CENTRE ON SKILLS, KNOWLEDGE AND ORGANISATIONAL PERFORMANCE

The Prospects for Skills and Employment in an Age of Digital Disruption: A Cautionary Note

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Abstract

Almost in a blink of the eye the policy focus on the 'knowledge' economy, with mass ranks of high skilled workers, has given way to claims of widespread 'technological unemployment'. This Working Paper will examine competing claims on the relationship between automation, skills and the future of work. It examines the research evidence on the scale of job losses anticipated as a consequence of digital disruption. It presents three scenarios of the impact of digital disruption on future skill requirements, before considering how evidence on automation and digital disruption is used to influence and inform UK government policy interventions on skills, employment and labour markets. In conclusion, we recommend caution in interpreting existing evidence. While high profile reports on digital disruption make for eye-catching headlines, they make for poor policy formulation. A key message is that technology is not destiny. It is human decisions that will determine the future of work.

1. Introduction

The 'digital economy' is argued to be transforming all aspects of economy and society, raising fundamental questions about the future of work and the skills required to meet the changing 'needs' of industry (House of Lords 2015). A number of high profile reports on the UK, for example, have identified future employment demand in Science, Technology, Engineering and Mathematics (STEM) related fields as key to Britain's economic future and to achieving higher rates of intergenerational social mobility (Sutton Trust 2017). The opportunities and challenges afforded by the digital economy have been widely reported in the UK media, although the benefits of the 'new machine age' (Brynjolfsson and McAfee 2014) are often over-shadowed by concerns about the impact of automation, and in particular robots, on the world of work. Many commentators draw on the work of Frey and Osborne (2013), citing dramatic numbers of potential job losses:

> 'Robots are coming for your job: and faster than you think' (Daily Telegraph 21/1/16).
>
> 'More than 10 million UK workers are at high risk of being replaced by robots within 15 years as the automation of routine tasks gathers pace in a new machine age' (The Guardian 24/3/17).
>
> ''40% of jobs' taken by robots by 2030 but AI companies say they're here to help' (Metro 10/5/17).
>
> 'Society may COLLAPSE in 30 years as robots take half of all jobs, ex-Facebook exec warns' (Express 7/8/2017).

Such headlines have also been fuelled by reports from official bodies, such as the Bank of England and the House of Lords Select Committee:

> 'For the UK… up to 15 million jobs could be at risk of automation… Yet the smarter machines become, the greater the likelihood that the space remaining for uniquely-human skills could shrink further. Machines are

> already undertaking tasks which were unthinkable – if not unimaginable – a decade ago. The driverless car was science fiction no more than a decade ago. Today, it is scientific fact.' (Haldane 2015)

> 'We are facing a tsunami of technological change, driven by the digital revolution, affecting virtually all areas of our lives.' (House of Lords 2015)

Media reports primarily focus on impending 'technological unemployment' (Pecchi and Piga 2008; Ford 2015), and on changing work patterns in the 'gig' or 'platform' economy (Kenney and Zysman (2016). Far less attention has been given to the policy and theoretical implications of 'digital disruption' for skill supply, demand and utilisation. This Working Paper goes some way in filling this gap by interrogating the implications of recent accounts of 'digital disruption', the 'fourth industrial revolution' or the 'second machine age' for the future of skill formation and for skills policy in the UK. For many decades, UK governments have based their skills policy on human capital ideas, with its primary focus on labour supply rather than demand.

Orthodox human capital theory has been wedded to a version of Say's Law, where supply creates its own demand, as employers seek to exploit the productive potential of an increasingly qualified workforce. More recently theories of skill-biased technological change (SBTC) have placed a greater emphasis on the role of new technologies driving the demand for skills, although they share much in common with earlier accounts developed by Schultz Becker and Mincer, in continuing to stress the importance of supply side-solutions based on the reform of education (Goldin and Katz 2008; Autor 2015). These theories, however, are being fundamentally challenged by rapid advances in digital technologies (Brown, Cheung and Lauder 2016, forthcoming).

This Working Paper explores competing claims on the relationship between automation, skills and the future of work. In Section 2 we examine different interpretations of the research evidence on the scale of job losses anticipated as a consequence of digital disruption. Section 3 outlines three scenarios of the impact of digital disruption on future skill requirements. Section 4 then considers how evidence on automation and digital

disruption is used to influence and inform UK government policy interventions on skills, employment and labour markets. The Conclusion recommends caution in interpreting available evidence, highlighting the need to avoid policy by 'technological determinism', and offers some suggestions for further research.

2. Automation, Employment and the Digital Economy

2.1 Automation and Technological Unemployment

A burgeoning literature highlights the impact of 'technological disruption', originally defined by John Maynard Keynes (1930:20-21) as the discovery of new techniques of economising on labour, outrunning the pace at which we can find new uses for labour. Today, this is driven by advances across a number of interdisciplinary fields and mutually reinforcing technologies such as machine learning and artificial intelligence (AI), Internet of Things (IoT), robotics, additive manufacturing, synthetic biology, and smart materials (Brynjolfsson and McAfee 2014). While recognizing that digital innovation is likely to disrupt established models of education, employment and job market structures, the implications for labour supply and demand are widely contested. Studies can be broadly divided into those that present a strong negative relationship between automation and employment and those that provide an alternative view.

2.1.1 Negative relationship between automation and employment

Frey and Osborne (2017) is probably the most visible example of research presenting a bleak picture of how automation may affect the future of skills and jobs. They use an occupation-based approach to analyse the relationship between automation and the future of work. They categorise 'occupations according to their susceptibility to computerisation' (meaning job automation by means of computer-controlled equipment) (Frey and Osborne 2017:254). They asked machine learning researchers to hand-label 70 occupations 'assigning 1 if automatable and 0 if not'. They explain:

> 'For our subjective assessments, we draw upon a workshop held at the Oxford University Engineering Sciences Department, examining the automatability of a wide range of tasks. Our label assignments were based on

> eyeballing the O*NET tasks and job description of each occupation. This information is particular to each occupation, as opposed to standardised across different jobs. The hand-labelling of the occupations was made by answering the question "Can the tasks of this job be sufficiently specified, conditional on the availability of big data, to be performed by state of the art computer-controlled equipment". Thus, we only assigned a 1 to fully automatable occupations, where we considered all tasks to be automatable. To the best of our knowledge, we considered the possibility of task simplification, possibly allowing some currently non-automatable tasks to be automated. Labels were assigned only to the occupations about which we were most confident' (Frey and Osborne 2017:263).

They then used O*NET variables associated with the level of perception and manipulation, creativity and social intelligence required to perform the job (believed to limit the potential of computerisation) to supplement these subjective judgments and correct potential labelling errors. Based on the 70 occupations reviewed in this way, they constructed a model with which to estimate the possibility of automation of 702 occupations. Looking at the distribution of jobs in the US economy, they conclude that 47 percent of total employment is at risk. Frey and Osborne stress that they focus on technological capabilities, not actual job losses. Moreover, they are not specific regarding timeframes as they analyse what 'occupations are potentially automatable over some specified number of years, perhaps a decade or two' (Frey and Osborne 2017:265).

Frey and Osborne's occupational approach has been used in a range of other countries, with the assumption that the automation risk level for an occupation is the same across countries; as such, cross-country differences in the level of potential automation are seen to be driven by the occupational structure (Arntz et al. 2016). Pajarinen and Rouvinen (2014) estimate the share of jobs at risk in Finland at 35 percent, and Bowles (2014) between 40 percent and 60 percent in Europe. Frey and Osborne, in collaboration with Deloitte (2014), estimate that 30 percent of jobs in London and 35 percent in the UK are at high risk of being made redundant by technology in the next 10 to 20 years – with a much higher proportion

for those jobs paying less than £30,000 per year. The Bank of England, based on a similar methodology, estimated that up to 15 million jobs could be at risk of automation (Haldane 2015; Houses of Parliament 2016).

Frey and Osborne, along with these associated studies, do not take into account new jobs that may be created as a result of automation. Therefore, these studies look at the potential for existing jobs to be automated, rather than examining the net impact of automation on jobs/ employment – for which an analysis of job creation is also required. Studies limited to the potential automatibility of jobs, have also been criticized for not taking economic aspects into account, such as the cost of replacing humans with machines, or as the Managing Director of VDMA Robotics, Schwarzkopf (2015) has put it: 'tasks are only automated when this is economical. On the shop floor potential automatability has no validity, here things need to pay off'.

McKinsey (2017) based on an analysis of 2,000 work activities across 800 occupations, estimates that half of the work activities taking place today could be automated by 2055, although this could 'happen 20 years earlier or later', depending on various factors (2017:8), including costs, labour market dynamics, economic benefits, along with social and regulatory acceptance. It also notes that 'less than 5 percent of all occupations can be automated entirely using demonstrated technologies, while 60 percent of all occupations have at least 30 percent of constituent activities that could be automated. More occupations will change than will be automated away' (2017:8).

The focus on job tasks in McKinsey's (2017) study involved disaggregating occupations into activities and assessing the extent to which 18 performance capabilities (associated with sensory perception, cognitive, social, emotional and natural language processing capabilities) were required in those activities, along with the required level of competence in those capabilities to perform the work activity 'successfully'. They then assessed the performance of existing technologies on the same criteria:

> 'By estimating the amount of time spent on each of these work activities, we were able to estimate the automation potential of occupations in sectors

> across the economy, comparing them with hourly wage levels. Drawing on industry experts, we also developed scenarios for how rapidly the performance of automation technologies could improve in each of these capabilities. The analysis we conducted for the United States provided us with a template for estimating the automation potential and creating adoption timing scenarios for 45 other economies representing about 80 percent of the global workforce' (2017: 14).

Grace et al. (2017) surveyed machine-learning researchers who had published during 2015 in two leading conferences on AI. They sought their views on when they believed AI would outperform humans on a range of activities. The results, based on a sample of 352 respondents (21% of the authors contacted), show that researchers predicted that AI will outperform humans in many of those activities (such as translating languages, writing school essays, driving a truck) in the next ten years, and will outperform humans in a number of others within a 40-year period (working in retail, writing a bestselling book, working as a surgeon). They further report that researchers 'believe there is a 50% chance of AI outperforming humans in all tasks in 45 years and of automating all human jobs in 120 years' (Grace et al. 2017:1).

Acemoglu and Restrepo (2017:2) 'move away beyond feasibility studies', such as those by Osborne and Frey and Grace et al., to focus on the actual use of robotics. They draw on data from the International Federation of Robotics (IFR) on the use of industrial robots (in 19 industries) between 1990 and 2007 in the US, together with data on employment shares from the US Census to show that the introduction of robots has 'large and robust' negative effects on employment. This study is based on a model 'where robots and workers compete in the production of different tasks' and takes into account that 'the share of tasks performed by robots varies across industries and there is trade between labour markets specializing in different industries'. This is argued to be important as robots are assumed to affect employment and wages negatively through displacement (of workers from tasks previously performed), but also positively through productivity effects ('as other industries and/or tasks increase their demand for labor'). Their model 'shows that the impact of robots

on employment and wages in a labour market can be estimated by regressing the change in these variables on the exposure to robots, a measure defined as the sum over industries of the national penetration of robots into each industry times the baseline employment share of that industry in the labour market' (pp.2-3).

These specifications provide the starting point for their empirical strategy. They thus exploit differences in the penetration of robots by industry and the local distribution of employment across industries to estimate that 'one more robot per thousand workers reduces the employment to population ratio by about 0.18-0.34 percentage points and wages by 0.25-0.5 percent' (Acemoglu and Restrepo 2017:1). This is equivalent to 'one new robot reducing employment by 5.6 workers' (p.4), taking into account increases in employment in other areas of the economy through productivity effects. Without taking this into account, the figure the authors provide is a reduction of 6.2 workers per new robot.

The OECD has started a new approach to add information on the relationship between computers and skills. Their 'computers and skills demand project' (OECD 2017) used the Programme for International Assessment of Adult Competencies (PIAAC) data (assessing competence levels in literacy, numeracy and problem solving) to compare the performance of computers and human workers. They report than less than 15 percent of workers use those skills 'on a daily basis with a proficiency that is clearly higher than computers' (Elliott, 2017). This study focuses on only three of the skills that are used at work. The OECD notes that the approach could be extended to other skills to develop a more accurate view on computers' capabilities to substitute for human labour.

2.1.2 An alternative view

Arntz et al. (2016:4) argue that much of the research evidence presenting a strong negative relationship between automation and work is methodologically flawed. In particular, they take issue with occupation-based approaches, such as that used by Frey and Osborne, on the grounds that they overestimate job automatibility: 'Occupations labelled as high-risk occupations often still contain a substantial share of tasks that are hard to automate'. Automation targets tasks rather than occupations, and many occupations have tasks that

are difficult to automate (Autor 2014:39). As a result, adjustments to technology often take the form of changes in tasks within occupation rather than changes in employment shares between occupations (Arntz et al. 2016).

They also use PIACC data, that gathers information about task structures across OECD countries, and estimate the relationship between workplace tasks and the automatibility defined by Frey and Osborne (Arntz et al. 2016:12). Using PIAAC individual level data on actual tasks performed, they take into account the way that tasks vary by job within the same occupation. This approach enables a better exploration of differences between countries, as it does not depend on the assumption that task structures will be constant across them.

Arntz et al. estimate that, on average for the 21 OECD countries that they include in their analysis, 9 percent of jobs are automatable –the range goes from 6 percent in Korea to 12 percent in Austria. This is much lower than in Osborne and Frey's study: 'not taking account of the variation of tasks within occupations exerts a huge impact on the estimated automatability of jobs' (Arntz et al. 2016:14). They underline that their own figures are likely to be an overestimation given (1) economic, legal, social and ethical barriers preventing or slowing down automation, (2) possibilities of job-task reorganization and workers switching tasks to focus on those that are not automated and (3) the creation of additional jobs 'through demand for new technologies and through higher competitiveness' (Ibid. p.4).

Their main conclusion is that 'automation and digitalization are unlikely to destroy large numbers of jobs. However, low qualified workers are likely to bear the brunt of the adjustment costs as the automatability of their jobs is higher compared to highly qualified jobs' (Ibid.:4). Based on this premise, the implications of the study are that there is a 'need to focus more on the potential inequalities and requirements for (re-)training arising from technological change than the general threat of unemployment that technological progress might or might not cause' (Ibid:25). They find that high educational requirements and jobs requiring cooperation or where workers spend larger proportions of time influencing others are less subject to automatability. Routine tasks (related to the exchange of information, selling, or using fingers and hands), and jobs that have high shares of those tasks, are more

exposed to automation. It should be noted that Arntz et al.'s task-based approach still relies on experts' assessment rather than actual use of technologies in the workplace.

Autor (2014) also argues that the extent to which machines will be able to replace humans at work is often overestimated because the challenges in automating tasks requiring flexibility, judgment and common sense, 'remain immense' (Autor 2014:1). A central point in his argument is that machines' complementarities with certain types of human labour can increase productivity, earnings and demand for skilled workers. He notes the 'deceleration of employment growth in abstract-intensive occupations after 2000' and provides evidence suggesting that the 'locus of displacement of middle-skills employment is moving into higher skilled territories' (2014:23-24). Autor examines whether this may be due to technology having climbed up in the task domain so that it can now substitute for professional, technical and managerial occupations. While he notes that this possibility should not be dismissed, he uses data on computer and software investment to cast doubt over this interpretation: if technology could now substitute for highly paid work, he argues, we should be seeing a marked corporate increase in investment in technology whereas the opposite has happened. Autor interprets the reduction in investment after 2000 as the 'bursting of a bubble' (Ibid. p.29) after the 1990s craze in investment, which restricted innovation and demand for high skilled workers. He concludes that even in this era of uncertainty, we can be fairly confident that 'the technological advances that have secularly pushed outward the demand for skilled labor over many decades will continue to do so' (Ibid. p.39). The implication is that 'human capital must be at the heart of any long-term strategy for producing skills that are complemented rather than substituted by technology' (p.39).

Graetz and Michaels (2015) use the increase in industrial robots between 1993 and 2007 (in 17 countries across the developed world) to analyse their impact on employment. Using data from the Industrial Federation of Robotics (IFR) to estimate 'robot density' across 14 industries, they examine differences in real value added, labour productivity and hours worked.[1] They find little reason for concern during that period, noting no significant effect on total hours worked, although they also observed 'some evidence that robots reduced the hours of both low-skilled and middle-skilled workers' (Graetz and Michaels 2015:1). They do

not find effects on the hours worked by high-skilled workers, those with a college degree and above, which they take to confirm skill-biased technological change (SBTC) arguments. They estimate that such increases in the use of robots were responsible for 10 percent of the GDP growth and 15 percent of the productivity gains in those economies, and documented congestion effects as 'larger increases in robot density translated into increasingly small gains in productivity' (diminishing marginal gains). The question is whether similar trends will stand today and in the near future. As the authors note 'there is plenty of potential for increased use of robots in new industries' and to use their increased capabilities to a greater extent in the industries where they are already in use – even though the congestion effects that they report suggest that 'robot densification is not a panacea for growth' (Ibid.:5).

2.1.3 Evaluating the Evidence

The different approaches identified above indicate that the impact of automation and digital technologies on employment are widely contested. The literature presents varied expectations regarding the potential of automation to replace workers, in part, because some studies look at what robots/ computers are able to do now, whereas others reflect on what computers will be able to do in the future (near or far). What computers will be able to do is a moving target, and expectations around it need to be continuously revised and reformulated.

The literature making prospective estimations (whether occupation or task-focused), relies overwhelmingly on expert judgment in making evaluations on the changing relationship between automation and the future of work. However, technical experts tend to overestimate the capacity of new technologies (Arntz et al. 2016; Autor 2014). There are also some 'retrospective' studies providing estimates based on the effects of the introduction of robots on employment, but the data used is somewhat dated, and there are significant methodological problems in assuming that investment in technology determines changes in employment statistics.

Blanket claims about the impact of digital technologies overlook the way that they are applied across sectors and occupations. Typically, it is low skilled jobs that are assumed to be most in danger, consistent with long established ideas about technological progress and the occupational structure. However, there is growing evidence of new technologies transforming professional, managerial and technical occupations. Moreover, the studies reviewed rarely take into account the potential for job creation around automation, or for the relocation of those made redundant as a result of automation. As a result, the picture of the net impact of automation on the labour market is partial.

Most studies focus on the potential for automation, without incorporating into their models economic and social factors that may stimulate or deter the replacement of workers by technology. As such, much of the literature falls back on technological determinism, with little reference to the way companies 'choose' to deploy new technologies or to the capitalist economy, which is the engine for technological innovation (Schumpeter 1943). Martin Ford, for example, suggests that the evidence already shows that, 'a race between technology and our ability to reform our political and economic systems is really no race at all… as… machines are likely to permanently take over a great deal of the work now performed by human beings.' (Ford 2009:4-5). But it is human decisions that are taken by people in power within organisations or governments that shape the introduction and use of these technologies. As Simon Head observes, although we are often talking about abstract electronic and statistical entities which are impersonal, 'all the system's rules and commands in fact have human origins in the superior expertise of the technical, managerial elite whose wisdom is baked into the system' (Head 2014:185).

Most of the research also provides little detail on the time-frames for replacing humans by technology. Almost without exception the literature on digital disruption is replete with vague references to how long it will take for the workplace, jobs and skills to be transformed in the way that industrialism transformed agricultural employment. The failure to specify when tomorrow's world become today's world, is particularly important to all stakeholders as there is a vast difference between half of existing occupations disappearing or being significantly reformed in the next 10 years as opposed to 25-30 years' time.

The next section goes beyond the focus on job numbers to look at the skills implications of the 'digital' economy. As we will show, research in this area has been much more limited.

3. Automation, Skills and the Digital Economy: Three Accounts

When we examine the skills implications of what can loosely be described as 'digital disruption', there are three main positions, although the boundaries between them are somewhat fuzzy and some of these accounts converge on specific points. Much of this literature is not directly comparable as writers focus on different aspects of digital disruption. Some, for example, concentrate on the potential decline in employment numbers resulting from automation and advances in machine learning, while others look at new ways of working in the 'gig' or 'platform' economy. The three views can be characterised as 'labour scarcity', 'job scarcity' and 'end of work'.[2]

1. ***Labour Scarcity*** – Despite an emphasis on changing skill requirements, occupational restructuring and labour market disruption, the labour scarcity (Autor 2015) approach retains a largely optimistic account of new areas of jobs growth and skills upgrading, consistent with established theories of human capital and skill-biased technological change. It claims that there will be an increasing demand for high skilled workers and a reduction in demand for lower skilled workers as more routine jobs are automated and people retrain for more skilled jobs.

2. ***Job Scarcity*** – This approach recognises that new technologies may enhance the skills of a relatively small proportion of the workforce, but the general direction of technological innovation is towards the redesign of existing jobs, where much of the knowledge content is captured in software that permit a great level of standardisation and potential to deskill or automate a wide range of occupations, including technical, professional and managerial roles. Here, job scarcity points to a significant skills mismatch between an expanding supply of educated and skilled workers, and scarcity of good quality job opportunities, primarily resulting from the

routinisation and segmentation of job roles rather than 'technological unemployment'.

3. ***End of Work*** – This approach views technological unemployment (Keynes 1930) as transforming the future of work, along with the labour market foundations of capitalism. In the post-capitalist era, it is claimed that we need to rethink the purpose of education, skill formation and the labour market.

3.1 Labour Scarcity

The labour scarcity approach conforms to the longstanding view that the economy and demand for skills are defined by the stage of technological development. The more technologically advanced an economy the greater the demand for skilled people 'doing clever things for a living'. As in the past, new positions and professions are believed to emerge to replace any job losses due to technological disruption. This view is informed by theories of human capital and skill-biased technological change (SBTC). According to its mainstream version, new technologies alter the relative demand for different types of labour, leading to an increased demand for skilled workers. The education system therefore remains at the heart of economic and social policy, as the relationship between technology and education is not only the source of economic growth but also wage (in)equality. David Autor (2015) writes 'the primary system of income distribution in market economies is rooted in labor scarcity; citizens possess (or acquire) a bundle of valuable "human capital" that, due to its scarcity, generates a flow of income over the career path'.[3] This is to envisage a future of work characterised by a shortage (or scarcity) of people with higher-level marketable skills.

Goldin and Katz (2008) argue that there is a race between education and technology, the outcome of which explains patterns of wage inequalities in America. The race is 'between the growth in the demand for skills driven by technological advances and the growth in the supply of skills driven by demographic change, educational investment choices, and immigration' (2008:91). They conclude that educational wage differentials and wage

inequalities since 1980 result from problems in the supply of skills that has failed to respond to an acceleration in demand due to shifts in technological change. Such accounts have helped to fuel the expansion of higher education around the world and contributed to a greater focus on STEM-related fields. Other interpretations point to the need for educational reforms to develop the skills that are seen as crucial for an advanced digital economy (Hanushek and Woessmann 2015; House of Lords 2015).

Integral to this argument is the view that 'digital disruption' may lead to technological unemployment but this is likely to be short term, as economic history suggests that new jobs will emerge even if we cannot specify them in advance. Such uncertainty, if anything, adds to the importance of education and skill formation in preparing people to be adaptable rather than simply skilled. Those currently in low skilled, routine jobs, who are judged to be most at risk of automation, will therefore need to upgrade their skills to take advantage of emerging, if unspecified, areas of higher skilled job growth.

Klaus Schwab, founder of the World Economic Forum, suggests that we have entered a 'fourth industrial revolution' although its full implications are yet to be grasped. He points to the 'unlimited possibilities' of billions of people connected by mobile devices offering access to real time data and leading-edge knowledge; unprecedented processing power and data storage; and:

> 'a confluence of emerging technology breakthroughs, covering wide-ranging fields such as artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, material sciences, energy storage and quantum computing, to name a few. Many of these innovations are in their infancy, but they are already reaching an inflection point in their development as they build on and amplify each other in a fusion of technologies across the physical, digital and biological worlds.' (Schwab 2016:1).

These technologies, he argues, will result in many new positions and professions being created. While these are currently difficult to foresee, he claims, 'I am convinced that talent, more than capital, will represent the critical production factor. For this reason, scarcity of a skilled workforce rather the availability of capital is more likely to be the crippling limit to innovation, competitiveness and growth' (Schwab 2016:44-45; Autor 2015). Although perpetuating the view that developing skills and individual talents is key to the future, he suggests that what we mean by 'high skill' is likely to change as it can no longer be limited to holding a degree or having a specific set of professional capabilities: 'the fourth industrial revolution will demand and place more emphasis on the ability of workers to adapt continuously and learn new skills and approaches within a variety of contexts.' (Schwab 2016:45).

Therefore, inequality in the era of digital disruption will be linked to 'ontological inequality', separating those willing to adapt and those who resist change, as he predicts, 'we may witness an increasing degree of polarization in the world, marked by those who embrace change versus those who resist it' (Schwab 2016:97). Such a view is consistent with orthodox human capital theory, where individual incomes are primarily a result of whether people are willing to invest in their education.

The literature we categorise under labour scarcity, includes writers and researchers with divergent views on the impact of automation on existing and future levels of employment, but similar views on the 'supply' side solutions. David Autor, referred to above, suggests that claims of widespread technological unemployment are exaggerated, pointing to periodic warnings over the last two centuries, including the Luddite movement of the early nineteenth century: 'I expect that a significant stratum of middle-skill jobs combining specific vocational skills with foundational middle-skills levels of literacy, numeracy, adaptability, problem solving, and common sense will persist in coming decades' (Autor 2015:27).

Autor's view stands in stark contrast to Carl Frey and Michael Osborne's (2013) claim that 47 per cent of America jobs could be at risk of computerization. They suggest jobs in transportation and logistics, office administration and production occupations are

particularly at risk. But what makes these arguments consistent, is the idea that those with lower skills are at most risk and therefore there is a race between technology and education to develop more advanced skills to remain relevant in tomorrow's labour market:

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

Brynjolfsson and McAfee (2014:11) also make a direct link to the second machine age, in which 'technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead' but at the same time, they argue:

> 'there's never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only "ordinary" skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate.'

Here the fundamental challenge remains the reform of education systems to prepare the future workforce to take advantage of new opportunities emerging within a technologically advanced economy. This may include offering opportunities to less privileged students (i.e. poor families, women and ethnic minorities), by dismantling barriers to occupational mobility widely recognised to confront their access to the established professions (Brown 2013; McKnight 2015).

The labour scarcity approach can also be seen in much of the literature that focuses on the 'gig' or 'sharing' economy. The restructuring of work leads people to work in multiple contexts, breaking established models of employment and career development. Many

accounts of these changes highlight the need to 'reskill' the workforce as more people are given an opportunity to use their skills, knowledge and talent to earn a living, even if this no longer conforms to the conventional model of organisational success (Huws, Spender and Joyce 2016).

There has been a lot of discussion about online digital platforms with the potential to disrupt many areas of employment in a diverse range of business activities, including travel, accommodation, retail, banking, education and training, and software development (Srnicek 2017). Platforms such as Uber, Airbnb, Upwork, Profinder and Freelancer, are not only seen to offer a quick and cost-effective way of linking supply and demand but according to Schwab (2016:20) 'enables the effective use of under-utilized assets – namely those belonging to people who had previously never thought of themselves as suppliers (i.e. of a seat in their car, a spare bedroom in their home, a commercial link between a retailer and manufacturer, or the time and skill to provide a service like delivery, home repair or administrative tasks)'.[4]

The idea of the gig economy is often presented as new, exciting and entertaining. It describes how digital technologies are being used to break with out-dated ways of working based on the amount of time you spend in the office or factory. The gig economy presents a different world of work in which people are given greater freedom, no longer contracted to sacrifice five or six days a week in exchange for a pay check. Individuals are free to decide when, where, and for how long they want to work. It is typically represented by freelance consultants with expert knowledge and skills to sell through digital platforms such as freelancer.com, upwork.com, etc. It is also characterised as an inevitable shift in response to the changing aspirations of a younger generation of 'digital natives' who it is claimed no longer want to work 9-5, day-in-day-out for other people.

Such interpretations of the need for re-skilling has also been linked to 'bottom up' innovation and social (as well as economic) enterprise, driven by declining marginal costs of communication and production, meaning that you do not need to own factories, offices or expensive computers to participate in new forms of economic activities. In short, the same technological trends that are enabling companies to develop sophisticated global value

chains through process innovation also make available micro-level co-production. With the growth of digital platforms, such as itunes apps, etc. it is believed that it is possible for anyone to develop new applications for sale or make them free to others. There has been a lot of interest in the Internet of Things, 3D printing, open manufacturing, and MOOCs, within a 'sharing' economy enabling people to contribute to, and benefit from, the 'collaborative commons' (Anderson 2012).[5]

3.2 Job Scarcity

While some highlight reskilling, consistent with skill-biased technological change, others point to the prospects of digital disruption, resulting in increasing standardization, routinisation, and the de-skilling of a significant proportion of the workforce. This alternative interpretation raises fundamental questions about the future demand for 'knowledge' workers, job quality and human capital assumptions about earnings matching learning. Here the focus has been less on the impact of automation on overall (un)employment, and more on the future demand for high skilled workers. While the 'knowledge' economy is associated with scientific knowledge, technological innovative, and the creative industries, it is claimed that what is not adequately recognized is how digital innovation has also given company managers and executives new powers of control and command (Brown et al. 2011; Head 2014).

Job scarcity accounts reject the human capital view that higher-level skills are the route to income growth through raising productivity (Piketty 2014; Stiglitz 2012). Rather, there is a recognition that it is not only about 'technologies' but 'capitalism' (Schumpter 1943; Wajcman 2015). Technology is not destiny as its use is shaped by the forces and relations of production, that lead firms to deploy technologies in ways that sustain the proprietary rights of owners, shareholders, and senior executives. A view consistent with Schumpeter and insights from Marx, where capitalism is in a state of 'constant commotion' drawing on new technologies and business practices (Mason, 2015).

Harry Braverman's classic study of *Labor Under Monopoly Capitalism* argued that firms used technologies to enhance the power and control of business owners through a process of deskilling. He expressed skepticism about terms like 'skill', 'training' and 'education', which

he regarded as vague, making it difficult to assess claims of increasing skills 'upgrading' over time. He suggested that much of the work on skills upgrading is based on 'impressionistic theory' (Braverman 1974:424) and challenged the idea of an increase in the average demand for skill:

> 'Since, with the development of technology and the application to it of the fundamental sciences, the labor processes of society have come to embody a greater amount of scientific knowledge, clearly the "average" scientific, technical, and in that sense "skill" content of these labor processes is much greater now than in the past. But this is nothing but a tautology. The question is precisely whether the scientific and "educated" content of labor tends towards averaging, or on the contrary, towards polarization. If the latter is the case, to then say that the "average" skill has been raised is to adopt the logic of the statistician who, with one foot in the fire and the other in ice water, will tell you that "on the average", he is perfectly comfortable. The mass of workers gain nothing from the fact that the decline in their command over the labor process is more than compensated for by the increasing command on the part of managers and engineers' (Braverman 1974:425).

This presents a different interpretation of the relationship between technological innovation and skills, in contrast to SBTC described above, as Braverman (1974:425) went on to note that 'The more science is incorporated into the labor process, the less the worker understands of the process'. Therefore, while Braverman may be accused of underestimating the development of professional, managerial and technical employment in the latter decades of the twentieth century, the idea of knowledge being embedded in the labour process itself, rather than increasing opportunities for employees to use knowledge and skills, is of major significance to understanding today's digital disruption. More recent evidence suggests that new technologies are enabling new forms of command and control by using digital software to capture knowledge and automate business processes.

Brown, Lauder and Ashton (2011) argue that the twentieth century witnessed the widespread use of *mechanical Taylorism* characterised by the Fordist production line, where the knowledge of craft workers was captured by management, codified and re-engineered

in the shape of the moving assembly line, resulting in a clear divide between a semi-skilled workforce and the managers and professionals who controlled all aspect of factory life. Today, the same processes of knowledge capture are being applied to intermediate and high skilled employees in the service sector. Brown, et al. argue that the twenty-first century is an age of *digital Taylorism*. This involves translating *knowledge work* into *working knowledge* through the extraction, codification and digitalisation of knowledge into software prescripts and templates that can be transmitted and manipulated by others regardless of location. The result is the standardisation of functions and jobs, including an increasing proportion of technical, managerial and professional roles that raise fundamental questions about the future of 'knowledge' work:

> 'Companies may continue to pay a premium for outstanding talent, however it is defined, but they are increasingly segmenting their knowledge workers in an attempt to know more for less. Although some are given permission to think, increasing efforts are being made to translate knowledge work into working knowledge where what is in the minds of employees is captured and codified in the form of digital software, including online manuals and computer programs that can be controlled by companies and used by other often less skilled workers.' (Brown, Lauder and Ashton 2011:66).

Whereas the distinction between conception and execution in a period of mechanical Taylorism transformed the relationship between the working and middle classes, digital Taylorism takes the form of a power struggle within the middle classes, as these processes depend on reducing the autonomy and discretion of managers and professionals. As Wilensky (1960:557) predicted, 'the men who once applied Taylor to the proletariat would themselves be Taylorized.' The re-stratification or segmentation of 'knowledge' work, Brown et al. argue, restricts permission to think to those in 'developer roles', typically including staff in executive functions, along with those identified as high potential researchers, managers, and professionals. They are highly qualified and, in corporate settings, are expected to work on international engagements and are typically recruited from global elite universities.

Those in developer roles are distinct from 'demonstrator roles' where people are employed to implement or execute existing knowledge, procedures or managerial protocols. They include knowledge used by consultants, managers, teachers, nurses, and technicians, but delivered through digital software. Although demonstrator roles include well-qualified people, there is less scope to think outside the digital box as much of the expert knowledge is captured in expert (digital) systems. However, this does not always eliminate the need for good customer-facing skills as the standardisation required to achieve mass customisation still needs customers to feel that they are receiving a personalized service. This may contribute to a continuing demand for university graduates but these are far removed from the archetypal graduate jobs of the past.

In turn, demonstrator roles are also distinct from 'drone roles' that offer little discretion to employees, although a good level of literacy, numeracy, and teamwork skills are often required. Much of the work is digitally controlled and includes back-office functions such as data entry jobs or customer contact roles in call centres, where virtually everything is prescribed or scripted in software packages. Many of these jobs are highly mobile as they can be standardized and digitalized. They are often filled by well-qualified workers either attracted by relatively high salaries in emerging economies or struggling to find a job that matches their training or expectations in developed economies. These are also roles that are most likely to be superseded by digital automation given advances in artificial intelligence, voice recognition and biorobotics (Brown, Lauder and Sung 2015).

Simon Head's (2014) account is consistent with Brown et al.'s as he sees the coming together of new technologies to perform highly complex tasks in the control and monitoring of business processes and employees as a high-tech version of Fredrick Winslow Taylor's 'scientific management'. In what he calls 'the first machine age' he suggests:

> 'the working class occupied a world apart, tethered to factories and assembly lines and bearing the full rigors of industrialism. In the new machine age, the working class can be all of us. The new industrialism has pushed out from its old heartland in manufacturing to encompass much of the service economy, and it has also pushed upward in the occupational hierarchy to

> include much of the professional and administrative middle class: physicians as well as call-center agents; teachers, academics, and publishers as well as "associates" at Walmart and Amazon; bank loan officers and middle managers as well as fast food workers.' (Head 2014:5)

Therefore, the application of new technologies to manufacturing is nothing new but the application of digital Taylorism to 'white collar' rather than 'blue collar' work has real revolutionary potential. Rather than sparking a new wave of 'office' employment, it has seen office work being standardized, digitalized and modularized. Susskind and Susskind (2015), view this differently as the liberation of the professions, breaking the monopoly of professional practices as expert knowledge becomes more widely accessible through new modes of digital communication, 'as our systems and machines are becoming increasingly capable.' As they note, 'when it comes to the future capabilities of our machines, the overall trajectory of technological advance is clear and of great importance for the professions – more and more tasks that once required human beings are being performed more productively, cheaply, easily, quickly, and to a higher standard by a range of systems. And there is no apparent finishing-line' (Susskind and Susskind 2015:159).

Some writers have also pointed to the ways in which digital technologies have been used to develop standard platforms resulting in 'on demand' forms of non-standard flexible labour, in insecure or precarious jobs, with little access to basic employment rights, let alone skills training or career progression (Beck 2000; Standing 2011). Such models are associated with significant knowledge capture as customer information, billing, marketing and business development are controlled by those who operate the digital platforms.

3.3 End of Work

The 'end of work' approach pushes the discussion beyond changes in the nature of skills and work to include the future of capitalism. Jeremy Rifkin argues that the transformation of the workplace is part of a more profound shift in capitalism's ability to raise productivity to the point that it approximates what economists call the 'optimum general welfare' where the cost of producing additional products and services has 'zero' marginal cost (Rifkin 2014:2-3).

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

The point these authors and others are making is that the means of production are becoming cheaper because 'information' is positive sum, it is not used up in the same way as physical products. New technologies have reduced the cost of communicating and advanced computing so that anyone with access to the internet are plugged into a world of information. As the scope increases at the same time as costs decline, there is the potential for more social activities blurring the distinction between market and non-market activities. Facebook, for example, allows you to connect with family and friends but at the same time displays tailored adverts, depending on your recent web search history.

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

Paul Mason similarly suggests that such trends mark the beginning of a post-capitalist era:

> ‘the rapid change in technology is altering the nature of work, blurring the distinction between work and leisure and requiring us to participate in the creation of value across our whole lives, not just in the workplace. This gives us multiple economic personalities, which is the economic base on which a new kind of person, with multiple selves, has emerged. It is this new kind of person, the networked individual, who is the bearer of the postcapitalist society that could now emerge. The technological direction of this revolution is at odds with its social direction. Technologically, we are headed for zero-price goods, unmeasurable work, an exponential takeoff in productivity and the extensive automation of physical processes. Socially, we are trapped in a world of monopolies, inefficiency, the ruins of a finance-dominated free market and a proliferation of “bullshit jobs”. Today, the main contradiction in modern capitalism is between the possibility of free, abundant socially produced goods, and a system of monopolies, banks and governments struggling to maintain control over power and information. That is everything is pervaded by a fight between network and hierarchy.’ (Mason 2015:143-144)

Such a radical transformation of the occupational structure would render redundant the market distinction between labor supply and demand, between employers and employees, and between sellers and consumers. This would lead to a rapid growth in what Rifkin calls ‘prosumers’, who will ‘be able to produce, consume, and share their own goods and services with one another on the Collaborative Commons at diminishing marginal costs approaching zero, bringing to the fore new ways of organizing economic life beyond the traditional capitalist market model’ (Rifkin 2014:132; Frayne 2015).

In pursuing the same line of argument, Jeremy Rifkin raises the ultimate question of what is the human race going to do with itself if mass employment disappears from economic life:

> ‘What if the marginal cost of human labor in the production and distribution of goods and services were to 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? That too is occurring as tens of millions of workers have already been replaced by intelligent technologies in industries and professional bodies around the world. What would the human race do, and more importantly, how would it define its future on Earth, if mass and professional labor were to disappear from economic life over the course of the next two generations? That question is now being seriously raised for the first time in intellectual circles and public policy debates.' (Rifkin 2014:70)

This approach is different from the others in highlighting the end of work rather than the transformation of work, at least in the terms we have come to think about work as waged employment. The idea of digital disruption typically plays a central role in such accounts as it implies that the fundamental economic problem of material abundance, rather than material scarcity, has been solved by a revolution in productivity, facilitated by technological innovation no longer dependent on mass employment (Gorz 1999). This transforms the nature and purpose of education and skill formation, from an emphasis on employability skills to a more holistic view of life skills beyond standard models of employment and career development.

This section has distinguished three approaches with regards to skills, work and the digital economy: labour scarcity, job scarcity and the end of work. These approaches have different policy implications which mirror the current lack of consensus revealed in current research on automation and the future of work. Given this lack of consensus, the following section will examine the policy responses to 'digital disruption' in the UK.

4. Policy responses

How is the Westminster government responding to the potential impact of digital automation on employment and skills? In this section, we first explore UK Parliamentary

committees and government documents, identifying the evidence they draw upon and how they view the potential disruption to employment and skills. To date, there has been little in the way of analysis of the likely implications for employment, although there has been some shift in skills policy. The paper then outlines attempts by the robotics and AI academic community, and the social partners to influence government policy in this area.

4.1 Engaging with technological change

Rather than emanating from government, the first important reference to the employment and skills consequences of robotics and AI is a House of Lords ad hoc committee on digital skills established in 2014 to 'consider information and communications technology, competitiveness and skills in the United Kingdom' (House of Lords 2015:17). The subsequent report argues that major transformation is already taking place in digitalisation, citing the 35 per cent potential jobs losses derived from the Frey and Osborne methodology discussed above (Frey et al. 2014). In addition, the future poses a 'tsunami' of change:

> 'Over the coming years the UK will witness a transformation of unprecedented magnitude as workers will have to move to new occupations and industries. It is unknown whether there will be net job loss on a large scale or whether new jobs will be created in other areas—both familiar jobs and others no one has yet been able to foresee. In the past, workers have adapted to technological revolutions by acquiring new skills. To manage the coming transition successfully, an overhaul of the skills of the entire population is crucial. The labour market disruption ahead may be greater than anything we have seen in the past'. (House of Lords 2015: 21)

Relying on data that 'makes a judgement' about the type of digital skills that will be required in 361 occupations based on the SOC coding over the next two to three years (UKForCE 2014), the report claims that digital skills will be required across the workforce, although at varying levels. The general position is that there is currently a shortage of medium and high level digital skills, that reskilling and upskilling is required across the workforce, and that digital skills are urgently required to be integrated across the curriculum at all levels of the

education system. The report states that 'Whole industries are being wiped out due to changing technologies, with new ones emerging at the same time' (House of Lords 2015:50), although which industries have been 'wiped out' are not identified. Along with digital skills, there is some reference to the need for government to invest in lifelong learning to enable individuals to continue to access the labour market.

The House of Lord's report was followed by a very similar enquiry by the House of Commons Select Committee on Science and Technology into the 'digital skills crisis' (2016a). It also refers to the 35 per cent potential jobs losses derived from Frey and Osborne (2013), alongside claims that 'the rise of the Internet of Things, Big Data and robotics means that 65% of children entering primary school today will be working in roles that do not yet exist' (House of Common Science and Technology Committee 2016a:7), and that '90% of new jobs require digital skills' (2016a:13). While Frey and Osborne's approach may be controversial, their data are derived from a clearly specified methodology, as discussed above. However, these other figures, which have been widely reported elsewhere, do not appear to be based on any research and their origins are untraceable. Nevertheless, on the basis of such 'evidence', the report concludes: 'the evidence is clear that the UK faces a digital skills crisis' (2016a:3) and that, for businesses, developing the digital skills of their workforce is 'a matter of survival' (2016a:16).

The Committee, therefore, appears to adopt a negative view of the relationship between technology and unemployment, with the world changing dramatically and the potential for widespread job losses. At the same time, if government, the education system and employers are proactive, including upskilling and reskilling the workforce, great opportunities exist as new forms of employment will require higher level skills. While the focus is on digital skills, other skills tend to be glossed over: 'We must equip the next generation not just with the skills that we know industry needs today but also with the skills they will need for a future not yet imagined.' (2016a:36). How the education system can develop skills for an unimagined future is a point that is not considered.

A further Enquiry was launched by the same Committee in March 2016 into Robotics and Artificial Intelligence. A central aim of the Committee was to address the implications for

the 'future UK workforce and job market, and the Government's preparation for the shift in the UK skills base and training that this may require' (House of Commons Science and Technology Committee 2016b:7). Some positive views were presented to the Committee, suggesting that the overall impact on employment levels was likely to be small, as had happened in past technological waves, but that disruption would occur as some sectors would grow while others declined (Google DeepMind 2016; Deloitte 2016): 'it takes time for new technologies to actually change employment. Probably, the changes in the very near future will be relatively small' (Farquhar 2016).[6]

The Committee's Report also discusses the more pessimistic interpretations of the future of work, citing Frey and Osborne's work (2013) and the Bank of England's analysis of 15 million jobs at risk (Haldane 2015). There is also reference to a McKinsey report that 'AI was contributing to a transformation of society 'happening ten times faster and at 300 times the scale, or roughly 3,000 times the impact' of the Industrial Revolution' (Dobbs et al. 2015:2). There is some discussion about jobs that are more vulnerable, for example driving a taxi or truck, and those that are more difficult to replace, such as creative occupations. Some differences emerge as to whether the lowest paid (skilled) jobs are most at risk (Haldane 2015), or those in middle-income jobs (Deloitte 2016). Osborne (2016:11) is one of the few contributors to suggest that new occupations may 'not be sufficiently well paid to substitute for those that are automated away', thereby suggesting the potential for deskilling, as well as reskilling, and for growing levels of inequality.

The Committee's Report concludes that the extent of future change is unclear:

> 'there is no consensus about what this will mean for the UK workforce. Some expect rising unemployment as labour is substituted for AI-enabled robots and machines. Others foresee a transformation in the type of employment available—with the creation of new jobs compensating for those that were lost—and the prospect of robotics and AI augmenting existing roles, and enabling humans to achieve more than they could on their own.' (2016b:3)

Despite the lack of consensus, the Report claims that 'a much greater focus is needed on adjusting our education and training systems to deliver the skills that will enable people to adapt, and thrive, as new technology comes on stream' (2016b: 3). The position appears to be that, although we do not know how extensive changes will be, it is important to be prepared and this will involve both reskilling and upskilling.

> 'As a nation, we must respond with a readiness to re-skill, and up-skill, on a continuing basis. This requires a commitment by the Government to ensure that our education and training systems are flexible, so that they can adapt as the demands on the workforce change, and are geared up for lifelong learning.' (2016b:16)

The question of what skills will be needed is left unanswered, with the exception of a narrow focus on universal digital skills and STEM subjects to aid the growth of robotics and AI sectors. 'Addressing the UK's digital skills "crisis"… was repeatedly identified in written submissions as essential in order to mitigate some of the more potentially negative impacts of robotics and AI on employment' (2016b: 13). Recommendations from the committee focus on how to improve the competitive position of the robotics and AI industry, and responding to the 'digital skills crisis' and digital exclusion. There is no mention of any broader employment and skills implications of technological disruption.

The response by Westminster Government to the report focuses on the recommendations and does not address issues of employment change. In relation to skills, it claims that the Government is 'working closely with the industry, education and training bodies and charity organisations to reduce key skills gaps and address urgent shortages', and are developing digital skills in schools (House of Commons Science and Technology Committee 2017:3). More broadly, issues around the diffusion of new technology have been assigned to the productivity agenda, with the establishment of a Productivity Leadership Group, and an Industrial Digitalisation Review (2017), composed primarily of business leaders.

Policy in the field of robotics and AI has been primarily directed through the former Department for Business Innovation and Skills and, from 2016, the Department for Business, Energy and Industry Strategy, with some engagement with the Department for Education in England, and the Department for Digital, Culture, Media and Sport. In 2012 robotics and artificial systems were included as one of the 'eight great technologies' that would support the Government's new industrial strategy. Since then, the direction of policy has been primarily focused on developing the robotics and AI industry through, for example, investment in research and development. There has been rather less discussion about how to diffuse technologies across a range of sectors and their implications for work and skills.

The Industrial Strategy (Green Paper 2017; White Paper 2017) and the Digital Strategy (2017) are the three most relevant government policy documents. In the Green Paper, it is noted that the 'UK makes less use of robotics and automation than most other countries in Western Europe' (HM Government 2017a:15), and comments on the continued low level of investment in research and development. But the document makes little reference to the potential disruption to employment. Similarly, the Digital Strategy focuses on access to digital infrastructure and digital skills. The Industrial Strategy Green Paper makes one substantive reference to employment changes: 'The world of work is changing too, with one study [Frey et al 2014] stating that 35 per cent of existing UK jobs estimated to be at high risk of replacement by technology in the next 10 to 20 years, particularly at medium-skill levels'' (2017a: 39). Both the Green Paper and the Digital strategy make reference to the unsubstantiated figure identified earlier in the HOC report (HOC 2016b: 7), that 90 percent of jobs in the next 20 years will require some digital proficiency. Drawing on an Ipsos Mori (2015) survey, both reports note that 23 per cent of adults lack basic digital skills indicating a 'digital skills crisis'.

These strategy papers point to a reluctance to make any direct reference to the impact of digital disruption on employment, yet at the same time acknowledging the importance of competing within the new environment:

> 'As we leave the European Union, it will be even more important to ensure that we continue to develop our home-grown talent, up-skill our workforce

> and develop the specialist digital skills needed to maintain our world leading digital sector.' (DfDCMS 2017, Section 2, parag 4)

> 'Innovation can sometimes be disruptive, but ultimately we must embrace innovation to keep ahead of the competition, create more good jobs, and make sure jobs in the UK are secure.' (HM Government 2017a: 25)

There is also a long-established emphasis on the importance of skills for competitiveness, productivity and individual wages. The Green Paper, for example, points to the usual concerns around a lack of basic skills, intermediate technical skills and STEM subjects at all levels. These skills are seen as desirable for a modern economy but references are also made to technological change, although with a narrow focus on the robotics and AI sector as opposed to the broader prospects for employment. There is some recognition of the requirement for retraining over the life course:

> 'Faster changes in technology mean we need to help more people retrain in new skills, so we will embed the concept of lifelong learning. To renew communities affected by economic changes and support people in industries at risk of decline, we will explore new approaches including more effective outreach directly into workplaces to promote retraining.' (2017a: 16)

The White Paper *Industrial Strategy* makes even less reference to employment disruption, and instead notes on a number of occasions that employment has been growing over recent years: 'At the moment, our problem is not unemployment caused by technology, it is low earning power caused by, among other reasons, a failure to use technology' (HM Government 2017b: 98). An optimistic future is presented in terms of a growing demand for high skilled workers, and the requirement for upskilling and reskilling of the existing workforce:

> ‘Research predicts around 1.8 million new jobs will be created between 2014 and 2024, and 70 per cent of them will be in the occupations most likely to employ graduates.’ (2017b:100)

> ‘We will ensure that everyone can improve their skills throughout their lives, increasing their earning power and opportunities for better jobs. We will equip citizens for jobs shaped by next generation technology. As the economy adapts, we want everyone to access and enjoy good work.’ (2017b: 94)

The White Paper points to the importance of improving technical education, digital skills and STEM subjects, and much of the policy measures relate to changes in initial education, apprenticeships and additional funding for robotic and AI related research degrees. While current skills shortages are frequently cited as the problem, improving STEM and digital skills are also linked more directly to future changes in technology. To respond to concerns around the necessity for lifelong learning, enhanced access to basic digital skills and a national retraining scheme are proposed in the Industry Strategy: ‘We will also promote a new adult digital skills entitlement to support basic training and our new National Retraining Scheme will help people re-skill and up-skill as the economy changes, including as a result of automation’ (HM Government 2017b: 39).

Legislation has been introduced to give adults without basic digital skills the right to access free training in England (The Digital Economy Bill 2017). This builds on existing rights to free basic literacy and numeracy courses that were seen as a key part of the solution to the ‘basic skills crisis’. An advisory group to the Retraining Scheme has also been established with representatives from the CBI and the TUC, and an initial focus on digital skills and the construction industry.

While initially suggesting the potential for dramatic changes in employment, policy initiatives are then presented within an optimistic view of the future. There is, however, little reflection on any evidence about the scale and nature of any change and a lack of

detailed analysis of the implications for skills. A more active role for government in industrial policy is accepted, but the underlying assumption is that with the right skills and investment in infrastructure and R&D, jobs will be available for individuals to fill at a higher or equivalent skill levels. In other words, the policy response remains wedded to the labour scarcity approach outlined above.

4.2 Influencing policy

In the UK, a variety of interest groups have attempted to influence the UK Government's approach to robotics and AI. Scientific and technical experts have focused primarily on R&D, while the peak representatives of employers (the CBI) and trade unions (TUC) have called for a broad enquiry into the impact on future employment.

In 2013, the Technology Strategy Board, a BIS (Department for Business Innovation and Skills) funded body, established the Robotics and Autonomous Systems Special Interest Group which brought together 'researchers, industrialists and civil servants to produce a national strategy' on robotics and autonomous systems (RAS-SIG 2014).[7] Their strategy report focused primarily on how to enhance the capacity of the sector, although it also included the aim of establishing the UK as a leader 'in the *implementation* of RAS technology' (2014:4, emphasis added). In relation to the impact on jobs and skills, the tone is largely positive; references are made to the potential for automation to re-shore production in manufacturing, thereby creating jobs. It also suggests that technology in the care sector could provide 'lifting capability, automatic cleaning' so that workers' jobs could be redesigned to concentrate on caring activities. Although there is no general analysis of how skill demands are likely to change, the main skills-related policy proposals refer to extending higher-level engineering and science skills within the sector.

More recently, the university-based UK-RAS Network (funded by the EPSRC[8]) has produced a number of papers that include broad policy recommendations, alongside proposals related to specific industries and sectors, such as social care and the extreme environment. These explore the issues from an industry or technical viewpoint with an ongoing theme about the need to develop specialist skills for the industry. Overall, the view of most of

these reports is relatively optimistic about the changing job structure – with robots seen as replacing routine tasks and with the potential for a growth in higher skilled jobs (eg. UK-RAS Network 2016, 2017a). However, a more cautious tone is adopted in an overview paper (UK-RAS Network 2017b: 39) which warns that both manual jobs and office work at intermediate level are likely to be lost and that government needs to intervene to ensure that the benefits of automation are 'distributed equally'. These reports are generally dismissive of the pessimistic approach to employment decline, identified in the earlier part of this paper, although there is a more mixed account of how changes in employment will affect skill demands.

The recent government-commissioned Taylor report into modern work practices makes little reference to the impact of RAI, apart from its role in providing the platforms for the 'gig economy'. There is a short commentary on the potential changes in job structure drawing on Frey and Osborne (2013), Haldane (2015) and DeLoitte (2015). The report, however, confidently asserts that skills are the answer: 'ensuring the labour force is equipped with the necessary skills for a modern labour market will be important and will mitigate uneven redistribution of wealth caused by any possible 'hollowing out' effect' (Taylor 2017:30). It is an area of 'a watching brief' rather than immediate intervention (2017:31).

A number of these developments cut across the nations of the UK in relation to industrial policy, although skills are a devolved issue. In Scotland, the main focus has been on digital infrastructure and the provision of digital skills and encouraging more young people into STEM (DfDCMS 2017:15). However, it has established a new Strategic Labour Market Group comprised of government, academics, business and trade unions which will include issues related to 'how automation and digitisation will impact on the future of work'. The recent Scottish TUC and Scottish Government joint report on technological change and the Scottish labour market provides a more nuanced, reflective piece than has been seen from Westminster (Scottish Government 2018). Innovation Wales strategy was produced in 2014 and highlights the employment opportunities of developing high technology sectors rather than issues of jobs losses. It has recently commissioned an Independent Review on digital

innovation to investigate the challenges and opportunities it presents for skills, jobs and the labour market in Wales.[9]

The House of Lords and House of Commons select committees' reports emphasise that government should be doing more to explore the potential impact of digital disruption on employment. This view is echoed by both the CBI and TUC:

> 'Government should set up a joint Commission in 2018 involving business, academics, employee representatives and a minister to examine the impact of AI on people and jobs, with recommendations for action and policy.' (CBI 2017:11)

> 'The first step for Government in this area could therefore be to… convene a year-long inquiry on the future of work, with representation from unions, business organisations, and experts in the field. The inquiry could investigate how to ensure that technology can help meet the aims of the government's industrial strategy, including raising productivity, addressing regional inequalities, and most importantly improving the quality of and reward for work'. (TUC 2017:44)

The CBI presents a more optimistic picture of the impact of technology than the TUC, although with the caveat that government must take action to ensure that businesses are successful in the new environment:

> 'With leading entrepreneurial talent, a competitive financial ecosystem and world-class research and development the UK has a golden opportunity to lead the way in unlocking the potential of new technologies and build upon its reputation as a renowned hub for disruptive innovation.' (CBI 2017:3)

While there is little reference to potential employment effects in their most recent report, skills are identified as one of the barriers. In an earlier report (CBI 2017:2), there is a reference to the McKinsey claim that AI will have 3000 times the impact of the industrial revolution (Dobbs et al 2016:2). There is no mention of this type of figure in the latest paper, but instead there is a call for more AI specialist skills, and the need for an 'increasingly data literate workforce' (CBI, 2017:11).

The TUC has produced a discussion paper specifically focusing on the issues of employment. As with the CBI, they stress the importance of investing in these technologies but they are primarily concerned with the distribution of the benefits. Drawing on Frey and Osborne (2013), Arntz et al (2016), Haldane (2015) and PWC (2017), the report concludes:

> 'Perhaps the main conclusion to be drawn from this is that the impact of automation on jobs is uncertain – with estimates ranging from 10 per cent to 30 per cent of jobs in the UK being at risk. It is important to note that these do not mean that the total number of jobs will decrease by 10-30 per cent; if the past is a guide to the future, then the likelihood is that these jobs could be replaced by new occupations and professions. What we do know is that a significant number of current jobs are liable to be lost to digitalisation and that policy makers must plan to mitigate that outcome'. (TUC 2017:26)

The TUC report also presents a more pessimistic scenario of job losses, focusing on the digital divide and those 'left behind', given that new jobs are assumed to require 'reskilling'. The expectation is that those with lower level skills and lower wages will be more at risk and that 'a skilled and diverse workforce' (2017:45) is required to enable the UK to reap the benefits of technology. The report recommends a focus on those already in the workplace; 'mid-career workers' who are most likely to be 'left behind'. This would require increased investment in adult education and lifelong learning and retraining focused on those facing redundancy (2017: 46).

The review of policy indicates a lack of any systematic analysis of the evidence base for future employment changes. As outlined in earlier Sections, there is a lack of consensus about the extent of change, with much of the research driven by consultancy and high tech companies, rather than by academic researchers. Although there is an ongoing assumption that disruption to employment is inevitable, the policy response is predominantly focused on the supply side, in particular the digital skills crisis and the shortage of high level technical skills. The approach is consistent with a labour scarcity approach closely associated with orthodox human capital theory. Here the major challenge is one of reskilling or upskilling the workforce, rather than any concern that mid and higher-level jobs may be subject to digitalisation and, therefore, deskilling.

5. Conclusions

The reviewed literature has given rise to a stimulating and certainly relevant debate given that it addresses pressing social issues that are central to the future of economic development, income distribution, and individual wellbeing, across the globe. Some main points can be extracted from this review.

First, there are major limitations to the existing research on digital technologies and their implications for skills and the future of work. As outlined in section 2, there are major methodological differences in studies that attempt to predict the extent of automation, and the time scales for change are often vague or unspecified. It is generally conceded that it is even more difficult to identify the jobs that will be created over the next 30 years. An element of caution is, therefore, required when developing policy in the context of 'evidence' that is highly contested.

Second, we have identified three main approaches to the likely impact on skills, but it is the *labour scarcity* view which continuity to dominate policy discussions. It maintains that the economy will continue to create new employment opportunities as it has done in previous periods of economic upheaval. It also maintains a human capital approach to government policy with a focus on supply-side solutions. The *job scarcity* view has received far less

attention because it points to a splintering or segmentation of established forms of graduate or professional work, which presents a direct challenge to the core assumptions informing much of the existing policy literature. The *end of work* scenario is even more problematic from a policy perspective and is yet to receive serious policy consideration.

Third, government policy is focused on developing robotics and AI as a key industrial sector and employment/skills issues are defined predominantly in relation to lack of scientific, computing and engineering skills. The underlying assumption is that there is a shortage of workers in these areas and a shortage of skills across other sectors. The emphasis on basic digital skills for 'everyone' is justified in terms of inclusion (e.g. access to markets and to public services), and employment, where digital proficiency is seen in the same light as basic numeracy and literacy. There is an assumption that these technologies will diffuse across all sectors, requiring generalised 'reskilling' or 'upskilling'. It is important to question this technological determinist view of both the use and diffusion of technology and the consequences for skills. To date, there has been very little research examining the realities of how robotics and AI are reshaping occupations within the workplace.

Fourth, given the above, the policy focus in the UK is centred on the 'digital skills crisis', pointing to continuity rather than change in policy narrative. The supply side focus remains key in policy accounts as education and skills are seen as essential factors in enabling young people and those already in work to navigate the future successfully. Nevertheless, there is a lack of detailed discussion of what kinds of technical skills are required beyond broad STEM qualifications. While the 'digital skills crisis' is frequently referenced, there is a lack of specifics about what precise skills are being demanded by employers (and are currently lacking) that apply broadly to young people and those already employed. However, there is some recognition from the various non-governmental reports that it might be useful to focus on developing alternative skills that are not easily automated, such as those with strong components of creativity, interpersonal and social skills. In some ways, this reflects earlier debates about the type of education required to support workers in periods of rapid technological innovation. There are also many calls for education to develop the skills of the future or to 'future proof' young people by introducing an alternative curriculum. However,

government policy tends to emphasise ad hoc answers, such as to introduce coding in the IT curriculum for every pupil.

Fifth, there is little evidence that research on AI and automation, such as claims of large numbers of jobs at risk, is being used to ignite a wider agenda about the human capital bargain based on 'learning equals earning'. The *job scarcity* and *end of work* approaches both view a significant mismatch due to inadequate demand for skilled labour. They also point to the limits of the labour market to resolve distributional issues concerning who does what and gets what. Therefore, issues of (re)distribution are conspicuous in their absence, given growing interest in basic income initiatives in recognition that the future of work will not result in a shared prosperity, but depends on significant institutional reform beyond education and training systems (Haldane, 2018 Brown, et al. forthcoming).

Sixth, the process of developing policy in this area is largely seen as an issue for employers and government, as they respond to the forces of technological change. However, the introduction of technology is a social and economic process with actors playing an important role in shaping whether and how technological change takes place and with what consequences. Recent initiatives to develop policy around the digital economy in Germany and Norway include representatives from employer associations, trade unions and civil society, with a focus on consultation and engagement with society more broadly about a vision for the future workplace and how to shape it through technology (FMLSA 2017:216). There are some moves to a more social partnership model in Scotland and Wales in relation to policy in this area, but in England, the approach is largely one that emphasises competitiveness and productivity as a route to delivering a shared prosperity.

We have identified major difficulties in establishing the likely implications of robotics and digital technologies on employment and skill demand. Where might future research best be deployed? While there is always a place for predictions about future scenarios, their use is limited given the complex relationship between technology, employment and skills. The pace and shape of technological change is subject to a whole variety of factors from economic incentives to the social, ethical and regulatory aspects, as well as the different power relations within organisations among different groups (professionals, trade unions,

managers), and broader societal relationships. In the post WWII era, there were many in-depth studies of new technologies, but these are largely lacking today. International comparative research would also be helpful in exploring how national institutional contexts may help to shape different outcomes. Furthermore, the very notion of 'digital skills' requires unpacking in terms of the specific demands from employers, different requirements for specific occupational groups, and those needed for broader societal engagement.

In terms of moving forward on policy in the UK, engaging a broader range of stakeholders would enable the government to adopt a more pro-active approach to technologies that seeks to ask broader social and ethical issues about where automation can improve the quality of life and where it may be detrimental. It also requires an interdisciplinary approach to address its potential impact on all aspects of economy and society. In Clark Kerr and colleagues (1960:9) classic study of *Industrialism and Industrial Man* they observe that 'an age of change is an age of speculations and of decisions', and these decisions will reflect how we understand what is disruptive about disruptive technologies, along with its potential to shape technologies for the benefit of all rather than the few.

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[1] Acemoglu and Restrepo note, distinguishing their work from that of Graetz and Michaels: 'Although we rely on the same data, we use a different empirical strategy, which enables us to go beyond cross-country, cross-industry comparisons, exploit plausibility exogenous changes in the spread of robots, and estimate the equilibrium impact of robots on local labour markets. Our micro data also enable us to control for detailed demographic and compositional variables when focusing on commuting zone, check the validity of our exclusion restrictions with placebo exercises, and study the impact of robots on industry and occupation-level outcomes, bolstering the plausibility of our estimates' (Acemoglu and Restrepo 2017:6).

[2] The distinction between 'labour scarcity' and 'job scarcity' draws on Brown, P., Lauder, H. and Cheung, S.Y. (forthcoming).

[3] Autor (2015 p.28), clings to an orthodox view of labour scarcity rather than contemplating the wider consequences for economic change for the (re)distribution of income and wealth.

[4] Much is made of freelance professions selling their services on a global basis no longer requiring them to conform to traditional models of employment. Apple app developers are an example.

[5] This could include collaborative funding for innovative ideas through 'crowdfunding' (Baeck, Collins and Westlake 2012).

[6] Those submissions from scientists and engineers (in academia and business) tended to be relatively cautious in terms of the speed of change and, therefore, the ability of the economy to adapt (e.g. Royal Academy of Engineers 2016:1). They stand in stark contrast to the machine learning technologists reported in Grace et al (2016) (see Section 2.1.1), who emphasised the rapidity of change.

[7] The Technology Strategy Board was set up by the Labour Government in 2004, following a DTI Innovation Report, as an advisory body to its technology strategy. In 2007 it became a non-departmental public body with an expanded remit of 'stimulating and supporting business-led innovation' with the focus on areas that would improve UK growth and productivity. It was renamed Innovate UK in 2014.

[8] Engineering and Physical Sciences Research Council, a UK government agency that funds research in engineering and physical sciences.

[9] http://gov.wales/newsroom/businessandeconomy/2018/180316-economy-secretary-announces-digital-innovation-review/?lang=en