting point is that we accept Tegmark and other writers, for example, Du Sautoy (2019) arguments that it is conceivable in the medium terms, that particular forms of AI referred to as Machine Learning (ML) will continue to be developed and in the process expand exponentially its current capability to 'learn'. In other words, as Du Sautoy (2019) explains, that ML can trawl through data and identify new patterns and issues for humans to consider. An additional formulation is that ML is the application of artificial intelligence that provides systems with the ability to automatically learn and improve from experience without being explicitly programmed (Expert System, 2017).

The ability of a technology to be able to learn without continuous human input is of historic importance. As such ML can be regarded as the novel ingredient in the 4IR concept, making it distinct from previous technological revolutions due to the potential capacity to 'accelerate' in a more modest way than envisioned by the 'right' and 'left' accelerationists technological development. By the same token, ML also has the potential ability to shift the boundaries of NAI towards a more expansive AI, understood as Artificial General Intelligence (AGI) (Upadhyay, 2019). We maintain, however, that if this is to happen then there is a need for a fundamental rethinking of the mind-machine relationship because what is emerging is the prospect of a fully intertwined AI-human ecology based on an *extended* conception of mind, rather than the current binary conception of that ecology which is colloquially captured by phrases such as technology 'assists' or 'augments' human activity.

The problem with some proponents of AGI is, as we have seen, that they tend to focus on the radical evolution of AI rather than on the radical evolution of the HI-AI relationship and what this means for the path of technological development. A preoccupation solely with AGI and its evolution is susceptible to a form of technological fatalism in which its path of 'artificial consciousness' is at best 'tamed' by regulatory and ethical frameworks rather than to consider the emergence of 'fusions forms'.

An alternative perspective involves focusing on the development of the HI/AI ecology in an age defined by fundamental ecological, socio-economic and technological features - the Anthropocene and Climate Emergency; the crises/evolution of different forms capitalism and post-capitalisms and the possibilities of an emerging AI era. Put another way, the possibilities of technology need to be understood in the context of a necessary acceleration of human social intelligence (that we will refer to later as the General Intellect) to envisage different socio-technological futures and the role of accelerating AI as part of this.

We maintain that this development implies a fundamental rethinking of the mind-machine relationship because what is emerging is the prospect of a fully intertwined HI-AI ecology, based on an *extended* conception of mind. In making this claim, we follow, and deviate from, as we shall explain briefly here Clark's (2008) celebrated discussion about the 'extended' character of mind. He contends that the human mind has always extended beyond its biological limitations to include technological resources as part of its cognitive apparatus or functioning. The ML developments that Du Sautoy (2019) and Van der Schaar (2020) draw our attention to are, however, radically different from previous generations of technology which were characterised by a mixture of finite and 'autonomous' development (Winner, 1977). Certainly, humans have coded ML to have the capacity to learn; the critical difference being the direction this learning might take is not predicted by humans. Our interpretation of this development is to say there now exists an extended mind relationship between human and AI cognition. This conception of an emerging HI-AI ecology is moves beyond the current binary conception of the mind-machine relationship, which is colloquially captured by phrases such as technology 'assists' or 'augments' human activity. Of course, this is still an accurate characterisation of some mind-machine interaction, but, not at the leading edge of technological development as discussed above. We speculate

here, and consolidate our argument later, that the development of the aforementioned ecology is likely to have a significant bearing on the way in which societies chose to respond to Tegmark's and others blind faith in the future of AI-fuelled life.

Furthermore, we add another dimension to our conception of an Extended Mind by arguing that it has implications for the concept of *specialisation*. This concept has underpinned the purpose of both national education systems and occupational classification and demarcations, since the widespread acceptance of Durkheim's (1893) classic argument about the role of education in relation to the division of labour in society among nation states. The concept of specialisation is predicated on a linear and hierarchical relationship within a discipline, and the assumed relationship or 'fit' between a discipline and entry to a profession. Our concept of the Extended Mind, which includes a role for human learning and technologies that learn, simultaneously raises questions about the evolving nature of specialisation; how specialist forms of thinking and practice continue to develop in academic life, in the professions and in national educational systems. We are not alone in making this connection; a similar conclusion, albeit originating from a different line of inquiry, has been made by Roberto Mangabeira Unger (2019). The rethinking of the mind-machine relationship and its implications for extant and alternative conceptions of specialisation and the 4IR are pursued in later papers.

Specialisation and the General Intellect

We now turn our attention to a fascinating prediction to offer a very different perspective on the potential development of the 4IR. Writing in 1858, Marx anticipated, in many ways, the future development and deployment of technology in capitalist economies. He did so by engaging in a thought experiment titled the 'Fragment on Machines' which was only published nearly 100 years later in the *Grundrisse* (1973 translation). Here Marx speculated about the possibility that the intensive application of science to the productive process in capitalist societies would, at some point in the future, displace human labour from production and recast it as a supervisory or regulatory activity. To capture, the nature of the scientific and technological knowledge locked inside the machine, Marx coined the term *General Intellect* to indicate that socially-generated knowledge, rather than physical labour, would now constitute the epicentre of production. We will return to a fuller discussion of

the General Intellect and the various interpretations and contestations the concept has spawned later before introducing our own reconceptualization of that concept as the *Organic Intellect* and the role of *Organic Intellectuals* to understand the role of connective activity between different areas of knowledge in state (vertical) and civil society (horizontal) which, we argue, will be required to address what we refer to as the 'Tegmark challenge' defining Life 3.0. For now, we merely want to focus on one interpretation Paul Mason's (2015) argument about 'post-capitalism'.

Mason (2015: 141-2), drawing on Rifkin's (2014) insight about the Internet of Things (IoT) and the emergence of peer production, maintains that both pave the way for the emergence of a new type of economic system and society. This line of argument, although highly speculative at this point in time, nevertheless introduces the possibility of a very different outcome from the 4IR compared to Schwab's avowedly market-based, and Matthew's Polanyi-tinged market-transformation visions. In a nutshell, Mason (2015: 141-2) follows and gives a radical twist to Rifkin's argument. He accepts that firstly, the IT revolution has transformed the way we process, store and utilise information by corroding the price mechanism for extant digital goods, for example, music and facilitated the creation of a network economy where artists could engage in peer production and bypass the extant industry structures. Secondly, the colossal valuation Schwab and others attribute to the eventual financial impact of the IoT, masks that it will reduce the costs of existing products and services in sectors, such as manufacturing and healthcare, in other words significantly lower the marginal costs of their production and hence profitability. But Mason (2015: 143), unlike Rifkin who presents the outcome of the above developments as an co-existence between capitalism and peer-production, sees this contradiction in contemporary capitalism as a '*fight between network and hierarchy* (italics in original)' which will lead to the emergence of some kind of post-capitalist society. In making this argument, Mason skips over the alternative possibility posited by Mathews that capitalism will have to green itself in response to the inconvenient truth that new sources of energy will required. The extent to which there can be some rapproachment between Mason and Mathew's argument is explored in later papers.

Part 5. Conceptualising technological futures

In the preceding analysis we have situated 4IR/AI developments in wider economic, political and ecological contexts; made distinctions between different forms of AI/ML and highlighted debates about the emergent nature of a human/AI ecology. These wider and more integral ways of conceptualising 4IR/AI suggest that there is not necessarily a singular inevitable future, but several possible directions of development or what we refer to as a pluralism of technologically informed futures. This line of argument is in relation to the impact of COVID-19 even more important because countries will have different starting points for the rebuilding of their economies, industries within countries will also have very different starting points, and there may be new forms of partnership and collaboration between governments and industry to not only address these challenges, but also to develop a preventive strategy against the possibility of future pandemics. Situated in that context, our discussion of AI and ML is concerned with the 'near future'; the immediate aftermath of COVID-19 and coming decade in which important decisions regarding the potential paths of 4IR/AI will need to be made. What is being suggested is the need for a technological equivalent for what Mazzucato (2016), in the field of economics, refers to as 'mission-led innovation'.

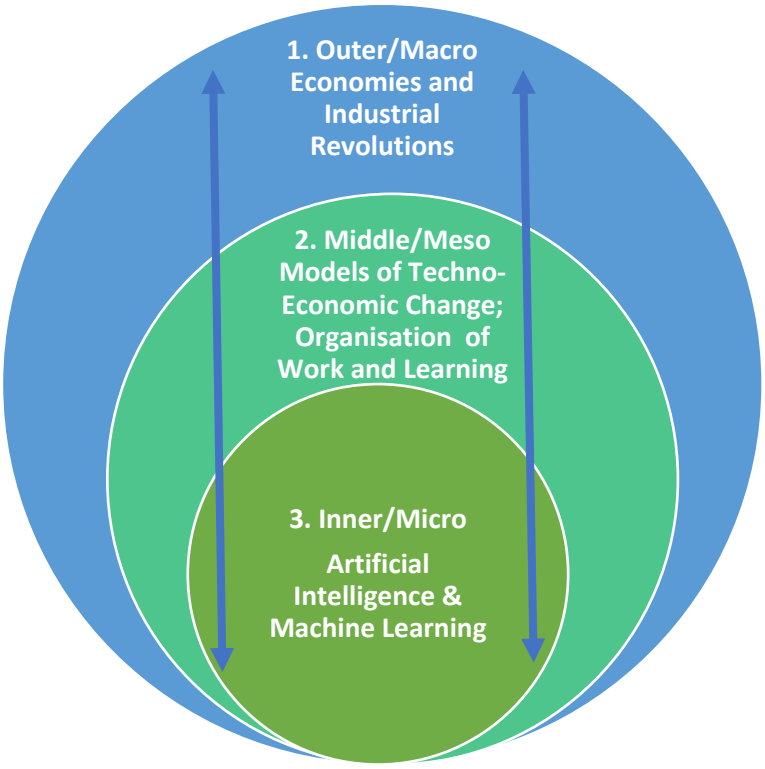
Bearing these observations in mind, we prefer to conceptualise futures as socio-technical due to take account of the 'mediating effects' of different dimensions and types of human thinking and activity that have the potential to 'shape' the technologies and their uses, rather than following the 4IR tendency to conceptualise them as technological inevitabilities.

In order to understand socio-technical possibility, here we introduce a conceptual model comprising three inter-related layers, that taken together constitute a 'technological future' (see Figure 2).

1. An outer/macro contextualising layer of industrial revolutions and types of economies.
2. An inner/micro layer of the technologies of AI/ML.

3. A complex mediating/meso layer comprising socio-technical paradigms of change that represent the contest of ideas about technological change; forms of work organisation as the immediate context for the application of technologies and intellectual/educative activity and forces that connect the inner and outer layers.

Figure 2: A multi-level technological future

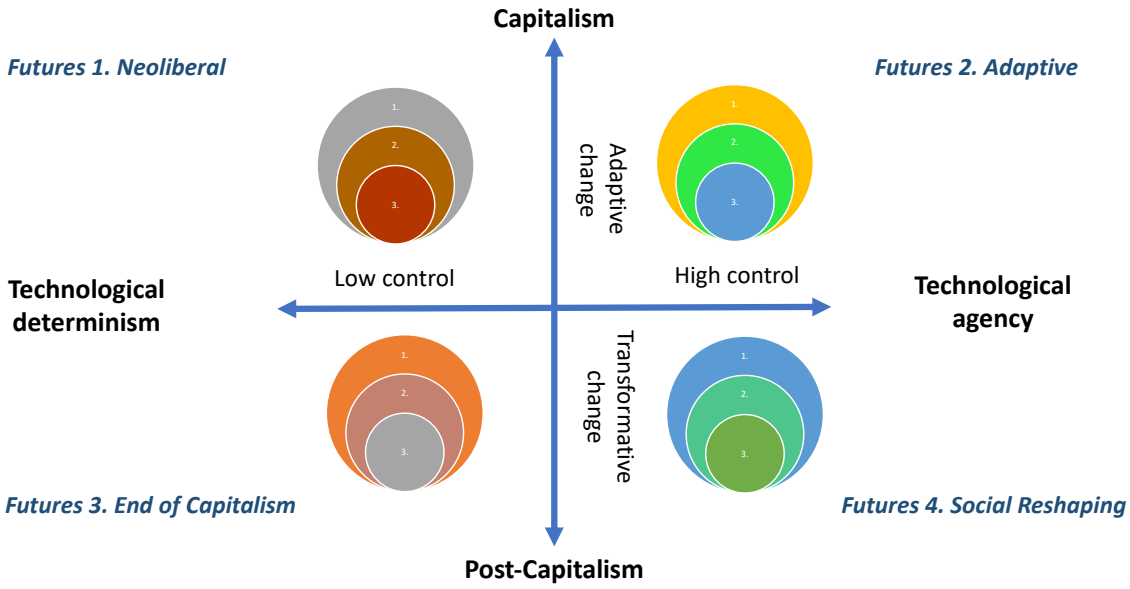


This generic Technological Futures Model can be used to discuss several possible Technological Futures (see Figure 3).

Our futures approach employs a conceptual framework based on a number of issues that have been discussed in the paper. The issues are firstly: the degrees of technological determinism or technological agency influencing thinking about the deployment of AI, and the relationship between technological change and existing economic systems (adaption or transformation). We conceptualise these issues as intersecting continua. Secondly, the debates about the end of capitalism or the emergence of post-capitalism, the greening of capitalism or 'inclusive vangardism'. Our initial formulation identifies four Futures: 1. Neo-liberal; End of Capitalism; 3. Adaptive; and 4. Social Reshaping. We will see, however, like

the historical industrial phases and varieties of capitalism, these Technological Futures will necessarily exist in hybridised forms. Each Future, while having dominant characteristics, will share certain features with others. For example, both the Futures 1. Neo-liberal and Futures 4. Social Reshaping have adaptive elements found in Futures 2.

Figure 3. Four Technological Futures



We are interested in particular with Futures 4 - Social Reshaping/Resocialisation - because of the necessity, and also the possibility at this point in time, of collective human intervention to steer the future development of new technologies in a profoundly social and ecological direction. As part of this 'mission' we focus on a particular part of the model - the role of an expanded mediating 'meso' layer (No 2) of human thinking and activity that we conceptualise as forming a 'bridge' between the wider economic/industrial system and the new technologies AI/ML. This meso layer is complex and may itself require further sub-division because it contains different categories of mediating factors that are human and societally driven. These will include:

- Visions of particular Technological Futures that point to the possibility of reshaping/resocialisation.

- The role of social, economic, political, ecological, technological national and international strategies (e.g. Green New Deal and the development of new types of work) that provide the medium for the enactment of the particular Technological Future.
- New work/living organisational settings and the practical uses of technologies in their local and social settings.
- Concepts of the augmentation/assistive and fusion of Human Intelligence and Artificial Intelligence/Machine Learning – the HI-AI/ML Ecology as a new form of specialist thinking and practice.
- The concept of a General Technological Intellect to develop a new level of societal awareness of 4IR/AI, its dangers and opportunities.
- Role of progressive specialist technological intellectuals to link the Micro and Macro layers in both.

In keeping with our concern and the degree to which role of AI/ML can be reshaped/re-socialised is the challenge of the lack of transparency about their underlying assumptions; what Chun (2013) refers to as, 'programmed visions' which have been programmed into algorithms that affect the way in which AI in general operates and ML will learn. At the same time, the relatively under-developed nature of present ML means that this technological world and the one in the near future is one that is, in principle, susceptible to broader forms of human accountability. One suggested strategy is Van der Schaar's (2020) 'interpretability, explainability, trustability' model which has been designed to make the decisions about the algorithms that underpin ML, the way in which they reach their decision and the forms of public accountability, more visible. Whether this will happen, however, will depend on the business models of tech companies and the ethical and political views of elected governments and wider civil society. How this complex dynamic might play out is explored below. It is, however, too early to speculate about the extent to which COVI-19 may influence the way in which this nexus of interest will plays out.

Futures 4 – reshaping and resocialisation of new technologies

The Futures 4 perspective starts from the premise that human society, through the exercise of collective human intelligence, is capable of exercising agency and foresight to reshape and re-socialise new technologies. This possibility is conceptualised on the horizonal axis of the technological futures model (Figure 3). However, in order to undertake this task, it may be necessary to move beyond market-oriented economic and social thinking.

A potential key feature of comprehensive ethical and politically-informed human decision-making is the reshaping' or 're-socialisation' of the design and implementation of technologies. The concept of 're-socialisation' is used here because existing technological relations (e.g. Facebook) are already socialised. A key question concerns the nature of the social priorities and who controls the process of development of technologies in the 'near future'. The issue of control suggests two pressing questions for the development of new technologies and AI in particular. First, that the purpose of all new technologies should be transparent – algorithms presently mask purpose. Second, that new technologies should serve more broad-based social purposes. This raises the issue of the role of the state and civil society to develop both modes of accountability and generating popular participation in informing the uses of technologies.

Beyond these important considerations, the main economic and technological difference between Futures 4 and the three other models is the centrality of work. Futures 1 and 2 (Right and Left Accelerationism) are premised on the eventually disappearance of work as human labour is replaced by machine labour (see for example Negri, 2014; Srnicek and Williams, 2015). Futures 3 (Adaptive), on the other hand, speculates at the macros-level about the emergence of fairer societies (Mangabeira-Unger, 2019) and at the meso-level about new the possibility of new types of jobs based on historical evidence from previous industrial revolutions (Hawksworth *et al*., 2019). Two options are evident: one rarely goes beyond speculation due to its continued reliance on the market rather than the state or popular participation in economic strategy (Brown *et al*., 2018); the other is equally speculative but envisions a new rapproachment between State and Market via notions, such as *mission-led innovation* (Mazzacuto, 2013), *inclusive vangardism* (Mangabeira-Unger 2019) or the *greening of capitalism* (Matthews, 2017). The result is that the adaptive

perspective has little inclination to envisage new types of work and to create the conditions for its emergence while the latter remains, at present, a feature of academic theorisation relatively absent from political discourse, yet, may prove to be significant sources of influence on how to rebuild societies and economies post-COVID-19.

Futures 4, on the other hand, adopts a transformative perspective that links 4IR/AI to inclusive economic development and new types of green jobs; to sustainable lives and the fight against the climate emergency in a post-COVID era. In support, there is an expanded 21st Century concept of lifelong learning. Futures 4 can, therefore, be conceptualised as the reshaping of future ways of *Working*, *Living* and *Learning* with a focus on the relationship between advanced technologies, better jobs, sustainable lives and improved forms of learning (Guile et al. 2018). This arguably should involve not only improved quality and meaning of work (machines may be able to do the most repetitive of jobs), but also reduction in the time that we spend at work (a four-day week for example) thus freeing up more time for other aspects of human activity.

Resocialisation and the learning challenge

'Technology really needs to be understood through the collaboration of specialist forms of knowledge about what it actually is and does'. This quote from McKenzie Wark (2017), with a focus on connective specialist knowledge, correctly associates a profound understanding of technological change with connective specialist knowledge. At the same time, there is also the issue of the use of AI in everyday life and the role of the general understanding of citizens.

Futures 4 perspective, in its attempt to supersede 'technological adaptiveness' and to promote the social reshaping of technologies, suggests that this 'dual educative mission' has to go beyond that of formal education to consider two dimensions in particular. Firstly, the development of economic systems focused on new forms of sustainable production in which technological change is associated with the creation of high skilled 'green' jobs in which education is understood as a form of 'innovation'. This will involve the nurturing of new forms of specialist knowledge and skill. Secondly, allied to this, is an assumption that a precondition for the full development and utilisation of AI is the expansion of human

intelligence through the creation of a human-machine ecology. By this we are referring to not only to the role of new forms of specialist technical knowledge, but also to a greater general awareness about the potential of AI and the optimum relationships to be established with advanced technologies.

Futures 4 thus points to an education and lifelong learning process that emphasises preparation for economic, social and ecological re-purposing and how these would be embodied in new types of work that utilises intermediate as well as advanced skills. The mission of technological repurposing would mark an era of learning experimentation; more participative forms of work-based learning thinking; a focus on new forms of knowledge production and the HI/AI interface as a 'generative process' that includes the development of 'hybridised data development' and 'complex problem creation' (Floridi, 2019) and learning to 'think algorithmically' (Royal Society, 2017). These developments presuppose the creation of new forms of learning in education and workplaces which, in turn, will call for new or revised theories of learning because AI is able to provide feedback on human or technological performance to offer new and unforeseen data and potential decisions and ML is able to learn and offer the insights accruing from its learning. By doing so, both provide a way for humans to extend personal and collective learning or, in other words, to expand HI.

At the same time, however, it is important to recognise that there is a fundamental role for formal education as it is presently understood. Futures 3 – Adaptiveness - carries an increasingly mainstream and reform-based response to rapid technological development – an increased focus on creativity and broad 21st Century competences. These capacities will be needed in order to gain access to the jobs that robots will not be able to do in the foreseeable future - to promote personalised learning and better access to learning; create collaborative environments and intelligent tutoring systems; prepare learners and teachers for AI-saturated future through new curricula for AI and the digital powered world; increase the use of data analytics to manage large-scale education systems and to focus on constant self-improvement through lifelong learning, including in workplaces (UNESCO, 2019).

Part 6. Conclusion - towards a Socio-Technological Future?

The prevailing narrative about technological change and its effects on employment has essentially been about the history of capitalism and the dominant forces of private markets and class power. Despite taking a historical view, recent examples of the analysis of technological change remain strangely ahistorical that is susceptible to a relatively uncritical acceptance of the never-ending role of markets in framing human behaviour and the inevitable disruptive power of new technologies. This twin determinism has fed the job replacement/end of work thesis with its accompanying narrative about the need for human adaptiveness in the face of the inevitable.

However, the analysis earlier in this paper (industrial hybridity and varieties of capitalism perspective) questions this fatalism with three related arguments. The first argument concerns the historical observation that new industrial revolutions do not overwhelmingly replace previous ones but establish relationships of co-existence in which the new form of production act as a 'leading edge'. Technological coexistence therefore raises the issue about how AI and the innovations of 4IR not only constitute a distinct and growing sector, but also how these innovations are applied to different areas of the economy and society in an augmentative role. The second argument concerns the nature of intelligence and knowledge that results from the use of AI in society and the new syntheses (fusions) between human and artificial intelligence. Here we have suggested that the positive application of AI/ML will be the result not only of technological innovations, but also of developments in human general and specialist social, economic and technological thinking that provides a sense of 'mission' to guide the development of the technologies. At the same time, we also speculate that within this 'mission framework' AI/ML can produce new forms of hybridised thinking and judgement.

However, the degree to which this happens has to be seen in the wider economic and political contexts. This brings us to our third argument about the role of politics and governance. It is clear from our preceding arguments is that technological change is influenced not only by markets, but crucially by the role of the state. Furthermore, the past 40 years of the neoliberal era has been one of the relative marginalisation of both

progressive and alternative thinking and of the power of the working people in economic and political life. Were this balance of forces to change, leading to the growth of a 'technological civil society', the more prevalent might become arguments and strategies for technological augmentation/fusion.

The technological augmentation/fusion perspective is represented in this paper by Futures 4 – Social Reshaping of technology - with its focus on sustainable economic strategies and the Green New Deal; the expansion of human intelligence through new forms of HI/AI fusions and the generation of the democratic state and political life. Futures 4 is, therefore, not only a theoretical perspective, but also an ethico-political strategy aimed at assisting the transition away from determinist forms of thinking and towards a new a democratic determination that new technologies can be reshaped to aid humanity at a time of existential threats to its future that include COVID pandemic and the Climate Emergency. In this sense, Futures 4 should be seen as a 'socio-technical future', guided by the generative fusion of what we will term the 'Technological Organic Intellect' and advanced technologies.

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