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EDUCATION, OPPORTUNITY AND THE FUTURE OF WORK IN THE FOURTH INDUSTRIAL REVOLUTION

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Abstract

It is widely believed digital technologies are transforming all aspects of economy and society, driven by scientific advances across interdisciplinary fields and innovations relating to artificial intelligence (AI), machine learning, robotics, etc. But what, if anything, is revolutionary about these developments and what are the implications for the neo-liberal opportunity bargain based on a market competition where 'learning equals earning'. This article outlines different interpretations of the 'fourth industrial revolution' presenting contrasting theories of labour scarcity and job scarcity, to highlight why we need to rethink education, opportunity and the future of work in a context of increasing job scarcity. This is urgent not because we are approaching the end of work, but the end of 'knowledge' work as understood in public policy, with no viable solution to how to create in a new opportunity bargain for a fair and efficient future of work.

Key Words: Labour scarcity, Job scarcity, opportunity bargain, generative AI, digital Taylorism, zero-sum productivity.

Introduction

It is widely claimed we've entered a fourth industrial revolution (4IR) transforming all aspects of economy and society, driven by scientific advances across interdisciplinary fields and digital innovations in artificial intelligence (AI), machine learning, additive manufacturing (3D printing), distributed ledgers (blockchain), big data, and the internet of things (Schwab 2016). This article describes some of the key ideas informing current debates about technological innovation and its implications for the education-work relationship. It begins by looking at 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, before returning to the question of what is, if anything, is truly revolutionary.

Much of the policy literature is premised on a *labour scarcity* theory (Brown, Lauder and Cheung 2020) where new technologies are assumed to accelerate the demand for knowledge workers with tech savvy skills (Goldin and Katz 2008; Autor 2015).¹ Here educational reform assumes greater importance in ensuring the continuing

employability of the workforce as the 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.

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 because technology is not destiny. Rather than a shortage of people with knowledge and skills, job scarcity theory points to an increasing scarcity of good quality employment opportunities that challenge established assumptions about the 'knowledge' economy and role of education as an efficient and fair means for the distribution of opportunities, work and rewards (Brown, Lauder and Cheung 2020).

The central argument is that today's policy discourse is based on a flawed theory of the future of work, in urgent need of being reformulated not because we are approaching the *end of work*, but the *end of knowledge work*, as understood in public policy, with far-reaching implications for education, work and society.

Smart Machines and the Fourth Industrial Revolution

Within public policy, it is widely believed we have entered a new phase, stage, or period of economic development, qualitatively different from what has gone before. This has been variously described as a second machine age (Brynjolfsson and McAfee 2014), third industrial revolution (Rifkin 2011), digital economy (Unger 2019), or a fourth industrial revolution (Schwab 2016). Here 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'. Therefore, 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).

To date, much remains unknown about the speed and implications of change, exemplified by vastly different interpretations of the employment implications of automation (Frey and Osborne 2013; Arntz, et al. 2016). But 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), where the exponential increase in computing power is 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. 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; along with 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 generative AI, autonomous vehicles, distributed manufacturing using 3D printing, and rapid advances in supercomputers (including quantum computing).

Although much remains unknown there is little evidence we are 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. Moreover, 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. For this reason, it is important to contest the dominant idea of education and work in the fourth industrial revolution.²

Education and Labour Scarcity

The theory of labour scarcity is premised on the idea 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 whilst at the same time automation replaces routine low-skilled labour. It shares much in common with human capital theory (Becker 2006) and the idea of a 'knowledge economy' which continues to underwrite government policies around the world. Here knowledge workers are viewed as the key source of capital accumulation, as future productivity rests on the application of 'knowledge to knowledge' (Drucker 1993), leading to a transfer in market power from business owners to knowledge workers who 'own their knowledge and can take it with them wherever they go' (p. 7). The challenge presented by the labour scarcity approach, therefore, is how to use AI and related technologies, to amplify the full intellectual and creative abilities of the workforce.

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.' By investing in education and training it is believed that people will continue to acquire human capital that, due to its scarcity in the labour market, generates a flow of income over the career path (Autor, 2015, 28).

When technological change is viewed as 'skill biased' or 'routine biased' rather than 'skill replacing', the policy challenge is an *alignment* problem of reforming education to keep pace with technological innovation, driving an upwards demand for a more educated and agile workforce. This focus on what people need to learn to keep pace with technological change, is often linked to concerns about those who may be left behind. 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 alignment problem requires education and training to focus more on the cognitive and non-cognitive skills that are difficult to automate: '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.’ (Brynjolfsson and McAfee (2012, 6).

However, an interesting theme is emerging around the future of knowledge work and the role of cognitive skills in defining what is scarce. There is a growing recognition 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.

Andreas Schleicher (2012, 11) at the OECD argues, ‘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.’

The argument here is that we must move away from rote learning for routine jobs, and shift to preparing people to engage in cognitive tasks that use creativity and intuition, especially where ‘great logical leaps of imagination’ are required ‘rather than step-by-step hill-climbing’ (Haldane 2018, 12). Although the proportion of the workforce required to think for a living may be far smaller than previously anticipated, labour scarcity theory stops short of more radical proposals given an enduring faith in market capitalism and the wage-labour system to deliver a fair ‘opportunity bargain’ to the workforce, rewarding individual ability, effort, and productive contribution.

Indeed, the only losers are presented as those individuals who fail to embrace the opportunities to invest in digital skills (Schwab 2016); businesses who fail to take advantage of the productive benefits of AI, cloud computing, etc.; and governments that fail to build the required, AI safety regulations, digital infrastructure or digital skills of the workforce. 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 points to far-reaching implications for education and the future of work. To get a better understanding of this ‘cognitive challenge’ (especially to the neo-liberal opportunity bargain), we turn to the alternative theory of job scarcity.

Education and Job Scarcity

The theory of job scarcity rejects the claim labour market ‘mismatch’ is due to a scarcity of trained workers with the knowledge and skills needed to keep pace with workplace innovation. It rejects the claim new technologies increase the demand for knowledge workers, or that an increasing supply of educated labour leads employers to invest in new ways of exploiting any new supply of talents. It views the race between education and technology in reverse, highlighting major capacity problems as market economies fail to create the kinds of jobs people want, with wages matching the level of education and training (Brown, Lauder and Cheung 2020, 3).

A job lens is used to explain the cause and consequences of this structural mismatch, evident in both advanced and emerging economies. It does not ignore supply side issues because the ‘scarcity’ created by a lack of decent, well-paid jobs, is exacerbated by the growing portion of university graduates in the workforce. We will

show how various attempts are being made to address some of the symptoms of job scarcity, including credential inflation, underemployment, declining social mobility, graduate unemployment, and social congestion.

But they can't resolve structural problems of job scarcity because an increasingly educated workforce confronts a future of work characterised by 'smarter' technologies, that threaten the foundations of the neo-liberal opportunity bargain based on human capital ideas, including 'learning equals earning'. It is also 'hoist by [its] own petard' because it has narrowed education and training to an 'investment' in marketable skills that for many people are delivering very disappointing rates of return (Brown, Lauder and Cheung 2020).

An obvious suspect for explaining increasing job scarcity is automation resulting in widespread labour substitution, or what John Maynard Keynes called 'technological unemployment'. Jeremy Rifkin (2014) along with others, suggest AI and automation are already revolutionizing the productive economy, leading to job scarcity because we're approaching the end of work, as 'tens of millions of workers have already been replaced by intelligent technologies in industries and professional bodies around the world.'

Here he suggests the transformation of the workplace is part of a more profound shift in capitalism's ability to raise productivity to the point where the cost of human labour in the production and distribution of goods and services could 'plummet to near zero as intelligent technology substitutes for workers across every industry and professional and technical field, allowing businesses to conduct much of the commercial activity of civilization more intelligently, efficiently, and cheaply than with conventional workforces' (Rifkin 2014, 70). Likewise, Paul Mason concludes the real danger in what he calls 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 should not discount the future possibility of mass technological unemployment, but to date there is little evidence of an imminent collapse in waged work (Handel 2022). However, we do not need to subscribe to the end of work thesis to recognise the importance of job scarcity, because it's not so much capitalism's capacity to create new markets that's in danger, but its capacity to generate the kinds of employment opportunities needed to sustain viable labour markets in the twenty-first century. Job scarcity is not only an issue of job numbers but of job quality, requiring us to look beyond 'robots replacing humans' to understand the wider contours of work in 'knowledge' capitalism.

Taking the Thinking Out of Thinking: AI, Digital Taylorism and the Re-stratification of Knowledge Work

Technologies come and go but capitalism is the DNA of all industrial revolutions. Here, 'the fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production and transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates' (Schumpeter 1943, 83).

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). And whether corporate executives wear a suit or tee-shirt, they are playing by the rules of the market, with little evidence those 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. Therefore, the future of work is never simply a question of the limits of technological possibilities but depends on what 'commands a decisive cost or quality advantage' for business (Schumpeter 1943, 84).

As the productivity of knowledge became a key economic asset, companies not only focused efforts on automating those in low skilled, low waged jobs. Indeed, in many areas of work this has proved to be very difficult because what constitutes 'routine' work may require little formal training but requires manual dexterity and/or human empathy that are difficult to automate at a market price. They will also look for ways to capture, control and cheapen the price of 'knowledge' work (Brown, Lauder and Ashton 2011, 68; Susskind and Susskind 2015). Here evidence is compelling because despite the rise of mass higher education accelerating the global supply of graduate labour, the benefits of productivity have largely been captured by capital rather than 'educated' labour as we will go onto discuss. This is also reflected in the realities of 'winner-takes-all' markets leading to egregious inequalities in income and wealth (Piketty 2014).

In respect to education and the future of work, we need to ask if digital transformations are being used to increase the demand for knowledge and skills at all levels of the occupational structure, or leading to increasing segmentation and re-stratification of knowledge work? This draws on the distinction Braverman (1974, 425) made between the scientific and skills content of labour leading towards 'averaging' across the workforce or towards 'polarisation'. With polarisation resulting in the separation between conception (thinking) and execution (doing) applied to the work of managers, professionals and technicians.

This is a key question because digital technologies enable new forms of command and control by using digital software to capture knowledge and automate business processes (Brown et al. 2011, Head 2014). 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 automation and labour substitution. Taylor's *The Principles of Scientific Management* (1911) provided the human engineering principles for large scale mass production characterised by Fordist production in the twentieth century. The *mechanical Taylorism* of the past 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 aspects of the labour process that 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 clear separation between conception (managers and engineers) and execution (semi-skilled and unskilled labour).

Today, *digital Taylorism* involves translating *knowledgework* 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 mechanical platforms of Fordist mass production are an early forerunner to the digital platforms which now structure many aspects of industry and commerce. Amazon Web Services (AWS) describes how:

'Software and the Internet have transformed the world and its industries, from shopping to entertainment to banking. Software no longer merely supports a business; rather it becomes an integral component of every part of a business. Companies interact with their customers through software delivered as online services or applications and on all sorts of devices. They also use software to increase operational efficiencies by transforming every part of the value chain, such as logistics, communications, and operations. In a similar way that physical goods companies transformed how they design, build, and deliver products using industrial automation throughout the 20th century, companies in today's world must transform how they build and deliver software.'³

This hi-tech rationalisation of work organisation has no inbuilt tendency for digital innovation to utilise and reward the skills of all rather than a few. There is also little evidence of a democratization of the discretionary powers of the workforce, as the CEO of *Standard and Poor Global* clearly acknowledged on the \$44bn acquisition of a UK financial analytics company makes clear, they were buying innovative tools for decision-makers to exploit speed and processing power, 'putting the tools in the hands of decision makers' that 'makes an information age powerhouse.'⁴

Elliott (2017), has shown that almost two-thirds of the workforce across OECD countries, are already operating with cognitive skills (literacy, numeracy and problem solving with computers), that digital technologies are close to emulating. In other words, if there is a race between education and technology, the primary focus on cognitive skills as the defining source of '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, 15).

This challenges the historical emphasis on cognitive skills ('head') rather than technical(hand) or emotional (heart) work. Haldane (2018, 10) argues that in earlier industrial revolutions 'the skills workers needed to keep one step ahead of the machine were largely cognitive.' But advances in AI are revealing that 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).

Today, advances in 'generative' AI are widely viewed as a step-change in digital innovation, exacerbating the 'cognitive challenge' of job scarcity. It is generative because of its capacity to *take thinking out of thinking*, in creating 'content' including text, images and code, based on hundreds of billions of data points. At the time of writing, generative IA is typically of a generic kind, but will rapidly integrate data lakes of professional knowledge, with major implications for many areas of managerial and professional work, including teaching.

Sam Altman, CEO of OpenAI at the launch of ChatGPT observed, '2023: \$30,00 to get a simple iPhone app created, \$300 for a plumbing job. I wonder what those relative prices will look like in 2028! The likely coming divergence between changes to cognitive work and changes to physical work could be quite dramatic.'⁵

Knowledge Work and the Agile Workforce

If job content is part of any measure of job scarcity, it also includes working conditions, such as contracts of employment, as more waged work has become contingent with little job security. Efforts to digitalise all aspects of workforce planning, recruitment, talent management and rewards, have developed into a flourishing industry around HR tech. The aim is to make workers, jobs and labour markets increasingly visible, transparent and benchmarked in real-time. 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 treated 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 indexed, evaluated and recombined, as 'agile' employees to perform specific, on demand, tasks. This is because companies are looking to *deploy* labour rather than *employ* labour, or to deploy labour in more cost-efficient ways.

In the absence of digital platforms and 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 and their knowledge, on-tap when required. 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.'⁶

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. Yet, a deployment model of the future of work is only possible due to the creation of digitally enhanced HR and in countries with 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. (Srnicsek 2017), aimed at creating a large global supply of sole traders. Digital platforms including, Amazon Mechanical Turk, CrowdFlower, Freelancer, Upwork and Microworkers, offer real-time connections between buyers and sellers with no formal labour contract, although there are national variations in labour law (Berg, et al. 2018).

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 participating in gig work is relatively small although growing. But if companies seek to take advantage of data visualisation tools to give them 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 (1776). 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 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). 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', where employers pay for the skills involved in performing specific tasks, avoiding, 'the loss arising from the employment of an accomplished mathematician in performing the lowest processes of arithmetic' (Babbage 1832, 162).

Today, a similar approach is being applied when hiring people to fulfil specific tasks, rather than employing them to perform a more widely-defined occupational role, either inhouse through 'agile' working practices, or through crowdsourcing, outsourcing, or offshoring. 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 (Wheelahan and Moodie 2021a).

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 rewards into a single, real-time, integrated global environment.'⁷

In the labour markets, a focus on skills rather than qualifications is 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, college and university leavers, as well as other job seekers looking to change industries, as part of creating a 'job ready' workforce, armed with up-to-date skills linked to micro-credentials, for the performance of specific tasks.

The promise of this kind of granularity is more flexible training provision, which might also enable people to 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. Amazon, for example was obliged to scrap its AI recruitment tool when it was shown to discriminate against female applicants (Burt 2019; Souto-Otero and Brown 2024).

While job scarcity theory turns the lens on the future of labour demand, as noted above this characterisation of the future of work is not inevitable. Although there is little evidence companies are moving away from a cost-reduction model, the creation of digital tools for industrial transformation, doesn't define how they will be used in shaping the future of work or how the workforce will be educated.⁸

Rethinking the Neo-Liberal Opportunity Bargain: What Is Truly Revolutionary?

What is truly 'revolutionary' about today's digital and social transformation remains uncertain, as 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...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, yet it also needs to be weighed against the fact that how we define the future, shapes the future. Even without the benefit of hindsight, our analysis suggests that education for a better future of work will not be achieved unless we contest 'labour scarcity' theory which has framed national and international policies on education and work for at least fifty years. Policy debates continue to be limited to a (mis)alignment problem of finding

better ways to prepare people for the new world of work, along with better ways to anticipate the future ‘needs’ of industry. But restricting policy to alignment issues underestimates the scale and scope of the changing contours of market capitalism, and the prospects for education, opportunity and social mobility.

Job scarcity theory does not anticipate a revolutionary ‘end of work’ anytime soon - even if less human labour will be required to deliver future improvements in productivity. It does anticipate a future of work that challenges the viability of the neo-liberal opportunity bargain, based on a linear progression towards a high skilled, high waged workforce.

What does have revolutionary implication, at least for the education-work relationship, is the transformation of knowledge work as we enter an era of generative AI where knowledge is not only captured in software, reducing ‘permission to think’ to a relatively small proportion of the workforce, but where it provides ‘answers’ for actionable decision-making (Crawford 2021). Therefore, if professional and managerial services can be redesigned on ‘smart’ platforms and applications (incorporating content generation), and when *thinking is taken out of thinking*, what is the future of knowledge work when a growing number of cognitive tasks are susceptible to advances in AI and machine learning, includes jobs such as teaching, designing, programming, etc., that were previously viewed at ‘low risk’ of automation (Frey and Osborne 2013)?

This poses a ‘cognitive challenge’ to the neo-liberal opportunity bargain, and much else besides, because as we’ve seen all industrial revolutions to date are characterised by a rising proportion of the workforce requiring the development of individual cognitive abilities linked to domain knowledge, to enhance the productivity of a more complex technological society. But today, we are at a tipping point. The race between education and technology is reversed, and 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.

In reimagining a new opportunity bargain in a context of job scarcity, we can address three interrelated questions shaping the education-work relationship, ‘who learns what (and when)?’, ‘who does what?’, and ‘who gets what?’

1. 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 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 was never resolved. The focus on giving people an ‘equal chance to be unequal’, by attempts to make the competition fairer or meritocratic, through intergenerational social mobility, has become even less viable in a context of job scarcity, because sociological evidence shows how much of social mobility recorded since the 1950s resulted from changes in the occupational structure, rather than from levelling the playing field. A task that has become more difficult given a context of cognitive automation reducing the demand for high skilled, high wage ‘knowledge’ workers, together with widening inequalities of opportunity between rich and poor in many countries.

A growing recognition of a faltering opportunity bargain has led to renewed questions of who learns what (and when), including debates about the future role of higher education. But rather than acknowledge the failed policy promise of the knowledge economy, we've seen how it continues to be presented as an alignment problem where blame is attached to the education system. 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.

The failure of university students to secure 'graduate' jobs or gain a graduate wage premium, alongside claims of shortages in craft and technician level workers not requiring a university education, have also resulted in policy initiatives aimed at re-pointing career pathways without passing through university. There are efforts to make higher education more 'applied' with a focus on entrepreneurial and employability skills. Any future decline in employer demand for 'knowledge' workers resulting from advances in generative AI or related technologies, will further intensify calls to rationalise and ration higher education, especially for those unlikely to reach the higher rungs of the job pyramid. Goodhart (2020) argues for a rebalancing of the relationship between 'head', 'hand' and 'heart' work, giving greater priority to more vocationally relevant courses, taught in more cost-effective ways and at a sub-degree level. Such arguments raise longstanding issues of parity of esteem (Banks 1955) that reflect inequalities in labour market outcomes and the fact that top vocational prizes remain monopolized by those with an elite university education.

Such attempts to regulate the future of labour supply also highlight a fundamental tension between organising education around the purported needs of industry as opposed to the needs of individuals to benefit from an education for a better quality of life and not just for paid work. If job scarcity defines 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).

Despite this, new digital tools to capture online job postings are being used to support a 'skills' model of labour market recruitment. This supports calls for a 'job ready' workforce, rather than a model of higher education for the development of generic cognitive skills linked to 'trainability' rather than a 'job ready' workforce. This risks education losing its meaning as an integral part of self-knowledge, experienced as little more than a portfolio of certified knowledge and skills, forming part of a modular personality, that can be (re)configured according to changing labour market demands.

The focus on skills also means that 'doing' is given greater emphasis than 'knowing' as the cognitive automation is extended in a context of generative AI. This repeats earlier distinctions between academic (knowing) and vocational (doing), used to organise the education and training of students and workers destined for different positions within a stratified occupational structure. Here Dewey's early twentieth century observations on vocational education seem particularly salient. In rejecting the distinction between knowing and doing, he believed the full intellectual and social meaning of a vocation include, 'training in science to give intelligence and initiative in dealing with material and agencies of production; and study of economics, civics, and

politics, to bring the future worker into touch with the problems of the day and the various methods proposed for its improvement. Above all, it would train power of readaptation to changing conditions so that future workers would not become blindly subject to a fate imposed upon them (Dewey 1916, 372-3).

Dewey was writing at the time Henry Ford was developing industrial mass production with labour treated as 'cogs in the machine'. Therefore, the empowerment of labour confronted both the 'inertia of existing educational traditions, but also...the opposition of those who are entrenched in command of the industrial machinery, and who realize that such an educational system if made general would threaten their ability to use others for their own ends.'

A new bargain needs to reconnect the relationship between the individual and what they learn, at a time when there's an ever-greater gap between 'knowledge and the knower'. 'Knowledge, after nearly a thousand years, is divorced from inwardness and literally dehumanised. Once knowledge is separated from inwardness, from commitments, from personal dedication, from the deep structure of the self, then people may be moved about, substituted for each other and excluded from the market' (Bernstein 2006, 122).

Today, changes in the human-machine relationship necessitate finding ways of safeguarding the integrity of 'knowing' and 'doing' not only in definitions of vocational education but also educational inclusion, to address rapid advances in artificial intelligence and machine learning. If more areas of economic and social life are being 'intermediated' and automated (partially or fully), through generative AI, smart platforms and predictive analytics, it requires extending the definition of the 'social' in social inclusion:

'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).

When presented in these terms, debates about social inclusion linked to a future of lifelong learning across the life-course have barely begun (James, Sadik and Brown 2021), as the cognitive challenge to the future of knowledge work 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 it means to be human, educated, high skilled, etc., and whether this is consistent with societal models of ethics, social justice and democratic freedom.

2. 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 are 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 both sides of the job market. Therefore, the structure of opportunity to translate skills and experience into paid work requires detailed analyses because there is no automatic relationship between learning, certification and labour market outcomes.

Indeed, If the 4IR is characterised by job scarcity more people including those with graduate qualifications may well 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, universities and jobs, fuelling social congestion (akin to a traffic jam), and resulting in an 'opportunity trap'.

This trap results from the unintended consequence of making additional efforts to stand out from the crowd, but if others do the same, it does little to improve existing chances of success. Therefore, the supply side policies recommended by labour scarcity theorists may incite unprecedented educational and labour market congestion, rather than opportunities for social mobility (Brown 2013).

A further unintended consequence is now evident as national governments seek to shore-up faltering 'bargains', resulting in even more competitive pressures on schools, colleges and universities to improve performance, typically measured by grades and qualifications, including the increasing policy focus on micro-credentials (Wheelahan and Moodie 2021b). This encourages narrowing of the curriculum to test material, following the same logic of firms breaking tasks down (both physical and mental) in determining what can be automated. In short, such attempts to improve educational standards and employability skills are playing into robotic hands.

But if the future is characterised by high levels of social congestion, it also challenges the meritocratic creed and the idea of a closer 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. 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 decent 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, and another is to reduce inequalities in prize money between winners and losers in the competition for a livelihood, which will be addressed below. On the issue of creating more and better jobs, encouraging job creation, whether through business start-ups, cooperative enterprise, and scaling existing companies, especially in tackling climate change, all have a role to play. Nevertheless, it's difficult to avoid the fact jobs lost to automation are unlikely to be replaced with more jobs of better quality.

Yet all is not lost, as we've argued private and public sector organisations have choices about how to introduce new technologies and whether they chose to use generative AI and related innovations to increase the analytical armoury of senior manager and executives or adopt more inclusive, human-centric approaches, by augmenting the capabilities and skills of the wider workforce. Where the focus is on cost-reduction there is more likely to be an active commitment to empower those at the top of organisations, including greater control over content using smart platforms and applications.

However, the further separation between conception and execution this entails, especially when more of the conception is aided by generative AI, runs new dangers for companies given the potential for generative AI to result in error, false data, and flawed decision-making (Crawford 2021). If oversight is in the hands of a few with 'digital scribes' being part of a small talent pool responsible for the verification and editing of computer generated content and solutions, they remain blind to the collective intelligence available to organisations to harness technologies to the capabilities of the wider workforce, who are more attuned to the daily operations and changing needs of customers, serving as an early warning system when problems arise, as well as recognising new market opportunities. But this will require a different managerial mindset and a different skill set across the workforce.

Related issues are raised by the shift away from standard models of employment and towards a more 'agile' workforce. When agile is defined as 'flexing' labour in the sense of hire-and-fire, a transactional 'plug-and-play' deployment model is assumed, leading to greater use of contingent workers. But at the same time, agile can mean something different in building workforce capacity in adaptation to change, including participatory innovation in job re-definition, re-design and re-distribution (including working hours), working for the majority of the workforce.

Addressing inequalities in opportunity to capitalise on individual knowledge and skills, in and through waged work, is also important for understanding why any new opportunity bargain involves reimagining 'who does what' and its relationship to current models of employment. At the same time, it also includes distributional questions of status, income and wealth, that cannot be explained by the human capital idea of 'learning equals earning'.

3. Rewards – 'Who gets what'?

The principle of people 'earning' a living through employment, and differential earnings reflecting the relative 'scarcity' value of individual brain power, often associated with graduate labour, remains at the heart of the neo-liberal opportunity bargain. This bargain also rests on the idea of workforce knowledge and skills becoming the major source of productivity and wealth creation, leading to a transfer of productivity gains to labour.

In answering the question what is revolutionary about the 4IR, it's due at least in part to the fact financial capital has trumped human capital (Piketty 2014; Brown et al. 2020). The very advances in technology that were assumed to drive the shift to a high skilled, high waged workforce, are undermining it, in what can be called *zero-sum productivity* for labour (rather than *positive-sum productivity*). This is because new

technologies are being used to both cheapen the cost of 'knowledge' work at the same time firms are capturing more of the productive value of business innovation through knowledge automation including generative AI, rather than the application of mass human brainpower.

Therefore, much of the gains from improvements in productivity are being captured by executives and company shareholders at the expense of the workforce (Stiglitz 2012). This is reflected in the incomes of 'super-managers' at the top end of national and global labour markets, that bear little relationship to individual marginal productivity (Piketty 2014), or the idea that they have scarce skills that command a very high market price.

Moreover, within the neo-liberal opportunity bargain the contributions of those in non-graduate occupations are often unrecognised and undervalued. Until recently, the very idea of a 'non-graduate' was widely used for the sole purpose of highlighting the wage premium gained from getting an undergraduate degree (Keep and Mayhew 2004). Covid-19 served as 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 not in a 'graduate' job.

It is also a stark reminder 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 for reasons already mentioned, and are vital to a civilised society, despite not requiring long periods of training or commanding 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 ignored precisely because they are not judged to have economic value – they stand outside formal employment. They are part of a hidden economy in which a lot of work, especially performed by women, goes unnoticed and unrewarded, leading Katrine Marcal to ask 'who cooked Adam Smith's dinner?' (Marcal 2015). 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). We also lack a vocabulary to 'see' things differently, as we talk about the education-work relationship in the language of academic qualifications, high skills, knowledge work, graduate work, and talent management, without any reference to what people actually do for a living or its social contribution (Sandel 2012).

Unsurprisingly, the scale of inequalities in income and wealth in many countries characterised by 'winner takes all' market competition, has renewed interest in the question of who gets what in the distribution of income and wealth. And if the future is characterised by significant job scarcity and longer-term technological unemployment, beyond the control of individuals to provide for their own economic welfare, it is inextricably linked to issues of educational opportunity and economic justice. 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. This is already 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 (Atkinson 2015; Van Parijs and Vanderborght 2017)

Rather than tightening the relationship between education and waged work as commonly proposed, loosening this relationship could provide the foundations for extending individual wellbeing, by 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.

Conclusion

This article examines different interpretations of what has been labelled the fourth industrial revolution, highlighting why we need to rethink the neo-liberal opportunity bargain in a context of increasing job scarcity resulting from a more highly educated workforce and smarter machines posing a 'cognitive challenge' to the future workforce.

The promise of knowledge work to become the major source of individual prosperity, productivity, and wealth creation, has unravelled and confronts being completely broken. Today, it is the end of knowledge work as defined in national policy that's revolutionary, rather than the end of work itself. The very advances in technology that were assumed to drive an 'age in human capital' are undermining it when used as a source of productivity capture by business executives and owners.

The unravelling of the neo-liberal opportunity bargain reflects the institutional pressures on education, work, and labour markets, to resolve what can't be resolved in present policy terms. The vast inequalities in income and wealth already evident, will not be narrowed unless 'positive-sum' productivity for labour is at the core of business innovation and public policy. It is no longer sustainable to maintain a 'fallacy' that the common interests of society are best served by subordinating education, labour, etc. to the requirements of the market. 'The economic order is merely a function of the social order' (Polanyi, p.74).

It needs to be shaped by human and societal purpose, as zero-sum productivity and the climate emergency, signal the need for new social priorities. Without a change in priorities the pressures on individuals and institutions, including education systems, become too great with unpredictable consequences. All, then, have a stake in finding a viable answer to job scarcity in the creation of a new opportunity bargain, which needs to be made a defining feature of the fourth industrial revolution.

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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.

² The ideas presented in this article draw on hundreds of interviews with corporate senior managers and executives, along with policy-makers in countries including China, Germany, Finland, India, Korea, Singapore, Vietnam, United Kingdom and United States, over twenty-five year of almost continuous funded research. The most recent is the Digital Futures of Work International Research Programme. <https://digitalfuturesofwork.com/>

³ <https://aws.amazon.com/devops/what-is-devops/>

⁴ 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.

⁵ Sam Altman, Tweet Post, 10.10pm 15th February 2023.

⁶ This interview was conducted in London in 2011 as part of ongoing research following the publication of *The Global Action* (2011).

⁷ <https://www.uflexreward.com/> [accessed 6 June, 2020].

⁸ This is a major theme of the Digital Futures of Work International Research Programme. See <https://digitalfuturesofwork.com/>