DIGITAL FUTURES OF WORK

WORKING PAPER 2

Education, Technology and The Future of Work in the Fourth Industrial Revolution

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WORKING PAPER 1

Education, Technology and The Future of Work in the Fourth Industrial Revolution

Introduction to an International Research Programme

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Abstract

It is widely believed that digital technologies are transforming all aspects of economy and society, driven by advances across a number of interdisciplinary fields and new technologies such as, artificial intelligence, robotics, additive manufacturing, synthetic biology, and smart materials. Public debate has largely focused on the threat of large-scale technological unemployment, although similar concerns were evident in earlier industrial revolutions. This raises the questions of what, if anything, is significant or 'revolutionary' about today's developments in digital innovation and what are the implications for the future of work, education and labour markets? This working paper will outline different interpretations of the fourth industrial revolution and the role of digital technologies in (re)shaping the education-work relationship. It will present two contrasting theories of 'labour scarcity' and 'job scarcity', to highlight why we need to rethink education and the future of work, and to challenge some of the key assumptions that inform current public policy in both Western and Asian countries.

keywords: digital technologies | technological unemployment | industrial revolutions | digital innovation | education | labour markets | education-work relationship | labour scarcity | job scarcity

Introduction

It is widely claimed that we have entered a fourth industrial revolution (4IR) driven by rapid advances in digital technologies such as artificial intelligence (AI), machine learning, additive manufacturing (3D printing), distributed ledgers (blockchain), big data and the internet of things. This working paper will describe some of the key ideas informing current debates about technological innovation and its implications for the education-work relationship. How the 4IR is defined, explained and represented in public policy will play a key role in shaping the future of work and the direction of educational reforms. The central argument is that policy debates are based on outdated assumptions that need to be reformulated in a context of digital transformation.

Much of the policy literature is premised on a *labour scarcity* theory of technological disruption (Goldin and Katz, 2008; Autor, 2015) accelerating a race between education and technology, with the demand for skilled and tech savvy employees increasing in line with advances in AI and machine intelligence (Brown, Lauder and Cheung, 2020).[1] Here lifelong learning assumes greater importance in ensuring the continuing employability of the workforce as the

[1] The distinction between 'labour scarcity' and 'job scarcity' theories of education and work draws on Phillip Brown, Hugh Lauder and Sin Yi Cheung (2020) *The Death of Human Capital? Its Failed Promise And How To Renew It In An Age Of Disruption*, New York: Oxford University Press. This book outlines a *new* human capital and offers a detailed account of the historical foundations, features and failings of orthodox human capital theory.

fundamental problem is viewed as one of *alignment*, in a race to get students, employees and supporting institutions including education, up to speed in response to digital innovation. Although it recognises a need for educational reform, it stops short of more radical proposals given an enduring faith in market capitalism and the wage-labour system to deliver economic prosperity, opportunity and social mobility. Indeed, the only losers are presented as those individuals who fail to embrace the opportunities to invest in digital skills; businesses who fail to take advantage of the productive benefits of AI, cloud computing, etc.; and governments that fail to build the required digital infrastructure or invest in upgrading the digital skills of the workforce.

A job scarcity theory of the fourth industrial revolution is presented as an alternative to labour scarcity, offering a less technologically deterministic view of the future of work future as technology is not destiny. Rather than a shortage of people with the right skills, job scarcity theory points to an increasing scarcity of good quality employment opportunities that challenge the assumption that through educational reform, the labour market can continue to serve as an efficient and fair means for the distribution of opportunities, work and rewards (Brown, Lauder and Cheung, 2020).

Job scarcity theory rejects the premise that we have entered a unique age of invention, but rather views technological innovation as contributing to a dynamic period of social and economic unravelling, unbundling and recombination.[2] The same technologies can be used to augment the discretion and skills of the workforce or lead to greater routinisation and deskilling, in the same way that they can enhance the learning experiences of students or lead to 'dumbing down' in a process of making machines more like humans and humans more like machines.

This working paper starts by looking at some of the defining features of the 4IR, even if there is little agreement about what term should be used to capture the current period of technological, economic and social change. It then presents a more in-depth analysis of *labour scarcity* and *job scarcity* theories, explaining why much of the current policy discourse is locked into a human capital framework no longer fit for purpose (Brown, Lauder and Cheung, 2020).

What is the Fourth Industrial Revolution?

It is widely believed we've entered a new phase, stage, or period of economic development, qualitatively different from what has gone before. Today, people variously talk about the second machine age (Brynjolfsson and McAfee 2014), third industrial revolution (Rifkin 2011), digital economy (Unger 2019), or a fourth industrial revolution (Schwab, 2016). David Landes (1960:1) warns against the tendency for the term industrial revolution to be used to characterise any period of significant technological change so that 'we shall eventually have as many "revolutions" as there are historically demarcated sequences of industrial innovation, plus all such sequences as will occur in the future'.

The true character of the fourth industrial revolution remains unknown, because we are at an early phase of anything that would distinguish it from the third industrial revolution with the shift away from mechanisation and factory mass production since the late 1970s, to the widespread use of electronics, computing and the birth of the internet, fuelled by early advances in computerisation. Much remains unknown about the speed and implications of

[2] Unravelling may result from the unintended consequence of purpose actions and institutional contradictions, while unbundling points to deliberate strategies to, for example, dis-aggregate jobs or skill sets, to take advantage of the granularity of big data.

change, exemplified by vastly different interpretations of the employment implications of automation (Frey and Osborne, 2013; Arntz, et al., 2016). But a defining feature of any industrial revolution is its far-reaching consequences for both economic organisation and the wider society (including the relationship between education and work), which is why previous industrial revolutions are not definitively knowable until long after the event. Schumpeter (1943:83) cautions:

> '...since we are dealing with a process whose every element takes considerable time in revealing its true features and ultimate effects, there is no point in appraising the performance of that process ex visu of a given point of time; we must judge its performance over time, as it unfolds through decades or centuries.'

This should serve as a timely warning to those willing to dabble in futurology, but this also needs to be weighed against the fact that how we define the future, shapes the future. Requiring public policy to be based on a careful analysis of current trends and a willingness to challenge the theories that underwrite existing policy which may no longer be fit for purpose.

Regardless of what term is used there is widespread agreement that advances in digital technologies amounts to new 'general purpose technologies' (Freeman and Louca, 2001), akin to the way steam power contributed to the productivity of agriculture and textiles, and electricity to the revolution in industrial production, transportation and urban development. An exponential increase in computing power supported by advances across inter-related scientific, commercial and academic fields, has contributed to the development of interconnecting technologies, including artificial intelligence (AI), machine learning, robotics, data analytics, Internet of Things, Blockchain, Additive Manufacturing (3D printing), and nanotechnology.[3]

Whatever the preferred definition, its general-purpose character includes novel products and services derived from advances in digital technologies, such as gaming, robotics, cyber security, wearable devices, and vitro diagnostics; more productive ways of doing existing things, such as the way people access financial services, engage in higher education, book a vacation, or firms organise global value chains and international logistics. It also includes a sense of what is to come such as the widespread use of autonomous vehicles, distributed manufacturing using 3D printing, and rapid advances in supercomputers (including quantum computing), etc.

To date, there is little evidence to support claims that the fourth industrial revolution will see us entering a period of mass technological unemployment (Keynes, 1930 [2008]), at least in the short to medium term. But there is clear evidence that digital innovation is already having a major impact on national economies, reshaping how we work, where we work, and what we do for a living. The Covid-19 pandemic has also drawn additional attention to the challenges and opportunities presented by digital innovations as much of everyday life moved online during national lockdowns aimed at mitigating the spread of the virus. At the same time, it highlighted vast inequalities between winners and losers in employment, living conditions and digital connectivity, as well as levels of job insecurity and wage disparities, that also characterise earlier industrial revolutions (Haldane, 2019). At the time of writing, an intriguing question is whether the growth in working from home (WFH) or online learning, will be

[3] This discussion draws on the Brown Review (2019) *Wales 4.0: Delivering Economic Transformation for a Better Future of Work*, Welsh Government, https://gov.wales/sites/default/files/publications/2019-09/delivering-economic-transformation-for-a-better-future-of-work.pdf

sustained beyond the pandemic, and whether these changes are the harbinger of a different future of work which is yet to be revealed.

Education and Labour Scarcity in the Fourth Industrial Revolution

The theory of labour scarcity is premised on the view that each period of industrial development (or industrial revolution), from the early days of steam and electrical power to the digital technologies of today, is driven by a rising demand for new scientific knowledge and technological innovation, requiring an increasing proportion of the workforce to use higher level cognitive, creative, and problem solving skills, contributing to rising productivity at the same time that automation replaces routine labour.

David Autor (2015:27) suggests 'the issue is not that middle-class workers are doomed by automation and technology, but instead that human capital investment must be at the heart of any long-term strategy for producing skills that are complemented by rather than substituted for by technological change.' Therefore, by investing in education and training it is believed that people acquire human capital that, due to its scarcity in the labour market, generates a flow of income over the career path (Autor, 2015).

A Race Between Education and Technology

When the starting premise is 'skill biased' rather than 'skill replacing' technological change, the key policy challenge is one of aligning education to the pace of technological innovation, as new technologies accelerate the demand for a more educated and agile workforce. Because labour can only maintain its scarce when in demand by employers, the focus is on the perennial question of what people need to learn to keep pace with technological change, often linked to concerns about those who may be left behind. Klaus Schwab, the founder of the World Economic Forum, predicts a rise in 'ontological inequality', separating those willing to adapt and those who resist change, 'we may witness an increasing degree of polarization in the world, marked by those who embrace change versus those who resist it' (Schwab 2016:97).

Brynjolfsson and McAfee suggest that in the United States, 'the stagnation in median income is not because of a lack of technological progress. On the contrary, the problem is that our skills and institutions have not kept up with the rapid changes in technology' (2012:6). This problem of 'alignment' has given rise to its own vocabulary including 'skills mismatch', 'skills gaps', 'skills shortage', etc. based on a neoliberal view of market equilibrium, which is treated as the 'normal' and 'desirable' situation when the market supply of people and the changing demand for specific kinds of workers are matched. The fact that this is not often the case is typically explained in terms of a race between education and technology (Tinbergen 1974).

Increasing wage inequalities between those with a college or university degree and those with a high school education in the United States, are also explained in these terms. When there is a shortage of suitably qualified people to respond to skill-biased technological change the college wage premium increases. Likewise, widening access to higher education is believed to have the opposite effect. It's assumed that by increasing the number of high skilled workers the college wage premium will decline. 'In explaining US educational wage differentials across the twentieth century, educational wage gains and overall wage and income inequality have closely followed changes in educational attainment against a backdrop of increased relative demand for more-educated workers from skill-biased technological change (SBTC)' (Autor, Goldin and Katz, 2020:1).

Moreover, despite the fact that some of the proponents of labour scarcity have pointed to significant disruption to business models and employment practices, including the threat of

labour substitution resulting in workplace automation, and despite much talk about the disruptive potential of digital technologies, influential commentators remain convinced that, as in the past, new positions and professions will emerge to replace any jobs lost in the current period of disruption.

'I am convinced that talent, more than capital, will represent the critical production factor. For this reason, scarcity of a skilled workforce rather the availability of capital is more likely to be the crippling limit to innovation, competitiveness and growth' (Schwab 2016)

While there are different interpretations of how education should be reformed to create an agile and employable workforce, it is also assumed that with the right reforms there are jobs for people providing there is a complementary relationship between humans and machines. This involves refocusing education on the cognitive and non-cognitive skills that are difficult to automate.

Brynjolfsson and McAfee (2012) illustrate this way of thinking, 'In medicine, law, finance, retailing, manufacturing, and even scientific discovery, the key to winning the race is not to compete against machines but to compete with machines. While computers win at routine processing, repetitive arithmetic, and error-free consistency and are quickly getting better at complex communication and pattern matching, they lack intuition and creativity and are lost when asked to work even a little outside a predefined domain. Fortunately, humans are strongest exactly where computers are weak, creating a potentially beautiful partnership.' (p.6) In a similar vein Levy and Munane (2013), present the challenge as one of 'dancing with robots', given that human beings are able to process and integrate many kinds of information, to solve complex problems, and handle unstructured tasks, which are beyond the current capabilities of computer technologies.

Even those such as Frey and Osborne (2013) who received significant media coverage after claiming that 47 per cent of the US workforce were threatened by automation, argue that it was primarily those in low-skilled, routine cognitive and non-cognitive roles, who were most at risk of technological unemployment and now in an urgent race to upgrade skills to take advantage of emerging job opportunities:

'Our model predicts a truncation in the current trend towards labour market polarisation, with computerisation being principally confined to low-skill and low-wage occupations. Our findings thus imply that as technology races ahead, low-skill workers will reallocate to tasks that are non-susceptible to computerisation – i.e., tasks requiring creative and social intelligence.' (Frey and Osborne 2013:45).[4]

However, an interesting theme is emerging around the future role of cognitive skills in defining what is scarce. There is a growing recognition that the scarcity value attached to cognitive skills such as literacy, numeracy or problem-solving, is being challenged by the very technologies that were supposed to drive the demand for a college-educated workforce.

In Autor, Goldin and Katz's (2020), *Extending the Race Between Education and Technology*, previously mentioned, they were forced to acknowledge the limitations of their approach but concluded it needed 'tweaking' rather than ditching (p.7). In claiming that it helps explain rising

[4] Andrew Haldane (2019: 10) makes a similar point: 'An 'adverse side-effect of technological disruption has often been rising levels of income inequality. Historically, those skilling-up to keep one step ahead of the machine saw demand for their skills rise and, with it, their wages. By contrast, those at the other end of the skills distribution saw their income fall, due to reduced demand and increased supply of their skills. The resulting rise in income equality has tended, historically, to heighten popular discontent and worsen social cohesion.'

wage differentials since the nineteenth century, they accept it needs to be 'augmented' to illuminate the recent evidence on, 'education returns and implied slowdown in the growth of the relative demand for college workers. Increased educational wage differentials explain 75 percent of the rise of U.S. wage inequality from 1980 to 2000 as compared to 38 percent for 2000 to 2017.' Even in their own terms, this represents a significant decline in the explanatory value of the theory as income inequalities increased more within the category of college educated, than between those with or without a college education.[5]

One explanation is the changing role of cognitive skills as a source of labour scarcity, recognized by Andreas Schleicher (2012, p.11) at the OECD, 'Many countries have seen rapidly rising numbers of people with higher qualifications. But in a fast-changing world, producing more of the same education will not suffice to address the challenges of the future. Perhaps the most challenging dilemma for teachers today is that routine cognitive skills, the skills that are easiest to teach and easiest to test, are also the skills that are easiest to digitalize, automate and outsource.'

But more recent work by the OECD has shown that there is little evidence to support claims of a significant shift in the use of higher-level skills, such as literacy skills. Elliott, (2017) has shown that almost two-thirds of the workforce across OECD countries, are operating with cognitive skills (literacy, numeracy and problem solving with computers), that digital technologies are close to emulating.[6] This leads him to conclude that although there is evidence of an increase in the use of literacy skills since the 1990s:

'This primarily reflects increased use by workers with low or moderate levels of proficiency. These findings contrast with many analyses in economics that use wages to measure skill and conclude that more workers now work with high skills because more now have jobs with high wages. That interpretation of the economics findings appears to be incorrect, at least with respect to literacy skills (Elliott, 2017: 13). In other words, if there is a race between education and technology, the primary focus on cognitive skills as the defining source of labour scarcity no longer holds, and points to a changing definition of high skills work. Elliott also concludes that the employment prospects for most adults one or two decades from now 'will increasingly depend on other types of skills', not measured by the current focus on cognitive skills (Elliott, p.15).[7]

This fundamentally challenges the role of cognitive skills in definitions of labour scarcity. It has also led to claims that the historical emphasis on cognitive skills ('heads') rather than 'hands' (technical) or 'heart' (emotional labour), may be reversed. Haldane (2018:10) argues that in earlier industrial revolutions 'the skills workers needed to keep one step ahead of the machine

[5] The reasons for this are discussed in Brown, P., Lauder, H. and Cheung, S.Y. (2020).

[6] Elliot uses the OECD's Survey of Adult Skills as part of the Programme for the International Assessment of Adult Competences (PIAAC) to assess changes in skill demand since the 1990s and to assess how advances in attempts to reproduce all human skills with computer capabilities will change skill demands in the near future. When the use of cognitive skills (literacy, numeracy and problem solving with computers) in the survey of adult skills is compared with expert assessments of advances in computer capabilities, they found the following: 'The expert assessment showed that 62% of workers in OECD countries use the PIAAC skills on a daily basis at work but with proficiency at a level that computers are close to reproducing. Only 13% of workers now use the PIAAC skills on a daily basis with higher proficiency than computers. The other 25% of workers do not use the PIAAC skills on a daily basis at work.' (p.14)

[7] 'To figure out what policy responses will be helpful in the years ahead, we need to assess computer capabilities across all skills used at work', not just those cognitive skills assessed in OECD studies. Elliot, 2017:15.

were largely cognitive.'[8] Here Haldane raises the prospect of non-routine cognitive skills also being performed by artificial cognition:

'The future could well be very different…the dawning of AI means that humans will no longer have the cognitive playing field to themselves. Thinking or non-routine tasks may increasingly be taken up by machines. They will be able to process more quickly, more cheaply and with fewer errors than their human counterpart, at least in some activities. That could make the hollowing-out of human tasks, now cognitive as well as manual, far greater than ever before.' (p.12)

Haldane suggests that there will still be a role for those engaged in cognitive tasks that use creativity and intuition, especially where 'great logical leaps of imagination' are required 'rather than step-by-step hill-climbing.'[9] Yet by implication the proportion of the workforce require to think ('heads') for a living may be far smaller than previously anticipated as we will go onto explain. He also suggests that a second area of prospective demand for humans is bespoke design and manufacturing ('hands') as it has proved difficult for computers to do non-routine technical tasks, including the manufacture of luxury goods, rare art and artefacts and independently produced foodstuffs and beverages.[10] While important the biggest potential growth area of all according to Haldane are areas of employment requiring social skills ('hearts'). This is because it's difficult for robots to replicate emotional intelligence, such as empathy, relationship building, or resilience and character, rather than cognitive intelligence alone. 'Professions involving high degrees of personal and social interaction – such as health, caring, education and leisure – could see demand rise. Indeed, it is possible the balance between cognitive and social skills might alter significantly even among jobs which traditionally have been cognitively-intense.' (Haldane, 2017:16).

The implications of this for labour scarcity theory, including the race between education and technology, are left largely unexplored by Haldane. But if the fourth industrial revolution is characterised by a fundamental shift in the role of cognitive skills, for which more evidence is clearly required, it would have far-reaching implications for education and the future of work.[11] It presents a fundamental challenge to orthodox human capital assumptions, that increasing investment in higher education is the route to individual prosperity and national economic growth. We will return to these issues, but next we outline an alternative theory of job scarcity.

Education and Job Scarcity in the Fourth Industrial Revolution

The theory of job scarcity offers a different way of understanding the relationship between education and technology. Even before the sharp increases in joblessness following the recent global pandemic, trend data highlight a major capacity problem at the heart of western economies in failing to create the kinds of jobs people want and have been trained for. This

[8] Haldane (2019), 'During the first three Industrial Revolutions, the skills workers needed to keep one step ahead of the machine were largely cognitive. Machines undertook largely manual ("doing") tasks, which had previously used labour-intensive technologies. Cognitive ("thinking") tasks remained, by and large, the exclusive domain of humans. So institutions emerged to nurture thinking skills, largely in children and young adults, to increase the chances of successful transition to the cognitively-intensive future world of work.' (p.10)

[9] Ibid. Haldane, 2019:15.

[10] Ibid. Haldane, ibid. p.16.

[11] This raises some interesting questions about gender, given that so-called 'heart' work has traditionally been associated with female labour and typically lower waged.

capacity problem not only results from the substitution effects of automation, but from the way new technologies are used in job redesign to limit 'permission to think' to a relatively small proportion of the workforce (Brown, Lauder and Cheung, 2020). It also results from increasingly precarious models of employment, reflecting the use of new technologies to introduce 'agile' work practices. But there is nothing inevitable about these trends.

The fourth industrial revolution is not only defined by the latest stage in technological development - creating more and better jobs than it destroys - but by a transformation of the division of labour under market capitalism. It rejects the analogy of a race between education and technology, as an example of technological determinism that leaves little conceptual space for alternative understandings of technology and the future of work.

Schumpeter aptly describes the central character of capitalism as a 'perpetual commotion' in the relentless pursuit of new markets, new consumers, new goods, new ideas, new methods of production, new advances in transportation and logistics, and new forms of work organization (1943:84). It is the powers of creative destruction, as well as the destruction of the creative, that holds the key to understanding any industrial revolution (Brown, et al., 2011).[12]

Notwithstanding rapid advances in digital technologies, we have not entered a unique age of technological invention, but rather an age of unravelling, unbundling and recombination.[13] A study of American patents from 1790 to 2010 found that in more recent times most patents involved the recombination or refinement of existing combinations of technologies rather than the creation of new technological capabilities. In part reflecting the infinite space of technological configuration in today's world.[14]

This does not ignore the value of research and development in the creation of new markets for goods and services, or the major advances currently being made in universities and research establishments around the world. But the general-purpose applications of digital innovation, involves new ways of recombining existing practices to create novel products and ways of making and doing things. Therefore, its impact is across the whole economy and wider workforce beyond 'knowledge' workers, that have dominated policy debates on the future of work.

Jeremy Rifkin (2014), Paul Mason (2015), along with others, suggest that AI and automation are already revolutionizing the productive economy, and therefore our understanding of the

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[12] The idea of the destruction of the creative relates to the attempt to scale innovation through standardizing and modularising the labour process. J.Tate argues that industrial revolutions are revolutions in standardization, see Chapter 5 Digital Taylorism, in Brown, P. Lauder, H. and Ashton, D. (2011) *The Global Auction.*

[13] See *Now and Then – The Process of Invention*, The Economist, April 25, 2015, and Hyejin Youn, Deborah Strumsky, Luis M. A. Bettencourt and Jose Lobo, 2015 *Invention as a Combinatorial Process: Evidence from US Patents*', Interface, 12, pp.1-8. https://www.economist.com/science-and-technology/2015/04/25/now-and-then
It's important to study unravelling/unbundling as integral to recombination/renewal as it's part of the same process. Indeed, digital technologies bring these processes closer together. See the discussion about the triple helix of education, jobs and rewards below.

[14] This highlights the fact that process innovation is every bit as important as new market products/services. The Economist article cited above also notes the decline of the hero or superstar inventors, but there is a wider point here because most innovation is not of the step-change or radical variety but incremental (refining; rearranging, repurposing) that flourishes when there is a culture of innovation. See Phillip Toner (2011).

impact of technology on the future of work. For Rifkin the transformation of the workplace is part of a more profound shift in capitalism's ability to raise productivity to the point that it approximates what economists call the 'optimum general welfare' where the cost of producing additional products and services has 'zero' marginal cost (p.2-3).

To put this differently, it means that the profits typically made by those involved in delivering a college course, publishing a book, or making products, are eliminated because of the declining cost of communicating, manufacturing and selling. Rifkin suggests that over a third of the world's population are already producing their own information on relatively cheap smart phones and computers which they can share via video, audio and text at near zero marginal cost.[15] Likewise, Paul Mason concludes that 'the real danger inherent in robotization is something bigger than mass unemployment, it is the exhaustion of capitalism's 250-year-old tendency to create new markets where old ones are worn out' (2015:175).

We do not need to subscribe to the view that we are moving to a world of zero marginal cost or the end of work to recognise that however the fourth industrial revolution is defined it has major implications for our understanding of work and the future of labour markets. Even when we take account of emerging occupations, including cyber security, software engineering, data analytics, Internet influencers, etc., it does not resolve the fundamental problem of job scarcity and the increase in social congestion that now characterize the labour markets of both developed and emerging economies.[16]

Technology is Not Fate

Digital innovation is an enabler but does not define what is to be enabled. It's not only a question of how complex or smart (ro)bots are becoming, but how the latest advances in technologies are used by companies, governments and the wider population. Whether corporate executives wear a tie, trouser-suit or tee-shirt they are playing by the rules of the market, and there is little evidence that corporate leaders in tee-shirts are any less profit oriented or prone to monopolistic behaviour than previous generations of business leaders who wore pin-striped suits. This is why it is never simply a question of substituting robots for people because it depends on what 'commands a decisive cost or quality advantage' (Schumpeter, 1943:84).

This explains why companies will not only focus efforts on automating those in low skilled, low waged jobs. Indeed, what constitutes 'routine' work is not as straightforward as the idea of 'low skilled' employment tends to suggest. Occupational projections offer little evidence routine jobs are going to experience a significant decline in the coming decades, as many involve service-based roles requiring manual dexterity and/or human empathy that are difficult to automate at a market price.

What has received less attention is the rise of digital Taylorism (Brown, et al. 2011), where companies adopt new technologies to restructure professional and managerial work, given labour costs are much higher. This reminds us that dancing with robots can be painful for all

[15] According to Rifkin it is no longer credible to argue that productivity creates more jobs than it replaces, as 'much of the productive economic activity of society is going to be increasingly placed in the "hands" of intelligent technology, supervised by small groups of highly skilled professional and technical workers' (Rifkin 2014:129). Therefore, it is claimed that advances in machine intelligence, robotics and advanced analytics, holds the prospect of 'liberating' hundreds of millions of people from work in the market economy in the next 20 to 30 years (Ibid. 121).

[16] For an analysis of 'social congestion' and its relationship to positional competition in education and labour markets, see Brown (2013) and Brown, Lauder and Ashton (2011).

workers regardless of skill levels (Souto-Otero, Freebody & Brown, 2021). It also points to a need to study abstract ideas about skill-biased technological changes and its relationship to education, in a more grounded, contextual way, to truly understand how the future of work in taking shape in today's private and public sector organisations.

Digital Taylorism and the Re-stratification of Knowledge Work

The future of high skilled work is central to the claim of a race between education and technology. We've seen how cognitive abilities, as a defining characteristic of high skilled work is now in question, but the theory of labour scarcity has little to say about the redesign of knowledge work. The main focus has been on 'hollowing out' of middle-income jobs, premised on skill-biased technological change (SBTC) which anticipates retraining for higher skilled job opportunities.

Job scarcity theory recognises a significant difference between the scientific and skills content of labour leading towards averaging or towards polarization (Braverman 1974:). Therefore, we need to ask if digital technologies are being used to increase the demand for skills at all levels of the occupational structure or to the segmentation and re-stratification of knowledge work? If it's the latter, then we can anticipate increasing job scarcity as the opportunity to use individual discretion and non-routine cognitive skills is concentrated at the top of organisational hierarchies.

This underlines the point that job scarcity not only results from the full automation of jobs but also from changes in job redesign. New technologies enable new forms of command and control by using digital software to capture knowledge and automate business processes (Brown et al. 2011). There is no inbuilt tendency for digital innovation to utilise and reward the skills of all rather than a few.[17] Following Standard and Poor Global's acquisition of IHS Markit - a UK financial analytics company - in a $44bn deal, Doug Peterson, S&P Global's CEO observed, 'Cleaning, processing, and managing data using technology to enhance the speed and processing power, and then putting the tools *in the hands of decision makers is what makes an information age powerhouse.*'[18] There is little evidence here of a democratization of big data to increase the discretionary powers of the workforce, but innovative tools for decision-makers to exploit new found powers of knowledge capture.

Indeed, if Frederick Winslow Taylor was alive today, he would look at the relationship between jobs and technology differently to the way economists have studied issues of labour substitution. Taylor's *The Principles of Scientific Management* (1911) provided the human engineering principles for large scale mass production characterised by the Fordist production. What can be called *mechanical Taylorism* stands in contrast to the *digital Taylorism* of today. Mechanical Taylorism involved the knowledge of craft workers being captured by management, with a view to identifying what aspects of the labour process could be mechanised. It also involved completely re-engineering the way manufacturing was organised in the shape of the moving assembly line. Only then were attempts made to scientifically measure the 'one best way' of using labour through time-and-motion studies, maintaining a

[17] The relationship between technologies and jobs needs to be studied within a wider context of business strategy, rather than in abstract studies of the potential for new technologies to substitute for human labour in different occupational roles. This also helps us to grasp the limitations of much of the recent research on automation and the risk of technological unemployment, because its focus is on occupations or job tasks rather than starting with the question of what companies are doing to improve productivity, increase market share or widen profit margins.

[18] Robin Wigglesworth and Eric Platt (2020) 'S&P Global's $44bn deal shows data is the oil of the 21st century', Financial Times, 1st December. https://www.ft.com/content/cd99579c-e01f-a71-a124-e9c03598e5b9 [Accessed: 6 January 2021]. Emphasis added.

clear separation between conception (managers and engineers) and execution (semi-skilled and unskilled labour).[19]

Today, *digital Taylorism* involves translating *knowledge work* into *working knowledge* through the extraction, codification and digitalisation of knowledge into software prescripts and templates that can be transmitted and manipulated by others regardless of location (Brown, et al. 2011). The same processes that enabled cars, computers and televisions to be broken-down into their component parts, manufactured by companies around the world and configured according to local customer specifications, have been applied to jobs that do not depend on face-to-face interactions with customers, clients or patients in the service sector.

The result is a further separation between conception (thinking) and execution (doing). When applied to the work of managers, professionals and technicians, it raises fundamental questions about the future of 'graduate' and professional work, especially when the coordinating power of big data are restricted to a relatively small proportion of the workforce who continue to enjoy 'permission to think' for a living, and in a context where advances in AI present a significant 'cognitive challenge'. Therefore, rather than the 'hollowing out' of the labour market, it reflects a fundamental shift in the character of managerial, professional and technical level jobs (and the relationship between learning and earning). Many jobs in the future may not live up to the expectations of an increasingly well-qualified workforce, despite the proponents of labour scarcity claiming that automation and AI will result in people moving into more interesting and better paid jobs.

*Digital Workers and the Agile Workforc*e

Efforts to digitalise work content have developed into a flourishing industry around HR tech, aimed at making jobs, workers and labour markets increasingly 'visible', 'transparent' and 'benchmarked' in real-time.[20] Here digital Taylorism is not only characterised by the separation between conception (thinkers) and execution (doers) in the restructuring of knowledge work, but by changes in the employment relationship: what it means to be employed and in paid work.

It's usually assumed that machines are made in the image of humans. The Turing Test (named after Alan Turing) is often the starting point for discussions about whether AI can substitute for human intelligence, leading to research on artificial cognition in learning, reasoning, perception, problem solving and language development. But if machines are being made to resemble humans, humans are being made to be more like machines, as data visualisation tools offer new possibilities for companies to re-imagine the workforce.

Human labour is under the digital scanner as never before. There are various attempts to codify people into units of skills, competences, and experience, to be recombined, indexed and evaluated as 'agile' employees to perform specific, on demand, tasks.[21] This is because

[19] Braverman (1974) and Drucker (1993) offer opposing views of Taylor's contribution.

[20] To reap the benefits of digital technologies in expanding global markets, transnational companies needed to find new ways of aligning business practices across national borders. They needed to codify business and labour processes, as well as streamline computer software systems and digital platforms on a global scale (Brown, et al. 2011). The rise of digital Taylorism led by western transnational companies, was intended to take advantage of advances in ICT, enabling them to extend corporate value chains from manufacturing to services and to benefit from labour arbitrage, moving more skilled jobs to lower cost locations.

[21] Here jobs and tasks can be unbundled and recombined in modular form, where companies and workers seek to capitalise on digital spot markets for human labour.

companies are looking to *deploy* labour rather than *employ* labour, or to deploy the labour it contracts with in more cost-efficient ways.

In the absence of data visualisations tools, it was more cost effective to bring people together in factories and offices. It was also much easier for companies to buy large chunks of an employee's time, and in some cases career, to have workers on-tap when required.[22] This standard model of regular employment was also associated with a bundle of commitments and entitlements, including pensions, paid vacations, and job security. The Head of Future Strategy for a global telecoms company told us the very idea of employment was 'pretty dumb', 'I gather together a group of people who can do certain things in the vain hope I'm going to have something for all of them to do and it will be the thing that they are capable of.'

It was then suggested, 'wouldn't it be better for businesses to deal with the thing that they really know about which is what they need to get done.' Rather than pulling in people and giving them work why not specify your requirements and 'seed it out and say who wants to do this?' This was thought to give the company access to a much larger talent pool and to 'stimulate all kinds of inclusion' as many more people in different circumstances and locations could bid for work. But a deployment model of the future of work is only possible due to the creation of digitally enhanced HR and highly flexible labour markets.

The growth of business and labour market platforms, illustrates this unbundling of labour contracts and the recombination of technology and human labour, leading to an increase in 'gig' jobs, crowdsourcing, etc. (Srnicek, 2017), where in theory everyone around the world becomes a sole trader. Digital platforms now offer real-time connections between buyers and sellers with no formal labour contract for those driving an Uber or Grab taxi (although there are national variations in labour law).[23]

However, the distinction between gig and 'on demand' jobs, as opposed to regular employment is increasingly blurred. This is important because the proportion of the workforce involve in gig work is relatively small although growing. But if companies seek to take advantage of data visualisation tools to give them much greater flexibility over the use of labour time, the implications for the future of work are far-reaching. The level of granularity offered by the curation of 'big data' gives new meaning to the idea of a detailed division of labour, dating back to Adam Smith's manufacturer of pins. Indeed, the principles on which today's detailed division of labour are based remain remarkably consistent.

Charles Babbage (1832), the inventor of the 'difference engine' for mathematical calculation in the 1800s, extended Adam Smith's original analysis of the detailed division of labour

[22] Today's redefinition of work within organisations is intended to provide more 'flexibility' than previous distinctions between a core and peripheral workforce – a shift from flexibility to agility.

Offshoring more valuable parts of global value chains to reduce costs also relates to the way technologies can be used to reduce costs and increase flexibility in the use of labour.
There may be some downtime, time spent on none optimal or less profitable activities (perhaps to fill time or due to inefficiency), along with the social and legal conventions associated with a contract of employment. Hence, using new technologies to unbundle/recombine different models of employment need to be studied to see how new technologies can lead to changes in job content that sustain or improve job quality.

[23] Creating new opportunities for waged work by giving more people an opportunity to start trading as, for example, a taxi driver taking paying customers, may also undercut the labour standards of existing taxi drivers and companies. In cities such as London, GPS technologies replaced 'doing the knowledge' of black cab drivers, as a detailed cognitive map of the city is no longer needed to get passengers around the city's complex road system.

involved in manufacturing pins, showing how it was possible to make additional savings by ensuring that the contribution of more educated or better-paid workers should never be 'wasted' on tasks that can be performed by others with less training or on lower-wage (Braverman, 1974:318).[24] This led Babbage to conclude, 'the effect of the division of labour, both in mechanical and in mental operations, is, that it enables us to purchase and apply to each process precisely that quantity of skill and knowledge which is required for it: we avoid employing any part of the time of a man who can get eight or ten shillings a day by his skill in tempering needles, in turning a wheel, which can be done for sixpence a day; and we equally avoid the loss arising from the employment of an accomplished mathematician in performing the lowest processes of arithmetic' (Babbage, 1832: 162).

Here people are hired to fulfil specific tasks, perhaps as part of a project team, such as those often used in making TV programmes, films or computer games, rather than being employed to perform a wider occupational role, either inhouse through 'agile' working practices or through outsourcing and offshoring.[25] Therefore, the same granularity applied to make organisations more agile are also applied to human labour, where individual skills and experience need to be indexed, badged (micro-credentialised) and authenticated.[26]

Such developments are often presented as consistent with the aspirations of tech savvy youth, who are seen to want to engage with employers to sell their skills in performing a specified task or role rather than being employed by them (Gratton and Scott, 2016). Hence the benefits of individual flexibility are highlighted rather than the high levels of job insecurity which may result.

Unilever's global digital reward system is at the forefront of such developments with a twofold mission of offering 'flexibility to employees by personalising rewards to their individual life needs; and, provide employers with insight and clarity through digitisation and consolidation of all reward into a single, real-time, integrated global environment.'[27]

This granularity applied to the labour process and reward systems is also applied to labour markets, aimed at getting a 'real time' understanding of changing employer skill requirements and job openings. Job postings are codified to create indexes of job-related skills and risk assessments of automation, to provide real time information to job seekers, employers and policy makers. This has led to the creation of self-service tools for school and college leavers as well as other job seekers looking to change industries.

The promise of this kind of granularity is more flexible training provision so people can reconfigure their skill sets in preparing to move between occupational or project roles, such as accountants who lose out to automation, retraining to fill identifiable skill shortages in cybersecurity firms, without the need for years of additional training. This changes the way both sides of the labour market interact, sometimes with unwelcome implications, such as

[24] The primary purpose is not 'divide and rule' which was a primary focus of Braverman's (1974) focus, but 'divide and prosper' as Babbage (1832) clearly understood, 'The pins would therefore cost, in making, three times and three quarters as much as they now do by the application of the division of labour'.

[25] The separation of work and place applies across global value chains as 'plug and play' on an international scale becomes a genuine possibility given the alignment of technological applications, business practice and 'agile' employment contracts.

[26] Head, hand and heart of workers are being converted into predictive analytics, which could be linked to spot markets for skills on digital labour market platforms or inhouse intranets.

[27] See https://www.uflexreward.com/ [accessed 6 June, 2020].

when Amazon deciding to scrap its AI recruitment tool when it was shown to discriminate against female applicants.[28]

While job scarcity theory turns the lens on the future of labour demand, it's characterisation of the future of work is not inevitable. The creation of new digital tools of industrial transformation don't define how they will be used in redefining the role of education, work and wealth creation. But it does present the challenge to how to get a better understanding of the opportunities and challenges of the fourth industrial revolution.

Conclusion

This working paper examines some of the key theoretical and policy issues as nations enter a fourth industrial revolution. It's argued that what is truly 'revolutionary' about today's technological, economic and social developments remains to be seen, but there is little doubt that we are living through a period of rapid transformation. Current uncertainty about the speed, scope and direction of change is not helped by a lack of robust evidence on the impact of AI and automation on the future of work. But we do not anticipate the 'end of work' anytime soon, even if less human labour is required to deliver future improvements in productivity.

This analysis also suggests that a better future of work will not be achieved unless we plan for it. Digital technologies are an enabler, leaving open decisions about what technologies to use and the way they are implemented. Such decisions will have an important bearing on the future of work, as employers in both the public and private sectors can use technologies in different ways to substitute, standardize or augment human labour, rather than digital innovation simply reflecting the limits of technological possibilities.

How we plan for the future will depend on the underlying theories that shape our assumptions about the changing relationship between education and work. When viewed through the lens of 'labour scarcity' - which has framed national and international policies on education and work for at least fifty years – the primary policy challenge is a (mis)alignment issue in a race between education and technology. Here policy debate is limited to finding better ways to prepare people for the new world of work, along with better ways to anticipate the future 'needs' of industry.

Alternatively, when viewed from a 'job scarcity' lens the policy implications look different. Restricting policy to alignment issues underestimates the scale and scope of the current 'disruption', although there are important questions to be asked about the future of education, skills and employability. Indeed, both theories recognise the need for major education reforms, even if they have very different views on its individual and labour market consequences.

Through a job scarcity lens the major policy challenge is a capacity problem of creating enough jobs of sufficient quality to match the expectations of an increasingly well-qualified workforce, as there is no inbuild tendency for digital innovation to utilise and reward the skills of all rather than a few.

Job scarcity points to a need for a holistic and contextual policy approach, including a recognition that there may be labour shortages requiring supply-side solutions. Indeed, whether *skills* or *jobs* are 'scarce' (or some combination of both), needs to be assessed in different organisational, industrial and national economic contexts.

Changes in the relationship between education, jobs and rewards also need to be studied in relational terms, as interconnecting strands rather than different fields of policy analysis. To

[28] See Andrew Burt (2019) The AI Transparency Paradox, Harvard Business Review, December 13, https://hbr.org/2019/12/the-ai-transparency-paradox

understand how these strands can be reconfigured in ways that are more human centric and inclusive, requires us to find new answers to longstanding question in the fourth industrial revolution.

Education – 'Who learns what (and when)'?

In the last century the question of 'who shall be educated' (Warner, Havighurst and Loeb, 1946) was answered by making education a universal human right (UNESCO, 2015). Many countries have achieved mass if not universal higher education (Trow, 1999). But how to prepare people within a universal system of education for different positions within a highly stratified division of labour has never been resolved. The focus on giving people an 'equal chance to be unequal', by trying to make the competition fairer, and holding out the prospects of intergenerational social mobility as a mode of social advancement are not without merit – especially in countries experiencing high levels of economic growth.

Equally, the widely held view that industrial development is characterised by an ever-tighter relationship between education, jobs and rewards is challenged by growing concerns about the scale of educational inequalities across the life-course, given an increasing emphasis on lifelong learning opportunities. This includes issues of how to reduce systemic inequalities fuelling a digital divide based on socioeconomic disadvantage, gender, race and age. A divide often presented in terms of access to digital 'tools' (wifi, laptop, etc.), and employability skills, that enable people to participate in a rapidly changing digital world.

But issues of who learns what (and when) in the fourth industrial revolution is already evident in debates about the future of higher education. While some labour scarcity theorists take it for granted that skill-biased technological change will increase the demand for graduate labour, others point to serious failings of educational reform. Caplan (2018) claims that the rapid expansion of higher education in America led to a proliferation of courses offering little market worth and poor value for money to student, parents and government, given a mismatch between what many students learn and the realities of the job market that does not require as many university-educated workers as commonly supposed.

We've also described a *cognitive challenge* to human labour posed by AI and (ro)bots, leading some to call into question the social status attached to a university education and the market advantages attached to cognitive abilities. Goodhart (2020) argues for a rebalancing of the relationship between 'head', 'hand' and 'heart' work, that would give greater priority to more vocationally relevant courses, taught in more cost-effective ways (such as online) and often at a sub-degree level. But the danger here is one of proposing educational policies for other people's children, when the real vocational prizes remain monopolized by those with a university education.

Entering the fourth industrial revolution also highlights a fundamental tension between organising education around the purported needs of industry as opposed to the needs of individuals to live meaningful and fulfilling lives.[29] Any decline in employer demand for

[29] While both approaches recognise a need to treat digital skills as integral to education rather than an add-on to existing curriculum or training content, it can no longer be assumed that all the talents will be absorbed in modern forms of work in a race against technology. The labour market does not reflect the innate distribution of talent. We hear that education needs to be tailored to meet the needs of industry, given the assumption that it can absorb human energies in increasingly self-fulfilling ways - the more advanced the tech the more skilled the workforce. The job scarcity view questions the assumption that work can be fulfilling for the vast majority of the workforce, and therefore reforming education to meet the needs of industry is consistent with the pursuit for individual fulfilment. If there is an increasing

cognitive knowledge and skills is not an excuse to 'dumb down' education for those unlikely to reach the higher rungs of the job pyramid.

Indeed, it can be argued that changes in the human-machine relationship require an extended definition of educational inclusion to address rapid advances in artificial intelligence and machine learning.[30] If more areas of economic and social life are being 'intermediated' through digital platforms and predictive analytics, rather than other human beings, it raises a question of how the 'social' in social inclusion can be preserved:

'In an age of machine learning, training humans to be 'smart machines', is an education in technological servitude. If machines come to do more of the work done by humans it is how we develop ourselves in a process of lifelong learning that offers the best chance of achieving productive wellbeing…It is the quality of our social relations, along with the quality of our machines, which holds the key to inclusive wellbeing and a vibrant economy (Brown, Lauder and Cheung, 2020: 221).

This requires policy analysts to go beyond questions of what humans can do better than robots or whether AI and automation will replace teachers, accountants, lawyers, soldiers, etc., to questions of what kind of society, workplaces, schools, or human being we want to create (and become) in the fourth industrial revolution. And if job scarcity comes to define the relationship between education and work, a significant proportion of those in paid work, as well as those locked out of it, may look for meaning and a sense of self-fulfilment beyond the workplace, especially given an increasing blurring of spatial distinctions between home, work, leisure, and learning (Gratton and Scott, 2016).[31]

Jobs – 'Who does what'?

For centuries waged labour has been at the heart of market capitalism (Polanyi, 1943). But what if there isn't enough paid work to go around, or enough of the jobs people have been qualified to enter? Today, the question of who does what job is not only one of finding efficient and fair ways of matching people to jobs, but the distribution of work itself.

Labour markets not only match individuals to job openings but manage scarcity. We've shown how this scarcity can exist on either side (or both sides) of the job market. Therefore, the structure of opportunity to translate skills and experience into paid work requires careful analyses because there is no automatic relationship between learning and labour market outcomes.

If the 4IR is characterised by job scarcity more of those with graduate qualifications could find themselves in precarious and less cognitively demanding roles, placing an added premium on job openings in companies looking to hire onto talent programmes where significant job opportunities and rewards continue to be offered. There is already extensive evidence that this is resulting in 'winner takes all' competitions, driving individuals and families to seek ways of achieving a positional advantage in the competition for the best schools, colleges,

separation between the kinds of skills/people companies want to hire and the kinds of lives people want to lead, the fourth industrial revolution will require a new reconciliation.

[30] This raises ethical issues around AI, and the extent individuals are (dis)empowerment to make a meaningful life-choices both inside and outside of waged work (Head 2014).

[31] Education will continue to play a crucial role, but the primary focus on 'frontloading' early years education (now extended to age twenty-five), which sees students banking their early years education to get them through to retirement, with some top-up courses along the way, is challenged by both the theories outline above.

universities and jobs, fuelling social congestion (akin to a traffic jam). Therefore, the race between education and technology presented by labour scarcity theorists may have the unintended consequence of inciting an unprecedented demand for higher education and contributed to educational and labour market congestion, with little hope of market correction through supply-side (educational) solutions.

If the future is characterised by high levels of congestion, it also challenges the meritocratic creed justified by what many have argued to be a reasonably close relationship between the distribution of job opportunities and innate difference in human capabilities (Brown and Souto-Otero, 2018). Adam Smith (1976 [1776]) reminds us that the distribution of labour market opportunities is not explained by the distribution of innate talent but rather the division of labour explains the character of human flourishing, 'The difference in natural talents in different men is, in reality, much less than we are aware of; and the very different genius which appears to distinguish men of different professions, when grown up to maturity, is not upon many occasions so much the cause, as the effect of the division of labour.[32]

Therefore, if the educational and labour market congestion found in many countries is not just an alignment issue of matching people to employers looking to hire them, but of matching an over-supply of qualified workers to an under-supply of job opportunity, how can the question of 'who does what' be resolved in a context of job scarcity?

One answer is to create more and better jobs. Encouraging job creation, including business start-ups, cooperative enterprise, and scaling existing companies, all have a role to play, but there is little evidence that jobs lost to automation will be replaced with more jobs of better quality and we cannot rely on the creation of unknown new sources of mass employment. But the above discussion also highlights the fact that private and public sector organisations have choices about how they introduce new technologies and whether they chose to use big data and AI to increase the analytical armoury of senior manager or executives or adopt more human-centric approach by augmenting the skills of the wider workforce.

The same issues are raised by the shift away from standard models of employment and towards an agile workforce. To what extent will employers exploit HRtech in an effort to reduce costs by moving to a transactional 'plug-and-play' deployment model, or can digital technologies lead to innovative approaches to job re-definition, re-design and re-distribution (including working hours), which work for all rather than a few?

Inequalities and opportunities to capitalise on individual skill utilisation in and through multiple jobs, projects, workplaces, and labour market platforms is therefore central to understanding the future of work and its relationship to education and lifelong learning. It is time to reimagine the division of labour and its relationship to current models of employment? But for most

[32] Adam Smith (1976 [1776]), pp.19-20. He continues, 'The difference between the most dissimilar characters, between a philosopher and a common street porter, for example, seems to arise not so much from nature, as from habit, custom, and education. When they came into the world, and for the first six or eight years of their existence, they were perhaps, very much alike, and neither their parents nor playfellows could perceive any remarkable difference. About that age, or soon after, they come to be employed in very different occupations. The difference of talents comes then to be taken notice of, and widens by degrees, till at last the vanity of the philosopher is willing to acknowledge scarce any resemblance. But without the disposition to truck, barter, and exchange, every man must have procured to himself every necessary and conveniency of life which he wanted. All must have had the same duties to perform, and the same work to do, and there could have been no such difference of employment as could alone give occasion to any great difference of talents.'

people (who have to work to earn a living) the answer will depend on wider distributional questions of income and wealth.

Rewards – 'Who gets what'?

The principle of people 'earning' a living through employment, and differences in earnings reflecting individual productive performance, remains at the heart of market capitalism (and national opportunity bargains based on human capital assumptions).

If the future is characterised by significant technological unemployment or job scarcity beyond the control of individuals to provide for their own economic welfare, it reopens the question of who gets what in the distribution of income and wealth. Such questions are already being asked given the scale of income inequalities in many countries characterised by 'winner takes all' market competition. There are growing concerns that much of the gains from improvements in productivity are being captured by executives and company shareholders at the expense of the workforce (Stiglitz, 2012). The incomes of 'super-managers' at the top end of national labour markets seem to bear little relationship to individual marginal productivity (Piketty 2014) or the idea that they have scarce skills that command an extremely high market price.

It has also left the contribution of those in non-graduate occupations unrecognised and undervalued. Indeed, the very idea of a 'non-graduate' has been widely used for the sole purpose of highlighting the benefits of getting an undergraduate degree, rather than being valued in its own terms (Keep and Mayhew, 2004). But Covid-19 is a stark reminder we've been valuing the returns to higher education at the expense of the contributions made by those who didn't go to university or are not in a 'graduate' job. It is also a stark reminder that we do not just live in a market but in a society, made up of a vast array of human needs as well as wants.

Millions of people (not restricted within national borders) are involved in meeting the basics of social life such as caring, nurturing, feeding, transporting, selling, protecting, etc. Many of these jobs are not going to disappear anytime soon and are vital to a civilised society, but they may not involve long periods of training or command a high wage.

The range of work activities found in all human societies does not neatly map onto models of employment. Some of the activities that may contribute to labour productivity, economic growth or human flourishing, are unrecognised or undervalued precisely because they are not judged to have economic value – they stand outside formal employment.

There is a hidden economy in which a lot of work, especially performed by women, goes unnoticed and unrewarded. We have been blinded from these realities by the idea that what people are paid reflects their level of education and social contribution (Brown, Lauder and Cheung, 2020).

In the fourth industrial revolution issues of inequalities in income and wealth are inextricably linked to issues of economic security. If the protective functions of wage work offered through standard models of employment are eroded to the point where they are creating high level of insecurity, alternative forms of income and social security will be needed. [33]This is already

[33] Indeed, we can see how the transaction costs of agile working (and the creation of an agile workforce) are being transferred from companies using labour deployment models onto individual sole traders or employees. If the economic security provided by regular employment is in decline a larger proportion of the workforce are unlikely to earn a living wage and experience frequent bouts of underemployment and/or unemployment.

leading to experiments with new models of flexicurity, including a universal basic income (UBI) to provide the foundations of economic security to individuals and families.

Reducing the need to earn would have profound implications for labour market participation and what we learn. Loosening the relationship between learning and earning could provide the foundations for extending individual economic freedom and removing some of the compulsion to earn a living.

In the 4IR it seems inevitable that more attention will need to be given to equality of condition, and to the substantive conditions of people's lives, rather than simply equality of opportunity, by offering people the chance to make something of themselves through occupational mobility. It will require reimagining much of what we take for granted about education, jobs and rewards. This is what is really at stake in the fourth industrial revolution.

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