Will we work in twenty-first century capitalism? A critique of the fourth industrial revolution literature

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Abstract
The fourth industrial revolution has become a prominent concept and imminent technological change a major issue. Facets are everyone's concern but currently no one's ultimate responsibility (perhaps a little like financial stability before the global financial crisis). In this paper, we argue that the future is being shaped now by the way the fourth industrial revolution is being positioned. Whilst no one has set out to argue for or defend technological determinism, anxiety combined with passivity and complacency are being produced, and this is in the context of a quasi-determinism. The contingent quantification of the future with regard to the potential for job displacement provides an influential source of authority for this. A background of 'the future is coming, so you better get used to it' is being disseminated. This favours a capitalism that may 'deny work to the many' perspective rather than a more fundamental rethink that encompasses change that may liberate the many from work. This, in turn, positions workers and responsibility for future employment (reducing the urgency of calls for wider societal preparation). Public understanding and policy are thus affected and along with them the future of work.

Keywords: Fourth industrial revolution; artificial intelligence; machine learning robotics; work; realism; Frey and Osborne; accelerationism.

Introduction

Cliché has it that change is the only constant, whilst philosophers and social theorists often state that change is poorly conceived. Polanyi, for example, states 'nowhere has liberal philosophy failed so conspicuously as in its understanding of the problem of change' (Polanyi, 1945, p. 41). One major theme of change at the moment is the seemingly relentless and widespread imminent impact of new technology. Surveys in the United States and United Kingdom consistently report that the public are concerned by what seems the rapid rate of change, and that they feel unprepared to fully comprehend or cope with it, and this remains the case even where some feel more optimistic regarding eventual benefits from new technology (see for example, surveys from YouGov and from the PEW Center, Smith, 2018; Anderson, 2017; Pew, 2016).

One major area of concern focuses on machine learning, artificial intelligence, robotics and a variety of other technologies' impact on work. The combination has been packaged as the concept of a fourth industrial revolution and Googling the term in May 2019 produced over 39 million hits. The literature is constantly expanding. For example, Deloitte's *UK skills* (upskills) research series recently reported that between 2001 and 2016, net employment increased in the United Kingdom by 3 million (Deloitte, 2018). However, employment actually fell in 160 of 366 occupations, and these occupations did not involve a primary element of human social interactions. The inference drawn was that this fits a narrative of eventual displacement of human workers by technologies, as technologies and automation spread. Significantly, this narrative is quantified. In the following paper, we set out a preliminary exploration of how the concept of a fourth industrial revolution is helping to shape the future. We argue that it draws on the authority created by quantifying the future and that the form and consequences of this are not neutral. The development and use of the concept so far has been skewed and has been associated with a 'capitalism that (may) deny work to the many' perspective, rather than one where 'the many may be liberated from work'.

The new (digital) machine age or fourth industrial revolution

There has been a great deal of debate over recent years regarding globalization, technology, organization, work and changes to social and economic life. This has resulted in various discourses such as global value chain and global wealth chain approaches, as well as specific foci such as the degree to which some jobs have been off-shored and how this relates to the way economies have restructured, including how wealth is protected and also off-shored (Neilson *et al*., 2014; Gibbon *et al*., 2008; Seabrooke & Wigan, 2017; Lysandrou *et al*., 2017). This issue of restructuring, in turn, has been embedded in a range of conceptual concerns, such as financialisation, and has raised further issues based on post-financial crisis social and political fracture (see Baker & Wigan, 2017; Christensen *et al*., 2016; Van der Zwan, 2014; Hay, 2013; Engelen *et al*., 2012).

The political economy of austerity, the ramifications of Brexit and of the tensions inherent in the election of Donald Trump as one expression of populist discontent provide the contemporary context in which increasing significance has been attached to the quality of employment, low wage growth, and job insecurity (for example, Morgan & Patomäki, 2018; Lavery, 2018; Fullbrook & Morgan, 2017; Jessop, 2017; Montgomerie, 2019). Amongst other things, strategic and partial 'deglobalisation' and 'reshoring' to increase domestic production has now become a policy issue. This is often phrased in terms of improving domestic infrastructure and skills to encourage international competitive advantage, able to attract investment, and thus the location of multinational enterprises (contrast the global race inherent in the current UK Conservative Industrial Strategy, DBEIS, 2017, with Labour's Manifesto, 2017; Morgan, 2019a).[1] Not only does this market conforming logic sit uneasily with incipient economic nationalism, it also invokes technical analysis regarding the feasibility and practicality of reshoring as a means to offer *more* employment that is 'decent', better skilled, higher wage and secure (e.g. Collard-Wexler & De Loecker, 2015).[2]

However, though not reducible to merely employment issues, a further and intersecting context for the future of work, heavily focused on new technology, has also arisen in the early twenty-first century, invoking claims regarding a new phase in capitalism. That is, what has been variously referred to as a new (digital) machine age, industry 4.0 or a fourth industrial revolution (hereafter we will simply refer to these as the fourth industrial revolution). This literature grew out of and still draws on the work of prominent scientists and futurists (most recently, Tegmark, 2017; Harari, 2017). This fourth industrial revolution has its crossovers (Ford, 2015; Brynjolfsson & McAfee, 2014). However, it has been dominated by consultancies, think tanks and modellers, mainly drawn from economics or working with economists. The World Economic Forum (WEF) under Klaus Schwab and the Global Institute arm of McKinsey under James Manyika, as well as the Boston Consulting Group, PricewaterhouseCoopers and Deloitte have been particularly prominent in shaping the concept of a fourth industrial revolution (Schwab, 2016; WEF, 2016, 2015; Bughin *et al*., 2018; Manyika *et al*., 2017a, 2017b; Deloitte, 2018; Hawksworth *et al*., 2018). In 2017, for example, Janna Anderson at PEW referred to the work emerging from WEF as 'the lynchpin of discussions' (Anderson, 2017).

Common to the various terms for the fourth industrial revolution is a focus on a number of technological changes. These include recent and expected advances in machine learning (ML), natural language coding, Artificial Intelligence (AI), robotics, sensors, connectivity, cloud computing, nano-technology, 3-D printing and the Internet of Things (IoT). As we shall argue, a major strand of this work involves basic problems that bring into question the claims and contribution of that work to public understanding and policy and this, in turn, is not without consequence. We begin, however, by providing some sense of the identified potentials of the relevant technologies. This is synthesized from the main literature, supplemented by reference to developments and projections from some of the main corporations and industry groups working in the area. Given the wealth of material this can only be indicative rather than comprehensive. For proponents, it involves an imagined near future pulled into the present based on trends in technology.

ML is a set of coding systems and AI is a categorisation of the capacity of a technology as an entity.[3] So, for example, in the imagined fourth industrial revolution factory of the near future, ML is able to make use of large datasets (in real time and drawing on cloud resources) to iteratively feed environmentally responsive updatable AI. This enables a system where the AI, in turn, is applied to newly lightweight, mobile and sensor imbued robotics to create networked management or control for heavily automated production. This system is conceived as reconfigurable within a factory setting, mobile as a whole factory form and potentially cost-effective at small scale.[4] The much reduced role of humans within this set-up includes working collaboratively with 'co-bots' and perhaps under the direction of AI whose programming encompasses 'responsibility' for task allocation, logistical timing and supply chains. The concept of a supply chain, meanwhile, extends to where natural language proficient Chatbot technologies following the format of Siri or Alexa act as household managers and facilitate consumption through coordination functions, which draw the just-in-time practices of contemporary warehousing into the home via an integrated (IoT alerted) delivery system of autonomous vehicles.

As the increasing integration of technologies into the home indicates, the idea of a fourth industrial revolution is not just production-focused but also diffusely service-providing within what is implicitly conceived as a whole life system. And this readily extends to a whole life-maintenance system, a cradle to grave network. Consider how the health service of the near future could draw on household management AI through a health monitoring function to seamlessly integrate this monitoring into personal calendar-matched (and so not missed) doctor and hospital appointments. This, in turn, could build forward from ML augmented AI diagnostics using recognition software and then follow through with treatments that extend from subtle dietary modifications, implemented seamlessly through changes to grocery orders, all the way to state-of-the-art surgical intervention. Here, the envisaged operating theatre of the near future combines remote expert participation via virtual reality, with augmented reality body scan overlays, and use of console operated surgical robotics capable of precision and steadiness that a human could not replicate (and where the task could be replacement of tailored 3-D printed bio-genetic parts).

Clearly, based on combinations of the technologies, one could provide illustrations that proliferate to cover virtually any activity within society. Furthermore, it is core to fourth industrial revolution material that it is the *confluence* of technologies that is considered socially significant. The timeline that has emerged for the technologies typically (but not exclusively) focuses around 2030, and if we draw on the concept of a Kondratieff wave, it is in combination that the technologies create the potential for the entirety of economies and society to restructure. So, the changes collectively represent an *anticipated* fundamental transformation. However, this anticipation by the main proponents is in so far as *individually* all of the technology is either available in initial form or is something particular groups are working on somewhere in the world and that they *expect* to develop via existing projects and research programs.[5] The media is constantly picking up on this and reporting novel breakthroughs and projects in robotics, ML, AI etc. (adaptive door opening robotic units that relentlessly overcome obstacles, tensile trousers that aid walking, exoskeletons that augment lifting and carrying, Smartphone online medical services etc.).[6]

Importantly, there is an additional step implicit in the fourth industrial revolution concept because of its emphasis on collective potential. Common to each example is the central role of information. The idea of a fourth industrial revolution and the individual technologies merely in aggregate are slightly different, since the functionality of the technologies and their combinations is implicitly dependent on and operative through the collection, transmission and use of information. It is this that underpins potential, and this includes at least one other anticipated fundamental potential transformation, the potential to measure and track resource use to facilitate reductions in use, effective re-use and possible balancing within a circular or 'regenerative' economy. *Survivable* capitalism is a final framing that fourth industrial revolution material has oriented on.[7]

Setting the scene for the future of work and is this time different?

Now, when merely set out without challenge or analysis the potentials we have briefly identified, and the many others that we could, can readily convey the impression that the technologies intrinsically lead to benefits (in so far as they ostensibly enhance some undefined concept of efficiency, deliver convenience, and facilitate the satisfaction of desires and the achievement of personal and societal goods, such as health and sustainability). At the same time, underpinning any Panglossian-posed sense of potential is an implicit perfection required for this seamless functioning, and this invites scepticism.

Our intent, however, is not to foster some Star Trek strawman that can be contrasted with Black Mirroresque critique, but rather to make the point that there are different positions and possibilities regarding the role of the technologies. As any sociologist, social theorist or philosopher with an interest in the subject might argue, and as a moments reflection reminds us, technology is a constituent of a constructed social reality rather than something that is developed in isolation from it (e.g. Lawson, 2017; Faulkner *et al*., 2010). Since at least Manuel Castell's work, most have been aware that information is not some ideally aggregated, freely available, inviolable and homogeneous digital unit (and the recent scandal surrounding Cambridge Analytica and the many and various counter-movements regarding the power of Google etc merely confirm this). Concomitantly, how technology develops is not a matter of strict determinism. Nor is any technology perfect (accidental failure and error will apply), invulnerable (malicious intervention is an ever-present threat) or free of the potential for manipulation (to have real consequence something – a disseminated claim or story - does not have to be true, merely causally efficacious or influential through belief based activity).[8] Furthermore, the development of technology is subject to the values and principles and mechanisms of societies. And it is limited by the very nature of material reality (as any ecologist will counter if offered a technological means to persist with unsustainable growth trends in the name of 'sustainable development').

So, what occurs in terms of any confluence of technologies will be contingent and varying. Notably, investment must actually occur in time and in places and issues of ownership will typically apply.[9] Similarly, institutions, rules, laws, behavioural responses, rights and obligations will all make a difference to the significance of technology, how that technology changes and how we are socialised to use and refuse it. We live in a broadly capitalist system of many states, supra-national entities, organizational and governance forms. This is anything but seamless.

There is thus an issue of realising the future and what form that future reality will *really* take. Futurists have adopted more and less positive accounts. [10] The fourth industrial revolution too, includes a range of approaches. As we shall argue, however, there are significant commonalities and limits to the range. The important point at this stage is that positions are not irrelevant for how the future *becomes* the present, since they affect how the future will be shaped *from* the present. Clearly, this applies also to work and the future of work is a major focus of fourth industrial revolution literature. *If* the confluence of new technologies affect any-and-all aspects of society and the economy, then they have the potential to affect any-and-all aspects of work. Analytically this has fallen into three categories: 1) the displacement of workers by combinations of the technology 2) changes to existing types of work, as the requirements of work modify to accommodate the new technology (what is termed a complementary rather than displacement effect), and 3) the creation of entirely new forms of work. A primary focus, however, has been that, since the convergent timeline is 2030 for a fundamental restructuring, it is possible that the rate of change of technology use in work could be so rapid and the dissemination of technologies so pervasive, that displacement dominates (there is more 1 than 2 and 3), creating a near future of mass technological unemployment.

In the literature, whether the possibility is *likely* has also been situated to a contrast with the recent technological past (see any of the main WEF or McKinsey sources). Formerly, automation and computerisation had their greatest impact on Fordist continuous flow mass production lines and on clerical and secretarial work. That is, work that could be reduced to strictly repetitive actions or multiply reproducible essentially identical forms – some kinds of work whose primary task base could be expressed in simple routines. However, the new technology introduces combinations of mobility, monitoring/surveillance, discrimination, multi-functionality, language and effectively more complex decision making capacity (which is not to suggest this requires an AI be conscious). This greatly extends the range of tasks that *could* be duplicated by technology and thus the types of work or employment that *seemingly* could be affected (Morgan, 2019b):[11]

1. Any form of retail employment within a shop space that can be configured as a smart location that automatically registers the customer's presence and consumption activity and combines this with a remote bank charging system on exit;[12]
2. Warehouse product storage and retrieval, port and airport container management employment whose dominant task base depends on ordered and integrated logistical systems in controllable environments;
3. Commercial driving, delivery and taxi service employment whose dominant task base is replicable by an autonomous driving or airborne drone unit;
4. Onsite commercial and domestic property construction employment whose dominant task base can be partially transferred to controllable (potentially mobile factory) environments in which prefabricated sections can be manufactured for delivery and assembly, and whose other tasks can be replicated by on-site mobile automated units (brick laying etc.);
5. Commercial and domestic cleaning services employment whose dominant task base can be replicated in similar ways to 2 and 3 (pipes, pools, tunnels, tanks, windows, floors etc.);

6. Online sales, customer and personal services employment whose dominant task base is information, direction and advice that an effective integrated natural language proficient Chatbot could emulate;
7. Insurance, para-legal, accounting and tax employment whose dominant task base is sorting, collation and categorisation of information according to well established rule systems;
8. Financial services, including portfolio management whose dominant task base can be replicated in similar ways to 6 and 7;
9. Medical imaging and diagnostics, safety, inspection and coordination employment whose dominant task base is vigilance, monitoring, remote testing and problem/anomaly reporting;
10. Policing and security services whose dominant task base can be replicated in similar ways to some combination of 3, 6 and 9;
11. Business, journalism and academic copyediting and limited range copywriting whose dominant task base requires syntactical proficiency, semantic discrimination and information extraction/summation from depositories and newsfeeds, reproducible using adaptive versions of technologies developed for 6;
12. Tuition service employment whose dominant task base can be replicated in similar ways to some combination of 6, 7 and 11.

Clearly, this list covers great swathes of employment in a modern economy. It covers many of the areas that have dominated employment growth in financialised, consumption driven and service based economies in recent decades: retail, driving and delivery, remote support services, and construction. In setting out the potential, there has also been a tendency to highlight some “basic” contrasts that can be applied to employment choices between humans and the technologies *if* that choice is a matter of possible substitution and hence displacement of humans. In processing and assimilation tasks, the greater the volume of material then the greater the speed and accuracy advantage ML and AI has over humans. In general, technology does not lose concentration, become distracted or go home to sleep. It is always available and will work any-and-all shifts. Technology may have terms and conditions based on intellectual property, but does not (unless electronic persons acquire these) have employment rights. It may involve costs, but is not paid wages. Technology may break down or be hacked, but does not get sick or strike, and it may become obsolete, but will not need to be replaced piecemeal since it cannot choose to secure alternative employment.

Reduced to this set of contrasts there seems to be a generalised rationale for a fourth industrial revolution transformation in instrumental, efficiency-directed, and productivity referenced economistic terms. Investment in the technology will ultimately pay dividends (in both senses of the term). Of course, this creates a basic dilemma that the literature tends to acknowledge but peripheralise or defer. The concept of the self-annihilating corporation is antithetical to capitalism. Firms do not choose to cease to exist and will individually (and through unofficial cartel behaviour) collectively adopt whatever gives them a market retaining or dominating advantage. If firms buy into the idea of a fourth industrial revolution, then they buy into the imperative to be early adopters or primary innovators (and states and governments similarly buy into the need to foster this). So, there may well be a self-fulfilling dynamic to displacement potential. However, widespread unemployment puts at risk the ability of humans to fulfil further functions within a capitalist system via wage labour: pay taxes and consume to provide aggregate demand, which, in turn, becomes profit, which, in turn, maintains the firm.

Still, within the fourth industrial revolution literature, the momentum of argument follows a format focused on providing grounds for adoption of the new technologies, in so far as they become available. For example, as Katy George, McKinsey senior partner states:

> The problem is not that we're automating so quickly that we're going to put people out of jobs. The problem is that we need to automate more quickly to get the kind of benefits in productivity and in our standard of living that we would like to enjoy.[13]

There is thus a 'this time is different' challenge, and it is, therefore, extremely important to be aware of how the future is being shaped through the material that defines and dominates the fourth industrial revolution.[14] How is the future being presented to us now?

Back to the future

Clearly, the material set out so far creates the potential for anxiety regarding the future of work. Equally, if viewed positively it can convey a sense of time-saved becomes time freed. The possibility of technological unemployment is thus mirrored by the possibility of working less and doing other things. There is, of course, nothing new about recognizing this. Perhaps its most famous articulation, and one referenced as a point of departure in almost all the main contemporary literature, is to be found in Keynes' essay 'Economic possibilities for our grandchildren', in which he states, "We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely, *technological unemployment*. This means unemployment due to our discovery of means of economizing the use of labour outrunning the pace at which we can find new uses for labour" (Keynes, 2009 [1933/1930], p. 360).

Keynes was writing at a time of economic crisis and yet approached the problem based on a fundamental optimism. According to Keynes, capitalism encourages technological change and within around 100 years this would solve the 'economic problem' of meeting material needs. There would, therefore, be no 'need' for a full working week and 15 hours would be sufficient to 'satisfy' a theologically posed primordial ('Adam') impulse to strive. People would be free to pursue social and cultural goods, many of the old principles of society would be shed, and notably, accumulation of wealth for its own sake would no longer be 'of high social importance'. In the meantime, this accumulation (its 'avarice and usury') remained necessary to drive capitalism to achieve the end of solving the economic problem.

At root, Keynes highlights but does not resolve a tension based on two different framings of 'need'. The need to interact, work and create as self-expression may be intrinsic to what it is to be human, but this is not the same as the need to earn a wage income in order to survive within a division of labour that operates according to disciplining principles or mechanisms. In this latter sense, labour is compelled and profit and accumulation drive the capitalist system. Historically, there is no simple relation where greater use of technology and higher productivity have *continuously* reduced hours worked. Over the long term there has been conflict between social and political movements that create individual and collective employment rights, terms and conditions and the most primitive drive of firms to dominate markets and increase profits through exploitation. Critique of zero-hour contracts and also the ambiguous work status of 'employees' of digital platforms such as Uber merely represent the latest version of this. Moreover, in so far as our subject is transformations, there is fundamental disjuncture between a socio-economic system premised on wage labour and one that *becomes* other than this.

So, it is important to note that the world of tomorrow that Keynes is focused on in his essay is not ours. That world is not just one that has achieved technological wonders, it is one that has implicitly transitioned to a radically different socio-economic form of organization. Moreover, Keynes does not specify how this new form will be structured or how transition to it will be achieved. The essay, though often referenced, thus has little directly to say about current twenty-first century problems of technology, except to suggest there are decisions that will have to be made regarding *how* society and the economy are to be organized: there will *eventually* be a 'this time is different' issue. Though Keynes was prescient in suggesting this would arise in around 100 years, from the present point of view there remains a fundamental and unresolved difference between a post-capitalism or capitalism that liberates the many from work and a capitalism that denies work to the many.[15] It is thus important to consider how the future is being presented as also an issue of w*ho* will influence the terms on which we decide how we live and work (*if* we work).

Two of the more interesting recent approaches to the issue of technology, work and capitalism are accelerationism and the critical branch of the quantified self-movement. Following Nick Srnicek's and Alex Williams' 'Accelerate manifesto' (Williams and Srnicek, 2013) and their book *Inventing the future* (Srnicek and Williams, 2015), contemporary accelerationists tend to argue that capitalism has become a constraint on the potentials of new technology to facilitate alternatives to modernity. From this point of view, the left need not fear and ought to embrace the potential in new technology. For the accelerationists, the technologies we have referred to previously should be encouraged in so far as they lead to automation, but only in so far as this is placed in an institutional context that is a liberation from work.[16] So, new versions of old ownership forms are encouraged (public, joint, cooperative, commons in the form of peer-to-peer systems etc.), as are reduced working hours and alternatives to work via initiatives such as universal basic income.[17]

Contemporary accelerationism directly addresses the issue that change is conditional on who influences the way the future unfolds. It does, however, sit uneasily with an earlier articulation of accelerationism that centered around the Cybernetic Cultural Research Unit (CCRU) at Warwick in the second half of the 1990s. At that time the argument was more that capitalism itself had been constrained by political means and, drawing heavily on a reading of the work of Deleuze and Guattari, what was required was an intensification of capitalist processes, since this would disrupt the status quo. Nick Land, in particular, argued that transgressive potential was essentially uncontrollable and any 'pretense' that it could be controlled should be abandoned. This, however, involves an implicit normative slide *if* one is pushing an intent to intensify, since advocacy rather than description implies influence. In the case of Land, this began as an odd dismissal of what is essentially Polanyi's double movement, but has become in later years the basis of a far-right anti-democratic politics (see Noys, 2014; Beckett, 2017).[18]

From the point of view of contemporary left-leaning accelerationism, Land's position is at the very least reckless and irresponsible. From this point of view, if the left do not take responsibility and seek to occupy decision making spaces then others will. As such, a socialist inspired variant on social democracy has emerged that is not anti-technology but nor does it fetishize technology. Srnicek and Williams' work has been taken up by Paul Mason, author of *Postcapitalism* (2015) and the ideas of all three have filtered into the rhetoric and policy prescriptions of both the UK Labour Party and, albeit in limited form, the TUC (for example, on the benefits of technology if reduced working hours are compensated, see TUC, 2018, pp. 21-30).[19]

The left position itself, however, is also not without problems. Pitts, for example, argues that Mason and others may be overly optimistic, since more is required than reduced labour time for capitalism to become something other than it is, and contesting the power of capital requires a deeper grasp of that power (Pitts, 2017).[20] This brings us to the critical branch of the quantified self-movement. Phoebe Moore (2018) and others have begun to develop a research program exploring the lacunae in current tech-optimist perspectives. One of the current dividing lines is between those who see the new technology as taking the 'robot' out of contemporary work and those who emphasize robots putting workers out of work. Moore draws on international political economy and neo-Marxism to reassess contemporary issues of management systems (moving on from Braverman's labour process and other resources).

Specifically, Moore makes the case that a more adequate sociology of work is required to understand the long-term impact of wearables and self-trackable technologies (WSTT), once these are widely adopted at work. WSTT are able to track movements, tone of voice, conversations, heart rate and many other motions, emotions and activities. For Moore, a capitalist context does not guarantee that the long-term impacts will be positive. Following a theme we introduced early on in the context of fourth industrial revolution potentials, she argues that there are problems with a management discourse that emphasizes that more information is better information, which necessarily translates into better outcomes via a mutually referenced well-being and performance for 'well-billing'. People analytics is *control* of information and this has a variety of disciplinary potentials that are subtly operative as power, once one places them in context. Artificial standards, psychological harms and alienation may emerge, despite any formal systemic expression to the contrary. For example, technology, including co-bots, may be introduced as complementary to humans working, but what humans will acquiesce to as practices if feeling insecure or vulnerable will not necessarily coincide with what they prefer or consider beneficial. Whilst 'affective labour' (Moore, 2018, p. 93; Clough & Halley, 2007) may involve traits and practices that are not readily susceptible to displacement, the prospect and fear of unemployment matters, and whilst this fear may not be new it has a new set of technological enablers (in a period of 'precarity'). Similarly, if WSTT makes the whole of one's life a set of data points then who one associates with, what one eats and drinks, when one sleeps etc. become points of discrimination and thus possible oppression. 'Taking the robot out of work' may come to be subverted in meaning, and thus ironic, irrespective of whether in fact technological unemployment rises (Morgan, 2018a).

To be clear, however, framings that emphasize transitions that are required for liberated labour or that add nuance to our understanding of the power of capital are *not* the dominant way the future of work is being articulated. The main sources of the fourth industrial revolution literature have pre-empted this. Moreover, they have done so in a systematically skewed fashion.

Skewed futures?

We began by stating that the main sources of the literature on a fourth industrial revolution are consultancies, think tanks and modellers, mainly drawn from economics or working with economists and we noted that that the World Economic Forum under Klaus Schwab, Boston Consulting Group, the Global Institute arm of McKinsey under James Manyika, Deloitte and PricewaterhouseCoopers have been particularly prominent. Most of these are revenue earning entities that operate according to mission statements and business models. By their very nature these organizations are public and policy facing. They intend to capture attention. In order to do so they define grand themes and the fourth industrial revolution is the latest of such themes. Concomitantly, economists and fellow travellers are the most policy conscious of social scientists and are apt to collaborate and contribute based on their skillset and outlook (a process that has only been exacerbated by the new REF's requirement to demonstrate 'impact').[21] Both the organisations and economists offer pathways to the future whose authority derives from the capacity to provide conditional quantities for that future; an empirics of what 'will' happen. Governments, meanwhile, draw on the themes and research to inform policy and to add quantities and hence credence to their briefs and reports. There is thus a reciprocation and feedback between parties.

So, for example, following initial McKinsey work and the WEF identification of the fourth industrial revolution as a key global theme in 2015 and 2016 the concept filtered into the UK *Industrial Strategy* Green Paper in January 2017 and developing an ML and AI economy were specifically incorporated as 'grand challenges' (DBEIS, 2017). In March 2017, the Department for Digital, Culture, Media and Sport published its *Digital Strategy* (DDCMS, 2017) and in October 2017, the Department for Business, Energy and Industrial Strategy published the *Made Smarter Review 2017* (Maier, 2017). The commissioned *Review* was led by 16 senior corporate executives, two university vice-chancellors, an entrepreneur in residence and the Director General of the CBI.

The aim of the *Review* was to assess the scope for fourth industrial revolution technologies to affect the UK economy by 2030 and to formulate a set of proposals to enable the United Kingdom to become a world leader in harnessing its potentials. This was positioned as a response to similar existing initiatives in Germany, China and the United States, and was specifically posed as confronting 'competitive threats' in a global race to adopt and dominate the new technologies. The *Review* includes a value at stake analysis for key industrial sectors and makes the claim, based on a 'best-case' scenario, that by 2025-2030 the United Kingdom may achieve £7.5 billion in new revenue from growth, £10 billion in cost savings, reduced CO_2 emissions of 4.5 per cent and a net increase in employment of 175,000 (based on 295,000 jobs displaced, 370,000 jobs created via growth, and a further 100,000 in new kinds of job). Significantly, the *Review* sets out and summarises what it considers key research on the future of work:

Figure 1:

VARIOUS INFLUENTIAL REPORTS

	The Future of Jobs World Economic Forum Jan 2016	The Future of Employment Frey and Osborne 2017	The Global Information Technology Report World Economic Forum 2012	The Skills Revolution Manpower Group Jan 2017	Man & Machines in Industry 4.0 Boston Consulting Group Sep 2015	Automation, labor productivity and Employment Copenhagen Business School 2011
CONS	7.1 million jobs lost globally across all sectors	47% of jobs in USA at risk of being computerised	The report does not estimate specific losses, but a positive net effect	12% of employers will decrease headcount due to automation	Reduction of 610,000 jobs in Germany in assembly and production	-10% employment in the short term if UK automated at highest level
PROS	2 million jobs gained globally across all sectors	The report does not estimate how many jobs could be gained	A 10 point increase in digitalisation score would decrease unemployment by 1%	19% of employers will increase headcount due to automation, 64% will not change headcount.	960,000 new jobs created in Germany – 760,000 due to growth 210,000 in IT/ analytics	+7% employment in the long term if UK automated at highest level
COMMENT	4.7m jobs lost in office administration and 1.6m from manufacturing. The report says "Manufacturing and Production roles are ... anticipated to have relatively good potential for upskilling, redeployment and productivity enhancement through technology rather than pure substitution".	"at risk" is defined as "meaning that associated occupations are potentially automatable over some unspecified number of years, perhaps a decade or two". This may mean some tasks have the potential to be automated rather than actual jobs lost.	The report estimates 45m jobs created globally by digitalisation from 2007-2011.	The report estimates that the UK will increase employment by 1-10%, compared to a 0-9% reduction in Germany, France, Switzerland and Finland.	The net effect is a 350,000 gain in jobs. The report assumes a scenario of 50% adoption of Industry 4.0 leading to 1% economic growth. A growth of 1.5% would double the additional jobs needed to 760,000.	The net effect is a 7% increase in employment over the long term. The report also estimates a 22% productivity growth in the UK, which is the driver of both short term need for less labour and longer term growth and need for more labour.

Source: Maier, 2017, p. 50.

A brief glance at the Figure 1 summary indicates that research has resulted in a range of claims about employment effects. Moreover, one could extend beyond this range to draw on more sceptical positions regarding the history of technology and displacement from longstanding researchers (see for example, Autor *et al*., 1998; Acemoglu & Autor, 2011; Autor, 2015; Mokyr *et al*., 2015). However, this is not the most important point. The identified range disguises a commonality. The methodology for the *Reviews'* own commissioned research is set out in appendix four. The appendix states the findings are 'reasonable' on the basis that the commissioned research groups, including Boston Consulting, who also did some of the initial research for WEF in addition to publishing on their own behalf, produced equivalent findings for other countries. It also notes that participants in industry workshops that assessed sectors tended to converge on the same problems and potentials. By way of critique, one could, therefore, describe this research as collectively self-referencing projection. Methodologically, all this means is that sector experts have similar understandings of current technologies and are aware of the same sets of mutually referenced disseminated grand themes and research on future potentials from the various well-publicized fourth industrial revolution sources. These are communicated in ways that reinforce a collective framing.

For example, WEF's *Deep Shift* survey (2015) specifically targeted industry experts and was widely reported in trade magazines and in the press. Similarly, the consultancies specifically target industry experts, since they are their potential client base. Deloitte's *UK skills* (upskill) series is explicitly positioned as 'insight studies' to appeal to UK business and government (whose current trope is 'contributing to the conversation'). Like McKinsey's output the series serves as a widely publicized signaling device to attract clients, rather like market analyst's reports in finance. To be clear, we are not suggesting participants see themselves as sinister, simply that they manifestly have influence in a sociology of knowledge sense.

In any case, as the Figure 1 summary illustrates, a core component in the accumulation of influence and authority is the provision of conditional quantities for the future. However, common methods cannot make the future certain from the point of view of the present, and there is a basic tension in quantifying the future at the same time as claiming that fundamental transformations are inherent to the confluence of technologies. In this context, common methods essentially offer a spurious (if contingently probabilistic) precision as a solution to what is a situation of fundamental uncertainty. This cannot be mitigated methodologically by reference to 'best-case scenarios' (using the *Made Smarter Review* phrase), and yet this is allowed to pass because it offers something to build an 'evidence based' report and hence policy around. However, this is not neutral, underpinning it is both a set of unrealistic modelling techniques and a common shared ideational framework.

What we want to suggest is that, whilst no one has set out to argue for or defend technological determinism, anxiety combined with passivity and complacency are being produced, and this is in the context of a quasi-determinism. This takes the form of a primary delegation to market processes, resulting in an acquiescence, a 'the future is coming, so you better get used to it'.[22] This, essentially remains confined within a capitalism that (*may*) 'deny work to the many' perspective (irrespective of how realistic the research that supports this is), and this, in turn, positions workers and responsibility for future employment (reducing the urgency of calls for wider societal preparation). Public understanding and policy are thus affected and along with them the future of work. With a nod to the Maier *Review* summary above, Frey and Osborne's influential work and the responses to it conveniently illustrate this.

Impossible futures impacting the present

In 2013 the economist Carl Frey and the ML coder Michael Osborne, both at Oxford, published the working paper, 'The future of employment: How susceptible are jobs to computerisation?'. The headline finding of the paper was that in the near future (an ambiguous term in the general context of the standard 2030 timeline), 47 per cent of total US employment was at high risk (a probability of more than 0.7) of displacement by AI and robotics, and 33 per cent at low risk (a probability of less than 0.3), leaving an intermediate 19 per cent (Frey & Osborne, 2013, p. 38). Unsurprisingly, these headline findings were widely reported in the media and over the subsequent years Professor Frey has been interviewed and has commented on the findings many times in the press.[23] In current academic parlance in the UK, he is particularly impactful. The working paper was eventually published in the journal *Technological Forecasting & Social Change* (Frey and Osborne, 2017). According to Google Scholar, as of May 2019, in combination the papers had been cited 3537 times.[24] The key findings, meanwhile, are cross-referenced in McKinsey's work on the fourth industrial revolution (e.g. Manyika *et al*., 2017a, p. 5), Deloitte's *UK skills* (2018, p. 25) and in the work of Klaus Schwab at WEF, as well as various policy documents such as (as noted) *The Made Smarter Review*. Importantly, much of the response has been either to replicate the model or methods or to modify or extend them without fundamentally questioning the basic realism of the methods. The quantities may vary but the basis does not, though one must be careful to explain what one means by this.

In 2015, responding to Frey and Osborne, the Bank of England applied the same approach to the UK economy and produced equivalent figures of 35 per cent of employment at high risk, 28 per cent at medium risk and 37 per cent at low (Haldane, 2015). Figure 2 expresses this graphically:

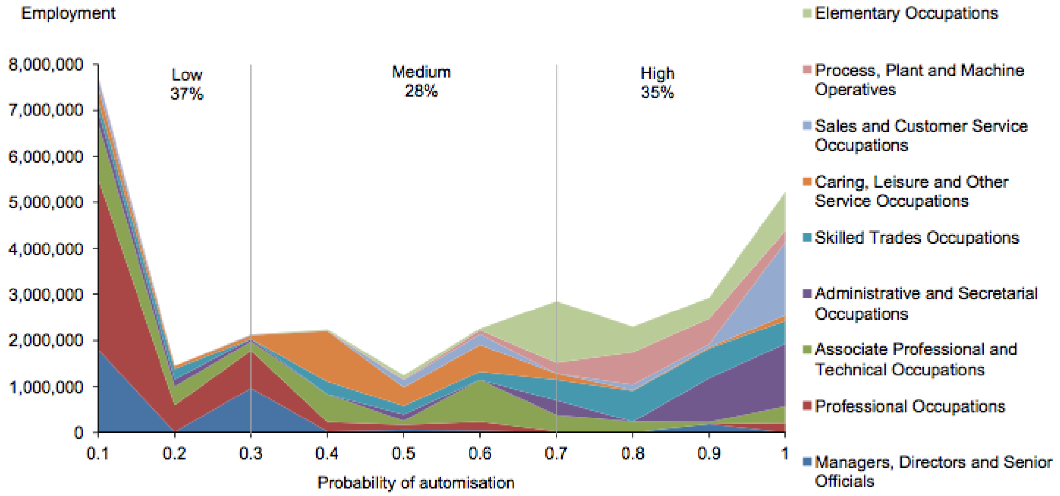

Figure 2: Distribution of occupational employment in the United Kingdom by probability of automation.
Source: Bank of England/Haldane, 2015, p. 33.

The method employed by both Frey and Osborne's original work and the Bank of England was to orient on the task structure of work and to look at whether a confluence of core fourth industrial revolution technologies could replicate the activity in that task structure. The task structures were matched to existing occupations and a group of experts at the forefront of AI, robotics etc. were asked whether they expected the technology to be able to duplicate the main tasks. If so, then it was assumed that the workers in the occupation could be displaced (and the decision was binary – a yes/no). The experts were asked to look at an initial 70 occupations drawn from the US Department of Labor service dataset (O*NET). Frey and Osborne then developed their own algorithm which was run repeatedly on the 70 initial occupations to refine and test its ability to reproduce the initial categorisations of the experts. Once refined, the algorithm was applied to the remainder of the 702 occupations in order to assign probabilities to each (in part based on 'bottlenecks'). The categorised occupations were then run against data from the Bureau of Labour Statistics (BLS) looking for correlations between displacement probability and wage income (to assess whether higher wage, more valued occupations were less likely to be displaced).

The headline findings of both Frey and Osborne and the Bank of England are troubling (47 per cent and 35 per cent of total employment at high risk of displacement). They invite anxiety. But what has actually been assumed and achieved? First, Frey and Osborne make use of an existing dataset of task structures for occupations. They are, therefore, and as they clearly state, focused solely on existing types of work and take no account of the creation of new types of work. Furthermore, since the categorisation is either/or, there is no incorporation into the quantities of whether and how work may be modified rather than displaced.

Second, it is important to note that the method is built around the convergence between expert classifications and a refined algorithm for the assignment of probability. When running the algorithm, therefore, what is being tested is the capacity to reproduce the expert classifications regarding technology which can via this process be applied to a broader set of occupations. The procedure is thus not a direct evidential test of technologies' effects on occupations as those technologies come into existence. Nor is it directly a test of the accuracy of experts in predicting the effect of technology on occupations, which is then extrapolated.[25] The procedure is not directly constructed around realising states of affairs. What the probabilities really mean is thus subtly different than what the headline findings might convey to an ordinary reader.

Third, it is also worth noting that 'susceptible' is a highly conditional term. The calculated probabilities are of what tasks *can* be duplicated by technology. However, what *can* be duplicated is a decision made by a set of experts in technology, looking at state-of-the-art, and with a view to the near future. It is more reasonably expressed as *could* be duplicated, if expected *technological* developments occur as anticipated and 'bottlenecks' are overcome. This is not a given, just as, if we return to our second point, it would be an error to conflate the accuracy of the algorithm with any confirmation of a true state of affairs regarding technology (it is an expression of expertise that assumes the adequacy of that expertise).[26]

Fourthly and finally, Frey and Osborne are clear that they make no claim regarding whether in fact displacement *will* occur. That is, whether it will be chosen. Instead, they focus on categorising what is essentially function (the task) as though the form and substance of technology could develop in isolation from society and as though how something is used and responded to by people will have no effect on whether work is modified or workers are displaced. This requires the assumption that the expert decision regarding the potential of technology can be isolated from possible influence based on behaviour, institutions and law. However, it is important not to traduce Frey and Osborne and those who have followed similar paths. As we noted early on, a moments reflection reminds us that technology is a constituent in a constructed social reality and there are many different ways in which the reality of technological change and its significance could be affected. We by no means wish to give the impression Frey and Osborne and others are unaware of or fail to acknowledge this. The point is, rather, that the method and model are necessarily separate despite this acknowledgement. This raises the question of what role is played by the numbers and by the procedure that produces the numbers?

Arguably, the model and the findings provide a baseline for discussion. However, consider again how the numbers are produced: a claim is made that a specific percentage of all occupations in a database are in the near future at high "risk" of displacement by technology, but simultaneously we are informed that the figures take no account of work modification, new jobs created, and the actual socio-economic environment for displacement within which the developing technologies will be substantively influenced and taken up. The method meanwhile is internally related to refinements of tech-expert decisions on classifications. The assumptions, therefore, not only lack realism, the numbers can have no real-world analogue now or in the future. Even if the future levels of (un)employment for occupations at some point in time coincide, *all* of what is put aside in constructing the model will have been influential in producing that outcome and so it would be more reasonable to describe "coincide" as coincidence in the ordinary language sense. Future reality will not be confirming the findings based on the method and there is something dubious about the typical way of referring to the kind of repeated running of simulations that is inherent to the approach as ‘experiment’. No causal powers are isolated and manipulated to explore or test some real relation. This is mathematics, it is computation, but is it science and is it *social* science?

One might, however, suggest that the method and model provide a point of departure and that different findings can be produced based on alternative assumptions. Arguably, this is progress in knowledge. If we return to the summary of well-known findings in the *Made Smarter Review* the Arntz *et al*. (2016) OECD research does just this. They apply Frey and Osborne’s approach to 21 OECD countries and ‘relax’ the assumption that whole occupations are displaced, focusing instead on the displacement of tasks. By treating occupations as bundles of tasks, they infer that few occupations are fully displaceable and that modification is, therefore, more likely in many cases (and this varies by country based on culture-specific content e.g. the value placed on the formality of person-to-person relations in Japanese retail). On this basis they estimate that only 9 per cent of total employment in the United States is at high risk and that the average in the 21 OECD countries, including the UK, is also 9 per cent.

The relaxed assumptions in Arntz *et al*. seem intuitively more plausible. However, the method is the same and the fundamental assumptions required to apply the method remain similarly restrictive in contrast to the openness and contingency of the construction of social reality. It does not follow, therefore, that one set of probabilities is more liable to be accurate than the other. The actual object of the research is in any case a situation of fundamental uncertainty (mutuality for socio-economic transformative combinations of technology). Neither set of probabilities is a guide to the future of work and we would suggest that given all of the points made, the numbers as constructs, are literally impossible. They represent a form of spurious (if probabilistic) precision. One could just as well refer to this non-pejoratively as elegant ignorance as much as progress in knowledge.

And yet as the web of references and uptake indicates, quantification of the future carries weight in various senses. The numbers are part of what constitute expertise and thus authority to be considered expert in the field. They induce anxiety (or if contested, and new numbers are produced, allay that induced anxiety) but otherwise add nothing, and yet they are an empowerment, the practice conveys the right to speak and be heard. The discourse also facilitates its own internal focus of models responding to models (which uses up intellectual resources and funding). This focus is simultaneously externalised to provide the ‘data’ that headlines convey.

To be clear, we are not suggesting that unrealistically produced numbers mean that nothing significant in reality is or will happen regarding technology and work. That too would be implausible. The fact that there is a concept of a fourth industrial revolution and that some organizations have co-opted the term and pursued research in its name or within its confines, does not suggest that potentially radical new inventions are also a mere ‘invention’. What we are suggesting is that the numbers start to translate highly contingent technological possibilities into a sense of something more definite that helps to fix a focus on the fourth industrial revolution and lend authority to proponents of the concept. The work of researchers like Frey and Osborne is one important way in which this is facilitated. This is in so far as the numbers start to produce a more settled sense of the future. However, ‘settled’ does not mean the ‘same’, but rather ‘creates a background’. A background sense that the range of numbers produced by different groups focused on the fourth industrial revolution technologies defines the range of possibilities for the future, and a background sense that there is something given about the eventual intrusion of the technologies into society. Thus, there is a sense of ‘the future is coming and you’d better get used to it’. This in turn is *not* neutral and we conclude with this.

Conclusion

In a speech to the TUC in 2015, Andy Haldane, chief economist of the Bank of England, reported the findings of the Bank’s replication of Frey and Osborne’s work (Haldane, 2015). The speech indicates he is, with due deference to his audience, acutely aware of the anxiety inducing nature of the findings. By contrast, three years later the Bank’s Governor, Mark Carney, in a speech titled ‘the future of work’, preferred to place greater emphasis on an update of the OECD work (estimating displacement of around 10 per cent; Carney, 2018, p. 6). Neither Haldane nor Carney are sceptical regarding the joint problem of how the range of numbers is produced and both tell similar stories based on the main fourth industrial revolution literature (McKinsey, WEF etc.). Each uses the numbers as points of reference for the future. More commentaries along the same lines will emerge as new studies are undertaken and more data is made available. Even as you read this, any online search will probably throw up new headline grabbing reports that foreground *future* quantities for work.[27]

In Haldane’s speech, the problem of how to respond to the future was posed as one of relax, retrain or redistribute (Haldane, 2015, p. 15). By relax he means choose to work less, and though he references Keynes’ ‘Grandchildren’ essay, the implication is a neoclassical type trade-off where individuals substitute leisure for work, but based on no obvious notion of how the difference is compensated for by a real human with bills to pay, and where the would-be worker does not control the context that dictates whether there is actually work to choose to do (see Fleetwood, 2016; Spencer, 2009). Retrain refers to adaption by workers through education to render their human capital less vulnerable to robot capital. Again, the implication is that all those who choose to work can be channelled into occupations where work will be available (and this includes new types of work). Both these options are firmly and unreflexively rooted in a ‘capitalism that denies work to the many’ perspective, though currently, at least, the context for this remains one of relatively high employment rates in the United Kingdom, despite the many claims that change is *imminent*.

Only with the final option, redistribute, does Haldane begin to consider that there may be a fundamental issue that cannot be confined within traditional economic concepts. Carney, meanwhile, chooses to focus on the problem as one of “transitional” frictions that will require new institutions able to facilitate lifetime retraining, combined with a supportive monetary policy (with an eye on the equilibrium rate of interest) to facilitate investment (the ultimate result of which will be a more resilient domestic economy able to compete internationally, and that no longer suffers from chronic low productivity growth).

Neither Haldane nor Carney are fools, but an open mind is not an empty mind. Their responses are conditioned not just by their perspectives as monetary policy officials but by their training as economists. In this context, Keynes' 'Grandchildren' essay is perhaps less relevant than his comments in the *General Theory* that it is difficult to escape the trap of one's training in theory and that practical men tend to be "slaves" of past economists (Keynes, 1936, pp. viii, 383). The primary response of both Haldane and Carney is to view the future of work as a market problem where individual responses aggregate to solutions. The concept of an institution is severely limited to a market facilitating mechanism and whilst institutions are not irrelevant, responsibility is, in the first instance, implicitly delegated to individuals to adapt to whatever the new technologies require. This perspective, of course, is not restricted to Haldane and Carney, nor is it restricted to technology as something to respond to. Delegating issues to the individual that are simultaneously socio-systemic is deep-seated in mainstream economics and instantly recognizable as constitutive of the last thirty years of politics.[28] It does little or nothing to reconsider capitalism, despite that the subject matter of the new technologies provokes this possibility.

Pointedly, Haldane was not able to direct his union audience to any government initiative or forum that constituted some kind of invitation to public deliberation regarding what might turn out to involve profound and basic socio-economic transformations. This has changed little since 2015, and one can only hope this does not continue. The closest the United Kingdom has come to such deliberation is the House of Lords Select Committee on Artificial Intelligence, and its 2018 report specifically states that there has been a general failure to create public awareness and debate and that this is as much social and ethical as it is economic: 'The UK must seek to actively shape AI's development and utilization or risk passively acquiescing to its many consequences…' (SCAI, 2018, p. 7). As others have noted, civil society and the public have become bystanders or observers. The fourth industrial revolution is slowly becoming a major issue – facets of it are everyone's concern but currently the future that may be shaped through new technology is no one's ultimate responsibility. This seems in some ways like the problem of financial stability before the global financial crisis.

Whilst a sense that technology can liberate the worker from work may now be on the agenda of left accelerationists at such venues as Labour Party fringe conference events (e.g. The World Transformed), the main policy focus remains dominated by a more business oriented and conventional set of capitalist concerns with the growth and profitability of the firm. From this perspective, the concerns of workers, the sociology of work and the broader issues of technology in society, are peripheral or additional. In the United Kingdom, the fourth industrial revolution has simply become part of an industrial strategy that may help to define its post-Brexit economy. The *Made Smarter Review*, for example, follows a similar reasoning to Carney: the UK lacks and must create a more conducive informational infrastructure to facilitate transition to fourth industrial revolution technologies (and there is no alternative to this because it is a matter of international competition to attract capital and grow trade). The means to facilitate this, however, are the creation of hub technology, skill dissemination centres and more training combined with some small-scale funding and loan availability. All of which amounts to, once applied to the government's 'grand strategy' approach, 'you do it, we know you can'. This, of course, is not only compatible with decades of policy framing, it is also a consequence of an austerity frame of reference where politics is dominated by Brexit negotiations, and where austerity based fiscal policy (despite declarations to the contrary) still deters government from undertaking more radical investment or social experimentation.

The framing of policy, therefore, is not neutral. It absorbs the fourth industrial revolution concept according to market conforming logics that allow government to limit its responsibility for shaping the future, even as it continues to herald the potential. And this, of course, segues easily into the kinds of concerns and foci that consultancies, such as McKinsey, necessarily find most conducive to explore: investment as a corporate wealth generating and protecting exercise. To be clear, we by no means wish to suggest that a technological future will be dystopian nor that the future of work involves worse-case outcomes of rapid catastrophic displacement as simply fate. It is rather that public policy is currently not really focused on preventing this latter outcome becoming fact. One might go as far as to suggest that a failure of public policy makes worse-case outcomes more likely, and so a creeping '*the future is coming, so you better get used to it'* is doing little to proactively shape the future in the interests of the workers of tomorrow *if* there are workers tomorrow (Morgan, 2018b). There is great scope for change here in every sense of that word.

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For clean versions of Figures the originals can be found:

Figure 1 p 50:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/655570/20171027_MadeSmarter_FINAL_DIGITAL.pdf

Figure 2 p 33:

https://www.bankofengland.co.uk/-/media/boe/files/speech/2015/labours-share

[1] There are various issues to disentangle. For example, globalization theory is underpinned by comparative advantage, but the theory takes an implicitly consumer point of view, and tends to ignore distributions and real time effects, whilst assuming capital is fungible rather than specific, static and destroyed if corporations relocate. As ideology, this conflates protectionism with the creation of domestic policy space to shape trade, and enhances both the power of MNEs and the scope of financialisation (see Fullbrook & Morgan, 2017).

[2] The issues are complex. For example, a focus on bringing factories back needs to carefully specify that assembly is a small fraction of the overall production process. Apple, for example, uses over 750 contracted entities around the world to produce an iPhone and only $8 of the estimated $378 cost of an iPhone X is attributable to final assembly. Moreover, this aspect of the process is most easily automated and least likely a source of secure high wage employment. Foxconn in China is already heavily investing in automation so the gains from any relocation into Europe (the United Kingdom) or United States might be small and, if one were to justify this in terms of redressing balance of trade issues, this seems more a matter of the failure of standard measures of trade to be calculated in terms of the value added in places rather than the total valuation of products shipped (the US deficit with China, for example, is likely a third lower than the recent figures that have exercised President Trump).

[3] AI discourse learning, intelligence etc. have been appropriated as reasonable terms to use regarding what machines/computers/programs do. This, of course, disguises a basic difference to the human who has intelligence or can learn - consciousness and self-consciousness, which makes the entity not just a system of symbol manipulation for functions but a being for whom processes are meaningful. This has created significant debate in the philosophy of AI initiated by Turing and Searle (Morgan, 2018b). ML and AI research has moved on from simple discrete-state input-output concepts and approaches, and Bayesian or Boolean solutions. The major innovation providing the background in current AI is 'deep learning' using artificial neural networks (ANN). ANN are described as software simulations of neuron connectivity (*The Economist*, 2016) That is, they are multiply layered sets of 'neural units' creating multiple dividing points for direction, as processing, from some given input to some output. The sophistication of the system or its capacity for difference and range is based on the number of layers, the 'depth', in the structure. What the system is directed to can then (currently) be set up in three ways expressed as learning modes: 1) supervised learning (a network system is fed an example dataset that exemplifies what it is intended to achieve, such as spam identification) 2) unsupervised learning (a network system is fed an example dataset and is set up to look for patterns, clusters, anomalies in the data, which then become the specific output within a broader data-defined remit, such as fraud patterns in insurance claims) 3) reinforcement learning (a network system is fed an example dataset and refines its behaviour based on rewards as feedback to achieve goals, creating a simulation of 'do what works best in situation x', such as playing and winning a video game). In all three cases the key innovation is that the network progressively refines the weighting between connections, and it thus fine-tunes the network system. The more data the system has to work with, the more layers to the neural network and the more simulations run, then the more effective the system becomes, over time and in real time, subject to processing capacity and speed.

[4] For example, the multinational enterprise ABB dominates the production and development of industrial robotics (its smallest of 4 divisions is larger in revenue terms than the next four largest corporations combined). ABB's Yumi range next generation robot is networked, sensor-fitted, dual-armed, multi-functional, easily reprogrammable, only 38kg and cost $40,000 per unit. Software support is also provided for hardware systems to allow virtual factory redesigns to improve (essentially Taylorist) production systems and to enable anticipation of mechanical problems based on analytics of wear and tear etc. The implication is that future factories can be small and flexible and require far lower initial investment. All the main corporations are developing similar ranges and support services.
See http://new.abb.com and http://new.abb.com/future ABB is one of the listed 'partners' of WEF's Centre for the Fourth Industrial Revolution, https://www.weforum.org/centre-for-the-fourth-industrial-revolution/about

[5] This in turn is reflected in the primary research published across the sciences, which intersects with operational research and technocratic organizational modelling problem sets, and this is where much of the formal work is currently being done making use of the fourth industrial revolution concept (typically as industry 4.0). See recent work in the journals: *Cybernetics and Systems, International Journal of Computer Integrated Manufacturing*, and *Production Planning and Control*. The range of current projects and programs is set out most clearly in the World Economic Forum *Deep Shift* report (WEF, 2015). The associated forecasts based on surveys are, however, highly contestable.

[6] For example, Boston Dynamics Youtube video is distributed via *The Guardian* newspaper's site:
https://www.theguardian.com/technology/video/2018/feb/21/human-robot-dog-boston-dynamics-door-opening-spotmini

[7] See also the WEF 'Fourth industrial revolution for the Earth' series:
https://www.weforum.org/agenda/2018/09/can-technology-save-life-on-earth

[8] This is to say nothing of the inherent dangers of a new phase in dependency: a society of division of labour creates a situation where we become mutually dependent and begin to lose the skills and capacity to survive in small groups or isolation, an increasing use of technologies and then delegation of activity to technological systems exacerbates the basic problem of how one survives any significant dysfunction to the system we call civilization. This is slightly different than AI singularity and Terminator scenarios.

[9] For example, according to the International Federation of Robotics there are currently fewer than 2 million industrial robots in the world and the vast majority are purposed for the automotive industry. Current investment trends indicate the growth in use of industrial robots is highly variable by industrial sector and geographical region (China and East Asia dominate based on production, investment and density). However, the eventual impact on jobs is considered to be significant and draws heavily on research findings from the main fourth industrial revolution literature. See IFR, 2017a, 2017b.

[10] These range from those focused on the near future of around 2030 to longer range futurist projections covering the next 10,000 years (contrast Tegmark, 2017; Harari, 2017).

[11] Numerous attempts to state the scope of effects in terms of categories have been formulated. See, for example, WEF https://www.weforum.org/agenda/archive/fourth-industrial-revolution/
and also WEF Digital Transformation Initiative (DTI), initiated 2015:
http://reports.weforum.org/digital-transformation/
Note there is also great scope for effects on agribusiness.

[12] This is just one of the areas where various other technologies may come together: smartphones, blockchain, cryptocurrencies and so forth.

[13] https://www.mckinsey.com/global-themes/future-of-organizations-and-work/the-digital-future-of-work-policy-implications-of-automation

[14] For example, Ford (2015) argues that this time is different because machines have ceased to be tools and are now workers and the long rise or virtuous feedback loop between productivity, employment and wages has been broken, something partly illustrated by the increased inequality in the United States in particular and other countries in general in recent years. Disruptive technology is a system wide problem requiring careful restructuring in order to enable prosperity to continue for the many.

[15] Amongst other things this creates additional context for recent debate over 'bullshit jobs'. That is, capitalism's capacity to create meaningless jobs that seem to serve no obvious purpose and that the worker knows need not exist (the organization would seemingly continue without it). These create new scope for alienation and are an odd mirror of the over-employment problem that existed in command economies such as China (e.g., the person whose job it was to sit by the door and guard the key). David Graeber (2018) initiated the current discourse in an article in *Strike* in 2013; a UK YouGov poll in 2015 found that 35 per cent of employees think their job is meaningless and 33 per cent experience no personal satisfaction in doing it. In any case, there is a normative issue of social value related to CEOs, investment bankers etc. despite that they may be at low risk of displacement.

[16] Note, though the movement is still generically referred to as accelerationism Srnicek and Williams have dropped the term as potentially misleading, since the aim is to transform and in some ways slow human existence against the trends inherent in modernity.

[17] The issue of ownership, in turn, raises longstanding issues regarding the nature of property and how these might also develop in a post-capitalist context (see Ireland & Meng, 2017).

[18] Land's early work is expressed in the postmodern idiom that had captured much of radical thought at that time. It is characterized by impenetrable self-referential verbiage, where no idea is completed or justified according to prevailing standards of reason and evidence (these are enemies), and whilst assertions abound, nothing is clearly explained in a way a reader might interpret as an attempt to be understood, nothing is definitively stated because nothing can be defined; one merely allows a stream of neologisms to accumulate and calls this an intervention. For example, 'Since the history of thermodynamics is the history of technicizing commerce – of modernizing machines – any account that autonomizes science inevitably moralizes social change (into political theatre)' (Land, 1995, p. 133). Land's writing works as a kind of provocation, sentence by sentence and in a literary sense. He has an excellent turn of phrase, but from the point of view of everything his style rejects, it is pretentious bombast.

[19] Later we argue that the fourth industrial revolution material has pre-empted debate by its capacity to quantify the future. This bleeds into the material published by and limited arguments of organizations like the TUC since they tend to rely on the data produced by the various sources associated with the fourth industrial revolution. They use these to position the significance of the issue, despite that, as we shall argue, the numbers are dubious.

[20] More prosaically, universal basic income (UBI) has its critics (see Fleetwood, 2014). UBI raises issues regarding the role of the state as a provider of services in relation to how basic income is provided, what it is spent on, and what it is intended to replace

(there is a neoliberal variant of basic income where the state is hollowed out in favour of further privatisation).

[21] For a specific argument at McKinsey regarding the scope for prediction offered in the context of AI see: https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/the-economics-of-artificial-intelligence

[22]Note, one must be careful not to misrepresent WEF and other contributors. The issue is emphasis and framing rather than lack of acknowledgement that many issues and considerations apply. For example, discussion of ethics and AI can be found at WEF's site: https://www.weforum.org/agenda/2016/10/top-10-ethical-issues-in-artificial-intelligence/

[23] For example, in December 2015 Professor Frey was interviewed by Raconteur for the headline piece in their *Future of Work* supplement provided with *The Times.* For an archive of Professor Frey's media activity see: https://www.oxfordmartin.ox.ac.uk/people/453

[24] Autor (2015), for example, is the main contrasting paper and that had 1026 citations, whilst the OECD paper Arntz *et al*. (2016) had 702 (see later).

[25] In any case, this would likely replace one problem of atomism, regularity and closure with another (see Fleetwood, 2017). Autor, for example, favours production functions and more standard econometric analysis.

[26] The use of the term 'risk' for the probability is perhaps intended to account for the issue of the 'given', but presupposes the efficacy of deriving a numeric probability for a conditional possibility (an issue ultimately of whether any kind of relevant distribution can reasonably be assumed to exist and can in some way be estimated or derived). Philosophy of mathematics and of analytical statistics have produced a great deal of critique of the problem.

[27] The Hawksworth *et al*. (2018), for example, repackage the transformative effects of a fourth industrial revolution into 3 successive (but partially overlapping) waves: 1. Algorithmic (affecting data driven-processing employment sectors in the early 2020s); 2. Augmentation (affecting robotics, warehousing and also more complex decision making tasks for data by the late 2020s); 3. Autonomous (extending to transport and construction, but building on 1 and 2 to affect all sectors to some degree by mid-2030s). They apply this to the same OECD dataset as other research and forecast gendered and education based displacement possibilities for current employment ranging from around 5 per cent initially to up to around 45 per cent in the mid-2030s for those with low education (affecting men more than women).

[28] Workers of course are socialized by this. For example, the PEW Research Center's *The State of American Jobs* survey based on a sample of 5006 people in 2016 found that 54 per cent of participants felt that retraining was essential to maintaining their employability and 72 per cent responded that it was the individual's responsibility to seek out training.