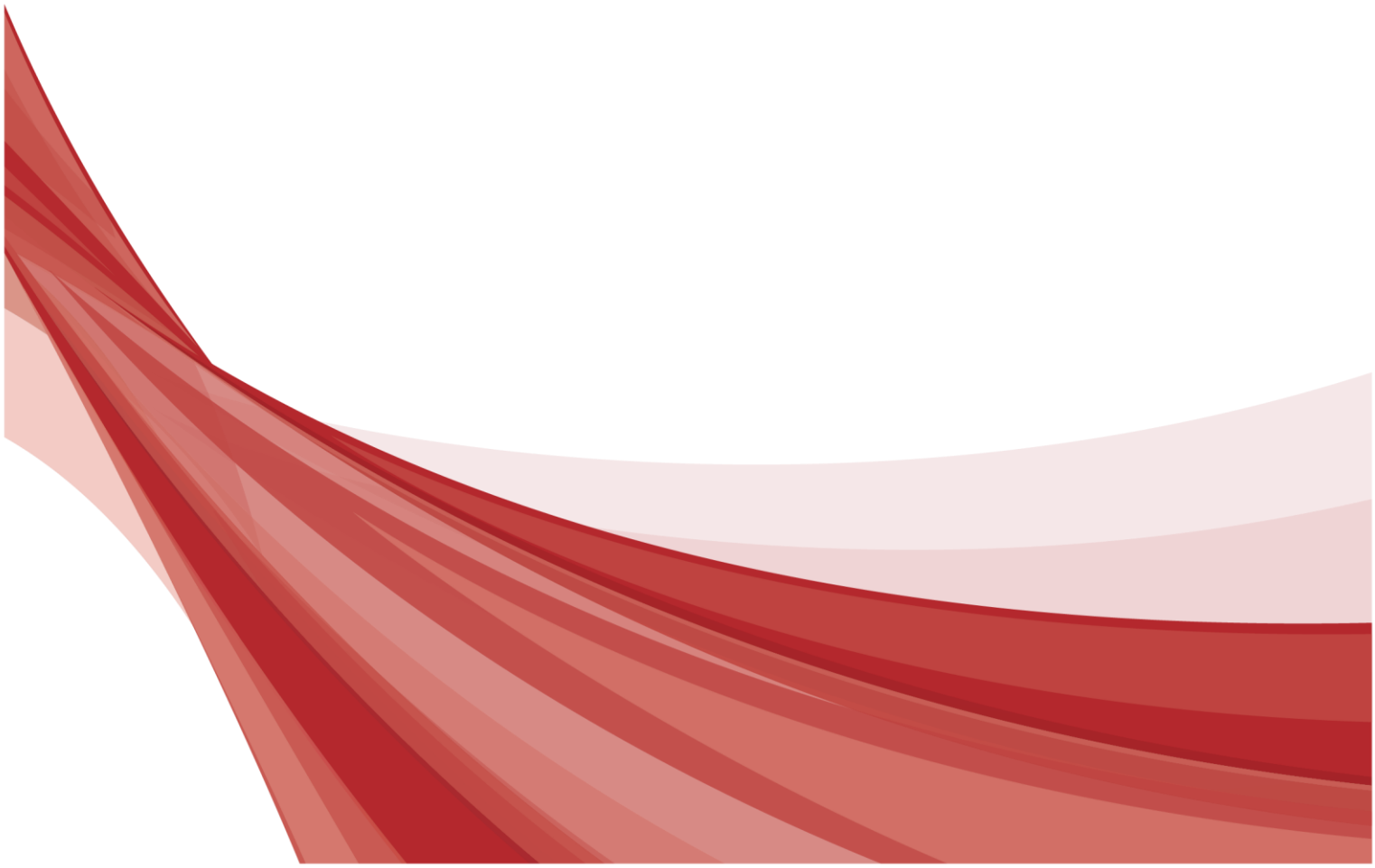
Shaping Our Digital Future

A TUC Discussion Paper



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Foreword

We are living through a period of profound and rapid technological change.

The phone that many of us carry in our pockets is millions of times more powerful than the combined processing power of the computers NASA used to put man on the moon just over four decades ago. We take for granted instant access to information and content in a way that was literally inconceivable 30 years ago. And in the last few years new digital technologies have driven changes in our everyday lives from the way we shop and watch films, to how we book holidays, pay bills, or keep in touch with friends and families.

This new technological wave is changing the way we work as well. From banks to supermarkets, call-centres to offices, classrooms to hospitals, new technologies are reshaping the world of work. Not all of these changes are immediately apparent. Robots on an assembly line or self-service check-outs are very visible manifestations of this new industrial revolution, but just as profound will be the widespread use of artificial intelligence and big data. Likewise, the pace and scope of technological change is not constant across, or even within, sectors. But even in those sectors where human interaction is, and always will be, key – education, health, social care – there is growing evidence that new technology will change the way we work.

This report takes as its starting point that technological change is not only inevitable, but also brings with it real potential benefits. But this doesn't mean that unions and their members can afford to be passive recipients of such change. How new technology is introduced; how it's benefits are fairly shared; how workers are engaged and supported through this period of industrial transformation – all these questions and more point to the need for government employers and policy-makers to seriously engage unions in shaping Industry 4.0.

This report doesn't attempt answer all these questions, but instead marks a first contribution to understanding what the coming wave of technological change will mean for Britain's workplaces, and how best unions can shape it to the benefit of working people, their families and communities.

That's precisely what we have done throughout the history of the trade union movement: engaged with the world of work as it is; shaped new technologies and ways of working to the benefit of working people; reached out to those working in new jobs and in new ways of working. I'm confident working together, we can do the same again and put great, well-paid, secure jobs at the heart of Industry 4.0.

Paul Nowak, Deputy General Secretary

Section two

Summary

The digital revolution is visible all around us. Artificial Intelligence, Big Data and the Internet of Things, taken together, are set to change the way we live, including the way we work. New technologies could bring massive benefits to aspects of our lives as varied as medical diagnostics and the fight against climate change. But at present, digital technologies are causing a degree of fear among the working population, with many people asking the simple question: is a robot about to take my job?

Based on the evidence before us, there is no need to panic about the impact of digitalisation, but there is a need to plan. Britain has the potential to become a digital world leader, using new technology to deliver growth and jobs. But that must be accompanied by a mission to ensure that the benefits of digitalisation are fairly shared across the workforce and society – avoiding the disruption to jobs and livelihoods and the rising inequality that have accompanied technological change in the past.

This report is an initial discussion about how trade unions and others should respond to the latest wave of technological change. It looks at the evidence of how technology has affected jobs and wages in the past, examines projections of the potential impact of new technologies, and draws on evidence from the US and Germany of how other countries are responding to the challenges posed by technological change.

The fact that digitalisation is sometimes called the 'fourth industrial revolution' reminds us that there have been three periods in which breakthrough technologies disrupted the established industrial order over the last 250 years. In each previous case, those technologies resulted in more, not less jobs. The UK employment rate is currently at a record high – despite widespread technological change over the past thirty years; it's worth remembering that the iPhone is only ten years old this year.

But the new jobs created in the last wave of technological change, from the 1970s onwards, have been different jobs, requiring different skills, and industrial change has brought widespread disruption to many workers' lives. In 1950, almost one in three workers worked in manufacturing, while one in 12 worked in professional and technical services. By 2016 these shares had reversed.

And while over the long run, technological change has enabled living standards to rise, in the last wave of change, the gains from growth have not been fairly shared. The share of national income going to labour has fallen over the last thirty years. Declining levels of union density is part of the reason for this, as is increased

globalisation. But technology has also played a role, with the automation of some jobs reducing workers' bargaining power.

Many have argued that 'this time is different' when it comes to the impact of technology on jobs. A landmark study by Frey and Osborne predicts that 47 per cent of US jobs are at high risk of automation over the next couple of decades. A Bank of England analysis of Frey and Osborne's data suggests that, for the UK, this could amount to 15 million jobs. Projections for wages in the wake of widespread technological change also suggest that the lowest skilled will lose out, and that income disparities could widen further. These of course are projections – not certainties, and it's worth noting that as yet, the promised productivity gains from new technology have yet to turn up; UK productivity has not increased since the financial crisis.

Several other countries have begun to discuss potential policy responses to automation, and this report looks at policy from the US and Germany. The Obama White House highlighted three important areas of focus in meeting this challenge: accepting the digital revolution, investing in more, not less, Artificial Intelligence; ensuring that the workforce is digital ready, meaning a skills revolution from pre-school years to college education, while expanding access to apprenticeships, and widening the pool of science, technology, engineering and maths talent to cover more women and other sections of society currently under-represented in STEM; and supporting the adaptation of the workforce, so that the benefits system is aligned with the needs of career transition, and minimum wages and strong unions are on hand to promote higher pay.

In Germany, a White Paper on work, to coincide with moves towards digitalisation, involved companies, unions, churches and other actors in planning and developing a response, in line with that country's social partnership philosophy. The DGB and the German metalworkers union, IG Metall, has driven the workforce response in Germany. The Works Council at Airbus in Hamburg has used its influence to protect jobs, skills and wages through a time of anxiety for many in the workforce.

How should the UK respond? Rather than a comprehensive set of policy recommendations, this report sets out directions of travel, for discussion by trade unions and others.

First, we believe **that rather than attempt to hold back the technological tide, the UK should plan how to use it to enhance productivity, jobs, and wages, particularly in the areas which previous waves of industrial change have left behind.**

As part of the government's industrial strategy, we suggest a "mission" for the UK to become a top five digital economy. Britain's current low levels of government and business investment, alongside cuts to higher and further education funding mean that at present we are at risk of falling behind.

That mission needs to be developed in consultation with the workforce. We advocate a UK equivalent of Germany's White Paper on work, so that digitalisation is approached as a workforce issue as well as a technological one.

Consultation is vital at the workplace level too. As the example of Airbus in Germany shows, where workers' have a say in the use of new production techniques, jobs can be protected. The UK has an exceptionally weak level of workforce participation, coming sixth from bottom in a European league.

Many unions are already planning how to respond to new technology, including piloting the use of technology agreements in companies in which they have representation, and thinking through how to respond to the challenges of, for example, autonomous vehicles. But a wider sectoral approach is needed, with a voice for unions on sectoral bodies charged with using technology to drive up productivity and pay.

In the past, technological change has caused widespread disruption to some workers' jobs and livelihoods. **A key aim for managing this wave of technology must therefore be to protect workforces and communities who are at greatest risk of seeing their jobs change.**

Dealing with this disruption will require significant investment in the skills of the existing workforce. Two thirds of those who will be in work in 2030 are already in the workforce –so investing in mid-career workers will be key to making sure that the next wave of technological change is one which benefits everybody.

At present, the UK invests half the EU average in workforce training – turning that around must be a priority. All workers should have access to a mid-life training review to assess their skills, and despite their chequered history, government will need to reintroduce individual learning accounts to give everyone a personalised budget for training. Some workers will need more extensive support from government to safeguard their position in the labour market. Groups facing redundancy due to industrial change should have access to retraining programmes to equip them with the skillsets required in a digitalised economy.

Finally, **we need to ensure that if the productivity benefits from new technology do show up, the rewards are fairly shared**.

Some have suggested that if robots threaten widescale unemployment, a tax on their owners could be used to help fund a Universal Basic Income.

We don't think that dis-incentivising investment in robots and other technological developments is the right approach. These technologies have the potential to liberate working people from routine, tasks and drudgery, and so make jobs more skilled and satisfying. But we do want to ensure that where these technologies lead to new wealth, the benefits are shared – both in terms of more free time and more money.

Sharing the benefits of greater productivity is at the heart of Trade Unions' mission. As widespread evidence shows, countries with greater collective bargaining have lower inequality in wages.

And we don't need to look to taxing robots as a means to ensure a fair balance of taxation between those who work with technology and those who own it. At present, cuts between the end of the financial crisis and the end of this parliament are set to see corporation tax fall by a third, while support for working families is cut. Changing that balance should be a priority.

Finally, if technology threatens to reduce the total amount of work, and there is a need to look again at how work is distributed, we could start by looking at the pension age. At present, government is suggesting saving 0.3 per cent of GDP in 2066/67 by bringing forward increases in the state pension age to 68 for workers now in their forties. Estimates of the productivity gain from artificial intelligence dwarf that figure, with PWC suggesting a 10 per cent boost to GDP by 2030 as a result of AI. If we do see those benefits arrive, reversing increases in the state pension age and enabling more people to enjoy a decent retirement should be a priority. This would be one way to ensure that new technology enables a fairer share of the rewards from work, and to help those whose working lives may be disrupted by technological change.

Over the course of the following year we will be developing this work further in consultation with unions, and looking at other aspects of new technology that affect working people, including the rise in surveillance at work, how platform companies are treating their workers, and the potential of digital technology to help trade unions ensure the rewards from growth are fairly shared

Section three

Introduction

The digital revolution is upon us. Artificial Intelligence (AI), Big Data and the Internet of Things, taken together, are set to fundamentally change the way we live, including the way we work. These breakthroughs could bring massive benefits, around issues as varied as medical diagnostics to the fight against climate change. And they are set to bring huge disruptions to the established order too. As Klaus Schwab, the Founder and Executive Chairman of the World Economic Forum has put it: "There has never been a time of greater promise, or greater peril.".[1]

Among those focusing on the promise are, perhaps inevitably, the technology companies themselves. Erik Schmidt, the Executive Chairman of Google USA, has said: "Everyone gets smarter because of this technology … and the empowerment of people is the secret to technological progress".[2] According to Vittorio Colao, CEO of Vodafone in the UK, "Today you're at the start of something amazing … I see the freeing up, not just of productivity and money, but also positive energy which can bring a more equal world".[3]

But there is more to this story. As we saw, robots introduced into industry in the last generation put many semi- and lower-skilled industrial workers out of a job. Some fear the next technological revolution, in which robots and other pieces of equipment 'talk' to each other, programme each other, and self-diagnose problems, could render another tier of workers redundant. The jury is out on how big an effect digitalisation will have on our lives: Angel Gurria, the Secretary General of the OECD told the organisation's 2017 forum that we are witnessing "a moment when the divides in our societies question the efficiency of our theories, of our policies, of our governments…".[4] There is certainly a fear that a new divide between the lucky few that thrive from digitalisation and the many that do not will create a new fissure in our societies. Digitalisation, alongside globalisation and climate change could be one of the great challenges of our age.

As the reader might expect, trade unions will try to meet these challenges head on. It is our job to campaign for a fairer, more equal society, so this report will seek to mitigate those threats. Where digitalisation can bring benefits – and some benefits will be huge – we will ask: how can those benefits best be shared? Where it brings

[1] https://www.weforum.org/agenda/2016/01/9-quotes-that-sum-up-the-fourth-industrial-revolution/

[2] https://www.weforum.org/agenda/2015/01/17-quotes-on-the-future-of-technology-from-davos-2015/

[3] https://www.weforum.org/agenda/2015/01/17-quotes-on-the-future-of-technology-from-davos-2015/

[4] http://www.oecd.org/about/secretary-general/oecd-sg-opening-remarks-2017.htm

risks, how can we minimise and mitigate those risks? What is the relationship between new technology, with its greater productivity, and the sharing of the gains from that productivity, so that workers are better rewarded? What more should we expect of governments to deliver fair outcomes and of companies to provide good jobs? This paper will explore these themes.

The next section seeks to define digital technology and explores the potential benefits of digitalisation.

The third section of this report considers what this means for the UK labour market. How has technology impacted on productivity, employment and wages up until now?

The fourth section considers lessons from the United States and Germany, where 'industrie 4.0' is perhaps the most advanced model of digitalisation that we currently have.

The report then sets out a framework for how trade unions and others could respond to the latest wave of technological change, focusing on how we can embrace the potential of new technology, the need to protect workers and communities as industries change, and on ensuring that the benefits of new technology are fairly shared.

What on earth are we talking about here?

Before going any further, it might be helpful to define more fully the technology under discussion in this report. The pages that follow discuss the impact of a range of

- Artificial Intelligence (AI), which has been defined as "the work processes of machines that would require intelligence if performed by humans. The term 'artificial intelligence' thus means 'investigating intelligent problem-solving behaviour and creating intelligent computer systems'."
- 'Deep learning', which is machine learning based on a set of algorithms that attempt to model high level abstractions in data. Deep learning describes a connectedness, which means that if one machine makes a mistake, all autonomous systems will keep this in mind and will avoid the same mistake the next time.
- 'Robotisation', which has been in existence since the nineteenth century, sees the use of machines to work alongside, or in some cases, instead of humans'.
- The 'smart factory', in which the intelligent machine takes an active part in the production process. In this context, the machines exchange information and control themselves in real time, which causes the production to run fully automatically.
- 'Big Data' is self- explanatory, although 'big' often refers to a scale so exponential that many might struggle to conceptualise it. The uses of 'big data' may also be difficult to understand, so it is a concept that we return to shortly.

- Technologies that are not necessarily digital in themselves but that are linked to those that are, also need to be considered. Industrial biotechnology, 3D printing and nanotechnology can all interact with digital processes in new and exciting ways.

This report is concerned with the impact of digital technology on jobs and wages, rather than its impact on the way we work. Technology is also having significant impacts on the way work is organised and monitored whether that is through platform companies, or the impact of surveillance at work. Those will be the subjects of future TUC reports.

Digital Technology as a potential force for good

These technologies appear both overwhelming and highly disruptive, so it is worth us outlining, at the outset, the scale and range of some of the benefits.

According to 'Artificial Intelligence, Automation and the Economy', published by the Executive Office of the [United States] President [Barack Obama] in December 2016 (henceforth referred to, for simplicity, as the White House paper), AI should be welcomed for its potential economic benefits. The Chair of the US Council of Economic Advisors, Jason Furman, says his biggest worry about AI is that "we don't have enough of it". AI technology has opened up new opportunities in health, education, energy, economic inclusion, social welfare, transportation, and the environment. Substantial innovation has taken place in AI, robotics and related tech over the last decade, but, it's argued, the US will need a much faster pace of innovation in these areas to significantly advance productivity growth going forward.

One illustration of the potential benefits of these new technologies, is given in a 2013 article in the Atlantic Magazine, 'The Robot will See You Now'.[5] Oncologists at Memorial Sloan-Kettering Cancer Centre are using IBM's Watson computer and big data to provide chronic care and cancer treatment diagnostics.

"Knowledge from 600,000 medical evidence reports, 1.5m patient records and clinical trials, and two million pages of text from medical journals, are used for benchmarking and pattern recognition purposes. This allows the computer to benchmark each patient's individual symptoms, genetics, family and medication history, etc, to diagnose and develop a treatment plan with the highest probability of success."

Digitalisation could help us to address the productivity crisis that has affected many countries since the economic downturn of 2008. Alastair Nolan, Senior Policy Analyst in the Directorate for Science, Technology and Innovation at the OECD, was interviewed for this report, Alastair Nolan said:

[5] https://www.theatlantic.com/magazine/archive/2013/03/the-robot-will-see-you-now/309216/

"… all of the OECD economies are facing a productivity crisis, and better use of digital technologies could help to remedy the decline in the rate of growth of labour productivity that we've seen, and which has been particularly marked since the financial crisis… the UK's challenges are particularly acute, because the UK has lower labour productivity than in many OECD counterparts, and also has relatively low levels of investment in research and development."

Alistair Nolan gave further examples of the varied ways in which digitalisation can increase productivity:

"General Electric has developed an AI for its wind turbines, so that each individual wind turbine can orientate itself to maximise its own electricity generation. Then it takes into account the effect of the backdraft from itself on other windmills in the farm, so there's a sort of collective optimisation process."

"Nano technology can … allow you to make certain plastics electrically conductive, so that if you're spray painting a car that has many plastic parts you can spray those plastic parts along with the metal parts. They don't have to be taken aside into a separate process. That alone will save about $100 a car."

Alistair Nolan also described how digital processes developed by Deep Mind, the AI company owned by Google, were used to save energy at Google Data Centres:

"… Google's data centres account for about 0.01% of all electricity consumption in the world… In 2016 Deep Mind's learning algorithms were applied to the management of Google's data centres and within hours that AI was able to reduce electricity consumption by around 15% and to reduce costs by about 40%. That's within hours, the system learning by itself, and potentially reducing 15% of 0.01% of global electricity consumption, that's a significant and immediate payback…."

As well as saving energy – and costs – for Google, of course, this use of AI reduced the company's carbon footprint and so played a small part in the battle against climate change. Other, possible sustainable practices require more monitoring and regulation. Alastair Nolan gave another example, this time with regards to nanotechnology:

"… scientists at Manchester University have found a way of using nano technology to develop a nano sieve from graphene. So this is a sieve where the pores would be so fine that they could physically filter out salt modules. That opens the possibility of water distillation processes with minimal energy consumption… which could have huge benefits for the developing world in particular for obvious reasons… At the same time there is a lot that we don't understand about the long term health impacts of nano particles. Nano particles are not easily recognised by the immune system, and they can get into the bloodstream because of their dimensions… So that's an example of where new technology requires monitoring, and possibly new regulation and enforcement on the part of public authorities; the technology could have socially beneficial effects … helping to deal with water purity issues, but also potentially harmful effects on health and safety."

There is little doubt as to the positive impact of much technology; its impact on the world of work, however, is not straightforward.

Section four

What impact has new technology had in the past?

AI and robotics have sometimes prompted a dystopian vision of the future but, of course, technological change is nothing new. The fact that these technologies are sometimes referred to as the 'fourth industrial revolution' indicates that there have been three similar breakthrough periods of economic history before this one.

The three previous 'industrial revolutions'[6]

Industry 1.0: Industrialisation

This is the beginning of the industrial age, around 1800. For the first time, goods and services were produced by machines. The steam engine was the essential invention of the first industrial revolution, replacing many employees, which led to social unrest. Steam engines provided energy at any location for any purpose.

Industry 2.0: Electrification

Electrification began at the end of the nineteenth century and led to the assembly line, which was first used in the automotive industry. Separate steps were executed by workers specialised in respective areas. Automatically manufactured goods were transported to different continents for the first time.

Industry 3.0: Information Technology

The 1970s saw information technology and further automation through electronics. Personal computers and the internet meant global access to information and automation of working steps.

Fears about the impact of these changes on jobs and wages have been persistent. In a speech given to the TUC in November 2015, the Deputy Governor of the Bank of England, Andy Haldane, quotes Gregory Ray Woirol as stating that fears of the negative impact of technology on jobs – so called technological unemployment – go back at least to the invention of the wheel.[7] John Maynard Keynes addressed this issue in the 1930s, though rather than seeing technology as a curse, he believed it to be a blessing that would create a new "leisure class". In 1964 US president Lyndon B Johnson convened a "Blue-Ribbon National Commission on Technology,

[6] As set out in IBA Global Employment Institute (2017) *Artificial Intelligence and Robotics and Their Impact on the Workplace'*

[7] http://www.bankofengland.co.uk/publications/Documents/speeches/2015/speech864.pdf

Automation, and Economic Progress", and in 1978, UK Prime Minister Jim Callaghan asked a Whitehall think tank to investigate the potential impacts of silicon technology on jobs.[8]

These fears rest on the idea that new technology will replace humans in the workplace, leading to lower employment, and, as workers compete for a decreasing supply of jobs, lower wages for those still in work.

Set against these fears is an optimistic vision that focuses on how the gains in productivity that technology can deliver lead to increased prosperity. As goods and services can be produced more efficiently, they become cheaper – for example, Hewlett Packard's first foray into producing a business computer in 1972 cost around the equivalent of $500,000 in today's prices[9] – compared to a cost of around $500 today. This means that people have more to spend on other goods and services – meeting new needs, or wants, and raising employment in these new areas of work and production.

Here we briefly review the evidence on what has happened in the past to employment and wages as technology has developed, before going on to examine the question of what might happen in the future. We find that while employment has survived previous industrial revolutions, since the 1970s, the share of wages going to workers has fallen.

What's happened to employment?

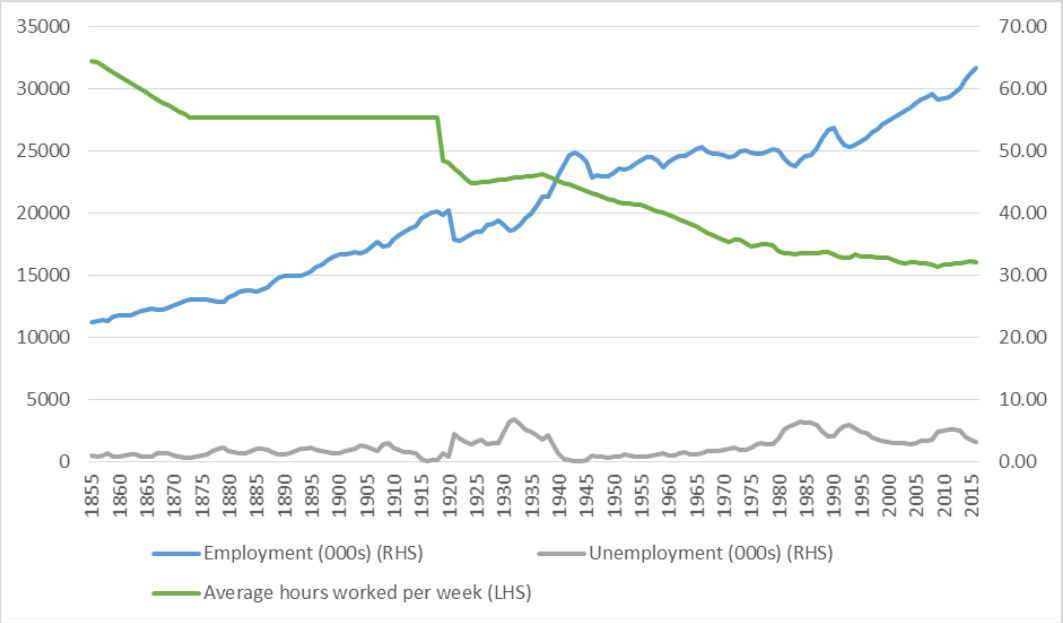
With record employment rates in the UK, fears about the impact of technology on jobs are yet to be realised. The graph below uses the Bank of England's long-run dataset to show the number of people in employment, unemployment, and the average hours worked per week since 1855.

Throughout the three 'industrial revolutions' experienced to date, employment has continued to rise. While unemployment hasn't yet returned to its post war lows, the fears of the '60s and '70s seem misplaced. Looking at hours suggests that some of Keynes' predictions have come to pass; there is more leisure in the working week, with average hours worked falling by 50 per cent between the 1950s and today – though the current trend would not quite get us to the 15 hour working week he predicted for the year 2030.

[8] Via https://timeline.com/robots-have-been-about-to-take-all-the-jobs-for-more-than-200-years-5c9c08a2f41d see https://news.google.com/newspapers?nid=2507&dat=19780620&id=8LZAAAAAIBAJ&sjid=sqUMAAAAIBAJ&pg=5867,4456977&hl=en

[9] http://247wallst.com/special-report/2016/04/15/how-much-a-computer-cost-the-year-you-were-born/2/

Chart 1: Employment, unemployment and average hours worked per week 1855-2016

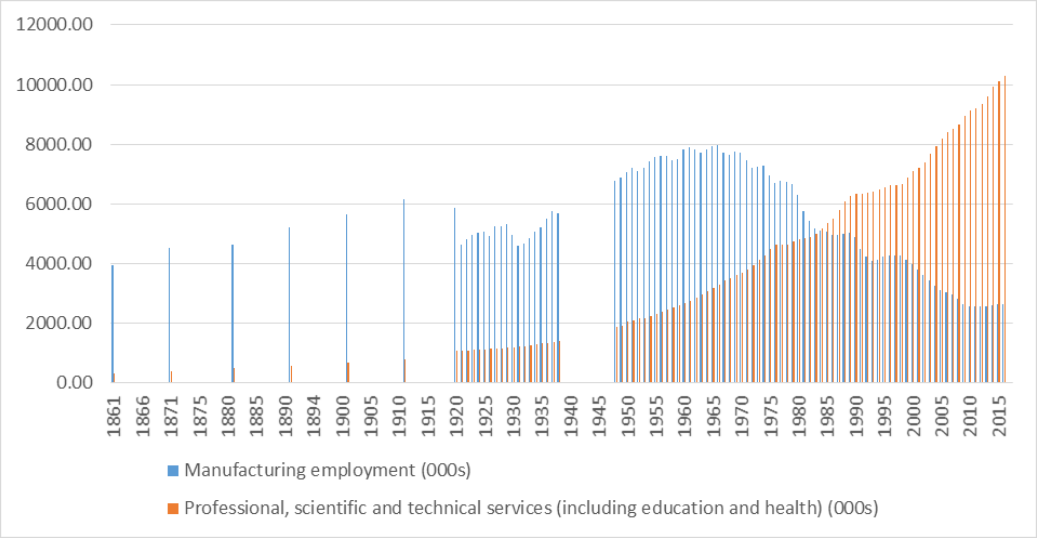


Source: Bank of England: *A millennium of macroeconomic date for the UK*
The Bank of England's collection of historical macroeconomic and financial statistics
Version 3 - finalised 30 April 2017

This doesn't mean that the introduction of technology has come without disruption. The nature of work has dramatically changed; the graph below (again from the Bank of England's long run data set) shows the shift in employment during the most recent phase of industrial change away from manufacturing, and towards professional service jobs. The graph shows the numbers of people employed in each job; looking at the share of employment in 1950, almost one in three workers (29 per cent) worked in manufacturing, while one in 12 (8 per cent) worked in professional and technical services. By 2016 these shares had reversed (29 per cent worked in professional and technical services, and 9 per cent in manufacturing).[10]

[10] Bank of England – a Millennium of Macroeconomic data
http://www.bankofengland.co.uk/research/Pages/datasets/default.aspx

Chart 2: Number of people employed in manufacturing and professional and technical services, 1861 - 2016



Source: Bank of England: *A millennium of macroeconomic data for the UK*
The Bank of England's collection of historical macroeconomic and financial statistics
Version 3 - finalised 30 April 2017

While the trend across the country may have been for one type of job to be replaced by another, this effect has been felt unevenly across the UK. In areas previously dominated by heavy industry, median pay is now around ten per cent lower than the national average, reflecting the poorer quality of jobs now available in these areas.[11]

What about wages?

In the middle of the longest wage squeeze since Napoleonic times, the impact of technology on wages may seem like a more pressing question than the impact on employment.

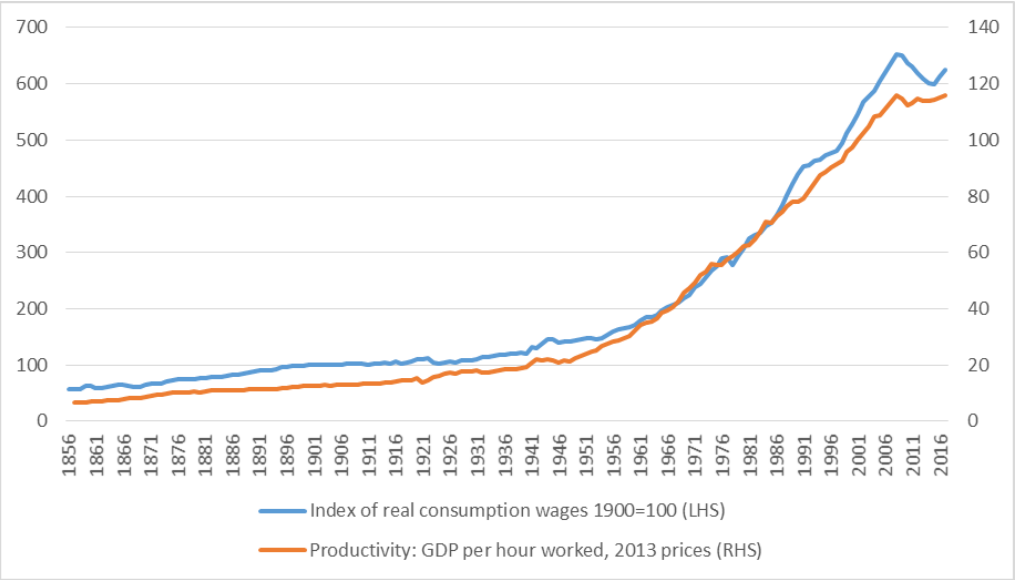
The last thirty years have seen a fall in the labour share

We are often told that for wages to rise, productivity needs to rise first – that is, before employers can afford to pay their staff a higher wage, they need to be able to produce more for each worker employed. The long-term evidence shows a strong link between wages and productivity – and suggests that the impact of technology on living standards has been positive. The graph also makes clear just how unusual the

[11] Industrial Communities Alliance (2017) Low pay in older industrial Britain http://www.industrialcommunitiesalliance.org/uploads/2/6/2/0/2620193/low_pay.pdf?mc_cid=454b722eed&mc_eid=43e55eb60f The Industrial Communities Alliance defines 'older industrial Britain' as "places once dominated by industries such as coal, steel, shipbuilding, textiles and heavy engineering".

current flatlining in both productivity and wages is in historical terms, and recent data shows that productivity has not risen in the UK since the financial crisis.[12] Looking at this suggests that future increases in productivity – fuelled by an upsurge in technology, could be what we need to help boost wages in the future.

Chart 3: Real wage growth and productivity 1856-2016



Source: Bank of England: *A millennium of macroeconomic data for the UK*
The Bank of England's collection of historical macroeconomic and financial statistics
Version 3 - finalised 30 April 2017

However, there is some evidence that the most recent wave of technological change – from the 1970s onwards - has not seen the full benefits of the productivity increases that we have seen passed onto workers.

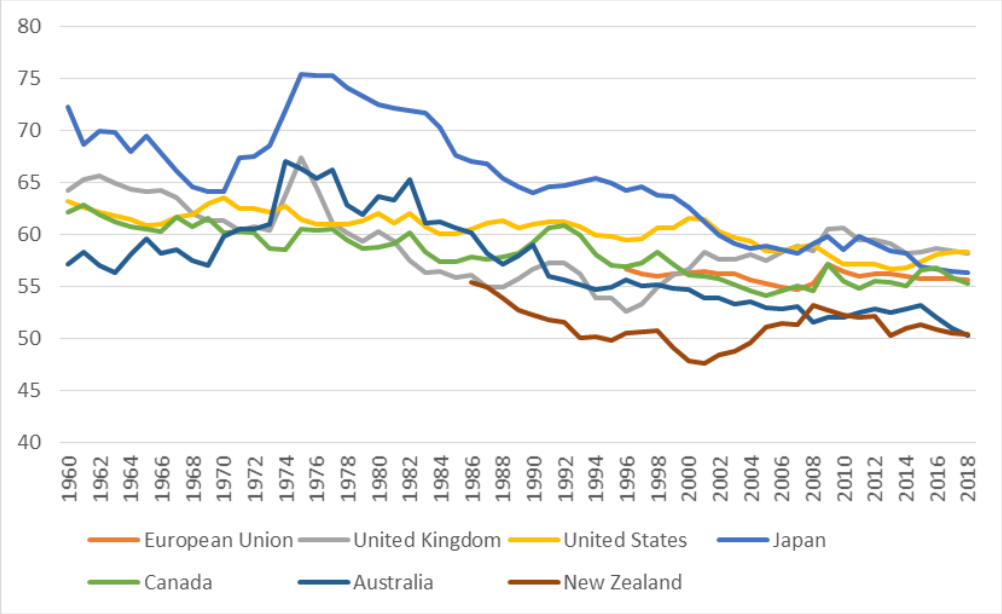
This is clearest at an international level, where there is increasing concern about the decline in the 'labour share' – the proportion of national income ending up in workers' pockets.

The Organisation for Economic Cooperation and Development (OECD) calculates that between 1990 and 2009 the labour share fell in 26 of the 30 advanced economies for which data was available. The median labour share in these economies fell from 66.1 per cent to 61.7 per cent over this period.[13] More recently the OECD has

[12] ONS (2017) UK productivity introduction: Jan to Mar 2017
https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/ukproductivityintroduction/jantomar20177
[13] http://www.oecd.org/els/emp/EMO%202012%20Eng_Chapter%203.pdf

calculated that the average labour share in G20 countries shrank by approximately 0.3% a year in the three decades from 1980.[14]

Chart 4: Adjusted labour share, selected advanced economies[15]



Source: *AMECO*[16]

There is debate about the drivers behind the decline in income going to wages, but the fact that it is common to such a wide range of countries, not just the UK, suggests that many of the causes are global. The IMF calculates that 90% of the decline in labour share occurred within – rather than between industries, rather than as a result of employment moving from labour intensive sectors to more capital intensive ones.

There are broad trends that can be seen across most developed economies. Falling taxes on corporate profits can strengthen the incentive to invest in capital rather than employ more workers, for example, while a fall in union density has weakened the bargaining power of many workers. Globalisation has also put pressure on the wage share in sectors of advanced economies that are most at risk of outsourcing to lower wage countries.

But the IMF finds that technological change has been the largest contributor, accounting for about half of the decline in the labour share across advanced economies. The impact of technology is twofold. Firstly, faster productivity growth in the capital goods sector compared to other areas of the economy means that the

[14] https://www.oecd.org/g20/topics/employment-and-social-policy/The-Labour-Share-in-G20-Economies.pdf

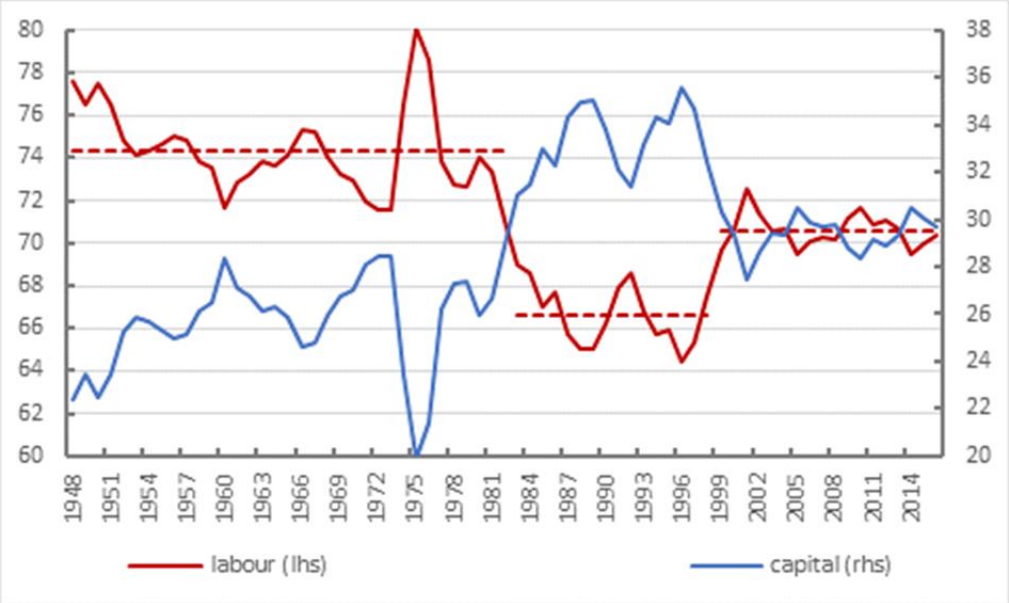
[15] Compensation per employee, multiplied by number of employees, divided by GDP at factor costs

[16] http://ec.europa.eu/economy_finance/ameco/user/serie/ResultSerie.cfm

relative price of investment in advanced economies has declined by more than 13% since 1990.[17] This has lowered the price of substituting capital for labour in many sectors. Secondly, advances in information technology have greatly expanded the range of jobs that can be automated or routinised. These two factors appear to interact, and the IMF calculates that, for a given change in the relative price of investment, economies with high exposure to routinisation experienced about four times the decline in labour share as those with low exposure.[18]

Within the UK, the share in income going to wages seems to have held up slightly better, but to have fallen since the 1970s. There was a strong fall in the labour share between the 1940s and the early eighties (with an average share of 74.3 between 1948 and 1982 falling to 66.7 between 1983 and 1998), with spikes around the three recessions over this period. These spikes were the result of the time lag that generally occurs between economic output shrinking, and wage levels responding to this, and do not affect the overall trend. The wage share then recovered somewhat in the decade ahead of the 2008 financial crisis, but has not recovered its previous heights (with the average between 1996 and 2016 at 70.6, around four percentage points below the 48-82 average).

Chart 5: Labour and capital shares 1948-2016



Source: *ONS and TUC calculations (derived as a share of compensation of employees plus gross operating surplus)*

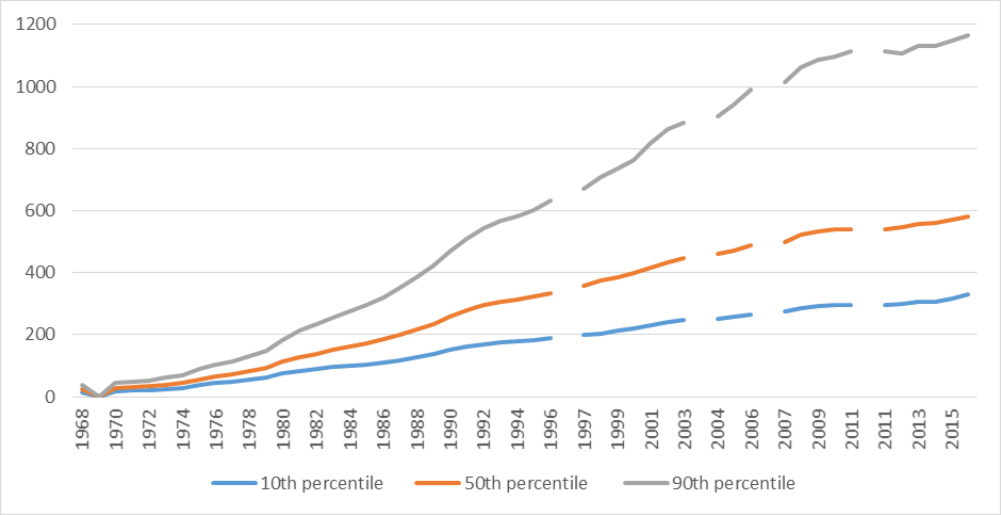
[17] http://www.imf.org/en/Publications/WEO/Issues/2017/04/04/world-economic-outlook-april-2017

[18] http://www.imf.org/en/Publications/WEO/Issues/2017/04/04/world-economic-outlook-april-2017

Earnings inequality has also risen

Wage prospects depend not just on the share of GDP going in total to workers, but also to how that share is distributed. The other significant trend in the last three decades has been a significant increase in the gap between the highest paid and the average workers. In 1968, the average male worker earned 60 per cent of a worker in the top ten per cent; by 2016 this had fallen to 50 per cent.

Chart 7: Male median weekly earnings at the 10th, 50th and 90th percentile, 1968 to 2016



Source: *ONS analysis of New Earnings Survey and ASHE*[19]

Shifts in the nature of work due to technological change have helped drive some of this change. The OECD's 2017 employment outlook identified technology as the main driver of increasing job polarisation over the past two decades, with a decline in middle skill jobs accompanied by a rise in low and high skilled employment in all countries they examined, including the UK.[20]

However, technology is not the only cause. The declining coverage of unions is likely to have widened inequality: As the International Labour Organisation have shown *"... broad collective bargaining coverage contributes to a narrower distribution of income and more stable growth."*[21]

The chart below shows the association in the UK, with the increase in inequality in the UK coinciding with the fall in the share of the workforce represented by a trade

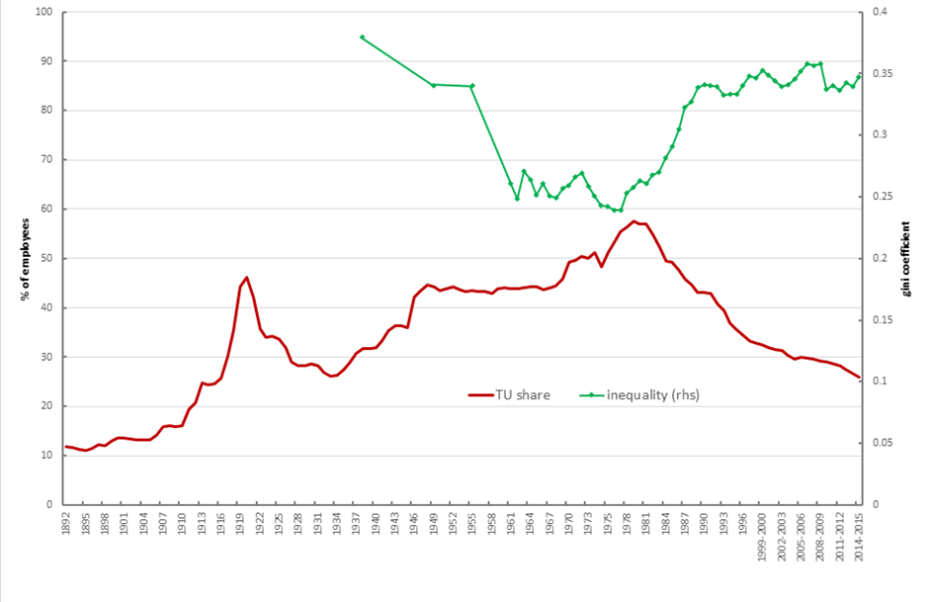
[19] See https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/adhocs/006302annualsurveyofhoursandearningsashetimeseriesofmediangrossweeklyearningsfrom1968to2016

[20] OECD (2017) Employment outlook 2017

[21] ILO (2017) ILO Global Wage Report 2016/17 see http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_537846.pdf

union, suggesting the importance of increasing collective bargaining within the UK as a key means of tackling inequality.

Chart 8: Trade union coverage of the workforce and inequality in the UK



Source: *TUC analysis of ONS data on trade union coverage and World Income Inequality database*[22] *on the gini co-efficient*

What does this mean for the next wave of technological progress?

In the next section we look at a range of predictions for how the next wave of technological progress could play out. Of course, there is nothing to say that this wave should have the same impact as previous episodes of technological change, and there are many who argue that 'this time is different'. But the evidence to date suggests that while perhaps we should be less worried about the impact of productivity gains on the level employment, we need to look closely at how the rewards from productivity are shared.

[22] See here: https://www.wider.unu.edu/database/world-income-inequality-database-wiid34

Section five

What can we expect to happen to work following this latest technological revolution?

So far in this report, we have identified what digital technologies are and we have explored their potentially positive impact on the economy, including boosting productivity. We have also seen how historically, productivity increases associated with new technologies have led to a rise in real wages but that this trend started to break down in the 1970s and has stuttered since. So what do we think will happen to jobs and pay following this latest technological breakthrough?

The impact on jobs

Previous technological changes have seen major shifts in the nature of work, for example, in the shift from employment in manufacturing to employment in professional services. Many of these shifts have involved a move from jobs involving more physical tasks, to those involving more cognitive work. A major question arising from the new wave of digital technologies is what will happen as more of these cognitive tasks can be performed by artificial intelligence and other forms of new technology.

The most famous study to attempt to predict the effects of digitalisation on jobs is *'The Future of Employment: How Susceptible are Jobs to Computerisation'*, by Carl Frey and Michael Osborne, published in September 2013.

Frey and Osborne distinguish between high, medium and low risk occupations, depending on their probability of digitalisation. According to their estimate, 47 per cent of total US employment is in the high risk category, which means that associated occupations could potentially be automatable over a certain timeframe, perhaps one or two decades.

Frey and Osborne foresee two waves of digitalisation, separated by a "technological plateau". In the first wave, they argue, most workers in transportation and logistics occupations, along with the bulk of office and administrative support workers, and labour in production occupations, are likely to be substituted by computer capital. Frey and Osborne also find that a substantial share of employment in services, sales and construction occupations show high probabilities of digitalisation.

Since its publication, the Frey and Osborne study has been subject to considerable scrutiny. Perhaps the best known alternative estimate is by Melanie Arntz, Terry Gregory and Ulrich Zierahn, authors of *'The Risk of Automation for Jobs in OECD Countries'*, a report which challenges the methodology of Frey and Osborne.

Whereas Frey and Osborne assume that whole occupations, rather than single tasks, would be automated by technology, the OECD study believes that many occupations listed by Frey and Osborne as high risk occupations often still contain a substantial share of tasks that are hard to automate. For this reason, Arntz et al suggest that Frey and Osborne's numbers are an over-estimate. Arntz et al estimate the job automatibility of jobs for 21 OECD countries, based on a task-based approach and find that, overall, on average across the 21 OECD countries, nine per cent of jobs are at risk of automation. The threat from technological advances thus seems much less pronounced compared to the occupation-based approach of Frey and Osborne.

Other studies have drawn on these two methodologies. The Bank of England has used Frey and Osborne's methodology to produce estimates of job susceptibility for the UK. The Bank's figures are shown in the following table:

Table One: Percent of employment at risk of automations:

Risk of automation	US (Frey and Osborne [2013])	UK
Low (< 33 %)	33	37
Medium (33-66%)	10	28
High (> 66%)	47	35

Source: *Frey and Osborne (2013); Bank calculations. Notes: The UK probability of automation figures are based on estimates in Frey and Osborne (2013) matched against UK occupations*

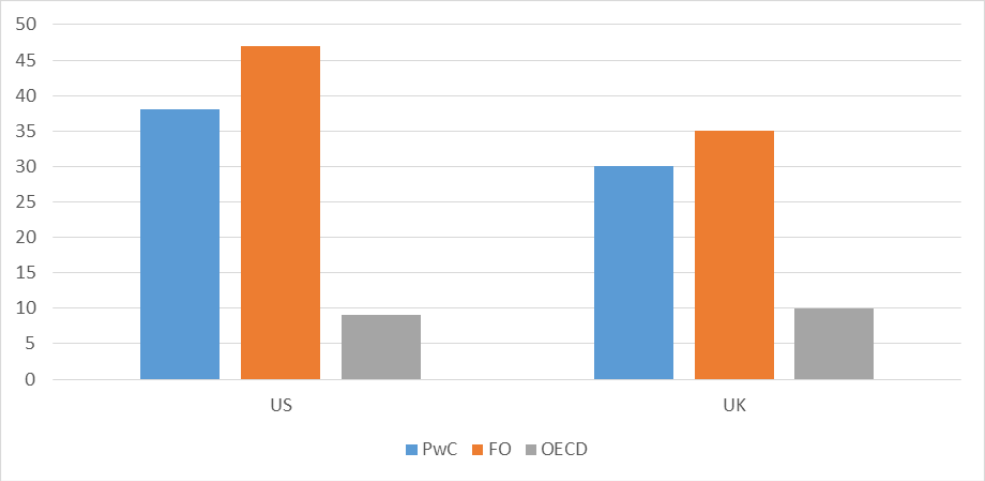
For the UK, roughly a third of jobs by employment fall into each category. Administration, clerical and production tasks, in the UK as in the US, are among those occupations most at risk. Andy Haldane told the TUC in December 2015 that by taking the probabilities of automation and multiplying them by the numbers employed, we can reach an estimate of the number of jobs potentially at risk of automation. For the UK, according to Haldane, up to 15 million jobs could be lost to automation.[23]

Following from the Bank's analysis, the consultancy PwC has offered a third look since, it argues, that whilst Frey and Osborne used a different methodology to the OECD, the difference in their results is nevertheless very large given that they started from a similar assessment of occupation level automatability. Using additional data and developing its own machine learning algorithm for identifying automation risk, PwC concluded that the methodology used at the OECD over-exaggerated the

[23] Andy Haldane (2015) Labour's share – speech at the Trades Union Congress http://www.bankofengland.co.uk/publications/Documents/speeches/2015/speech864.pdf

mitigating effect of measuring tasks rather than roles. Using its preferred methodology, PwC found that around 30% of jobs in the UK are at potential high risk of automation, compared to around 38% in the US.

Chart One: What proportion of jobs are potentially at high risk of automation?



Sources: *PwC analysis; FO; OECD*

A variety of studies have looked at how automation might affect different sectors and occupations. PwC found that over half of the potential job losses they identify are in four key industry sectors: wholesale and retail trade, manufacturing, administrative and support services, and transport and storage. The Resolution Foundation has suggested that the 'industry sectors' with the highest probabilities of automation are legal and accounting activities, forestry and logging, crop, animal production and hunting, and fishing and aquaculture.[24]

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.

What about wages?

If, as the long run evidence suggests, wages rise with productivity, then the new wave of technological innovation could enable workers' pay to rise. PWC have estimated that UK GDP will be up to 10 per cent higher in 2030 as a result of

[24] http://www.resolutionfoundation.org/app/uploads/2016/07/Robot-wars.pdf

artificial intelligence, the equivalent of an additional £232 bn, and equivalent to extra spending power of up to £2,300 a year per household by 2030.[25]

It's worth noting that these productivity improvements have yet to make their mark on the UK economy – with no increase in productivity since 2007 – a historic period of flatlining.[26] Could a new bout of robotisation help kickstart a productivity and in turn a wage revival?

Fewer predictions have been made about the impact of technology on wages in the future than on jobs, although as set out in the previous chapter, there is evidence that the last wave of technological change may have led to wider employment polarisation, and a decline in middle skill jobs. However, estimates of the types of jobs that are likely to be lost suggest that it is those who currently experience low wages who may see their work most at risk.

The PwC study included a breakdown into gender and levels of education, as shown in table 2:

Table 2: Employment shares, estimated proportion and total number of employees at potential high risk of automation by UK worker characteristics

Worker characteristics	Employment share (%)	Job automation (% at potential high risk)	Jobs at potential high risk of automation (millions)
Gender:			
Female	46%	26%	4.1
Male	54%	35%	6.3
Education:			
Low education (GCSE or lower)	19%	46%	3.0
Medium education	51%	36%	6.2
High education (graduates)	30%	12%	1.2

Sources: *PwC estimates using PIAAC data*

This table shows that those with lower levels of education are at greatest risk of job automation, and that men face a greater risk than women.

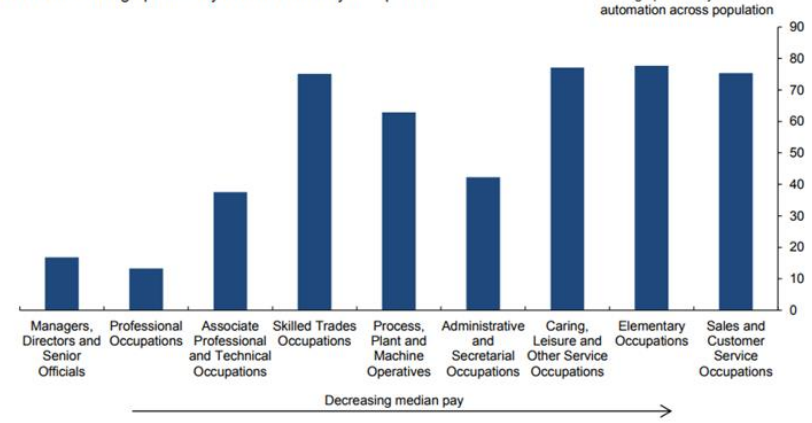
[25] https://www.pwc.co.uk/economic-services/assets/ai-uk-report-v2.pdf

[26] https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/bulletins/labourproductivity/jantomar2017

What can we expect to happen to work following this latest technological revolution?

The Bank of England have also used Frey and Osborne's methodology to see how automation might affect wages and skills throughout the economy. As is perhaps predictable, those most at risk from automation tend, on average, to have the lowest wages.

Chart 28: Average probability of automation by occupation



Source: ONS; Frey and Osborne (2013); Bank calculation
Notes: This chart shows the estimated average probability of automation across occupations using the probabilities in Frey and Osborne (2013) weighted by UK employment

This pattern suggests that we may see a repeat of wage trends in the most recent wave of technological change. As those with 'lower' skill levels see their jobs change or disappear, competition for the remaining jobs available may push wages downwards – unless there is pressure from elsewhere – leading to a further rise in wage inequality.

In a 2016 paper, IMF economists tried to develop a simple model estimating what would happen to wages, following the Frey and Osborne initial prediction that around half of all jobs could be replaced by robots. Their conclusions were gloomy, and again suggest that lowest skilled workers are at the greatest risk. They argue that robots will increase the supply of total effective labour – driving down wages. Investors will then choose to invest in robots rather than other forms of capital – for example, buildings or machinery, meaning there's less demand for workers in those areas, and lowering their wages again. Over time, robots become more productive, increasing the returns to their owners – with wages falling still further:

"Inequality now increases for two fundamental reasons…. capital receives a greater share of total income. In addition, wage inequality worsens dramatically. Productivity and real wages paid to skilled labor increase steadily, but low-skilled workers wage a lonely battle against the robots and lose badly."[27]

Much like the estimations of job loss, this is work based on a model using a range of assumptions – not a certain prediction about the future. But the fall in the labour

[27] http://www.imf.org/external/pubs/ft/fandd/2016/09/berg.htm

share, and rise in wage inequality experienced during the last period of technological change suggests that we should think not only about the impact of increased productivity on the number of jobs, but more widely about how the benefits of that increased productivity are shared.

The next section looks at how two different economies, America and Germany, propose to address that challenge.

Section six

Policy recommendations from the United States and Germany

This section compares policy responses to digitalisation from the United States and from Germany.

The evidence we present here from the US comes from the White House paper introduced above. The evidence from Germany, presented in two case studies, is based on new research undertaken through interviews with an official from the metalworkers union, IG Metall, and a senior member of the Airbus Works Council. Before that, we explore Re-imagining Work, Germany's White Paper, and Work 4.0. This latter report is the result of a consultation paper launched in April 2015, to which trade unions, businesses and other interested parties submitted evidence. The over-arching aim of the consultation paper was to preserve, or even strengthen, Germany's vision of quality jobs and decent work in an era of digital transformation and societal change.

The White House Paper

'Technology is not destiny'. Those four words were written by the Executive Office of the US President but could easily have come from the trade union movement, which has consistently argued that it is not economic developments or breakthrough technologies, as such, that determine the fortunes of working people; the issue is the policy response that greets those developments and technologies.

The White House paper recommends that we invest in and develop Artificial Intelligence for its many benefits. This includes AI research and development, and to develop AI for cyber defence and fraud detection.

The White House paper also calls for the development of a larger, more diverse AI workforce, especially in entrepreneurship, as well as science, technology, engineering and mathematics (STEM) fields. The paper highlights research showing that diverse groups are more effective at problem solving than homogeneous groups, further strengthening the argument for seeking more women and workers from minority ethnic backgrounds in STEM. Most of those recommendations could equally apply to the UK.

The single most important government intervention to prepare for digitalisation is education and training. Calls made in the White House paper with regard to education and skills include:

- high quality early education;

- education that results in all students leaving school either college- or career-ready and for young people to have access to an affordable post-secondary education that
- What is known in the UK as 'lifelong learning' i.e. "A commitment to preparing Americans to adapt to continuous and rapid technological change in the future… significantly expand[ing] the availability of high-quality job training to meet the scale of need;
- expanding access to apprenticeships, with the paper noting that, according to research, "apprentices earn a significant premium for their skills – as much as $300,000 more than their peers over a lifetime."

The third strategic recommendation from the White House paper is to aid workers in the transition to a digital future and to empower workers to ensure broadly shared growth. Aiding workers, according to the White House paper, includes:

- strengthening the social safety net, in areas such as improving unemployment insurance;
- work-sharing programmes to help employers to keep their key staff by reducing their hours instead of laying them off during times of transition, with workers whose hours are cut receiving partial unemployment benefits;
- Job-search assistance for workers who lose their jobs;
- strengthening other social safety net programmes, especially among low income workers;
- raising the minimum wage;
- modernising US regulations to protect overtime.

The White House paper then states:

"Growing and sustaining the middle class requires strong labour unions. Labour unions help to build the middle class and have been critical in restoring the link between hard work and opportunity so the benefits of economic growth can be more broadly shared. Unions have been at the forefront of establishing the 40-hour work week and the weekend, eliminating child labour laws, and establishing fair benefits and decent wages. Policymakers should explore ways to empower worker voice in the workplace through strengthening protections for organising and creating new and innovative ways for workers to make their voices heard."

The White House paper calls for 'place-based' initiatives, focused on economically challenged areas, which empower local leaders in participating communities.

'Re-Imagining Work' – Germany's response to 'industrie 4.0'

- 'Re-imagining Work' focuses on the six key questions that it believes the policy response to digitalisation must address:
- Will digitalisation enable everyone, as far as possible, to have a job in the future?
- What will be the impact of new business models such as 'digital platforms' on the work of the future?
- How can employees' legitimate entitlement to data protection be guaranteed?
- If humans and machines work together ever more closely in the future, how can machines help to support and empower people in the way they work?
- What might solutions to flexibility look like which also improve options for workers, in terms of when and where they do their work?
- What will the modern company of the future look like?

For 'Re-imagining Work', the technological and economic transformation that we are experiencing will likely transform occupations and activities, in the light of which it is necessary to invest in boosting skills and improving individual prosperity for advancement at an early stage. This support must be focused on prevention; it should not only target low skilled workers, take effect later in a person's working life or immediately prior to redundancy. Instead, it should follow a broader approach.

'Re-Imagining Work' proposes a new monitoring of future skilled-labour needs, to be undertaken by the Federal Ministry of Labour and Social Affairs. Analytical results could then be discussed by the government and social partners when assessing future skill requirements. This must be accompanied by a comprehensive strategy for long-term skills development and continuing vocational training, the implementation of which would involve all relevant ministries of the Federal Government, the Lander (regional governments), the social partners and other stakeholders.

Skills development must take into account both the specific needs of companies in relation to their immediate requirements and the wider needs of the workers for whom continued vocational education and training helps to maintain and improve their individual employability. The costs relating to continuing vocational education and training, release from work and wage replacement, must therefore be shared fairly between the state (as education and training is also in the national economic interest), companies and individuals.

Continuing education and training must address the relatively large disparities in the distribution of access, particularly bearing in mind the needs of people over the age of 50, low-skilled people, people from migrant backgrounds, employees of small companies and temporary, agency workers.

Another recommendation from 'Re-imagining Work' is the gradual transformation of the current unemployment insurance into an employment insurance, to allow more preventive support for workers. This would include the right to independent advice

on lifelong learning, training and upskilling. A future aspiration would be the introduction of a legal right to continuing vocational education and training.

'Re-imagining Work' also proposes the piloting of a Working Time Choice Act, which would combine greater choice for workers with regard to working time and location, with a conditional possibility to derogate from some provisions of the Working Time Act on the basis of a collective agreement between the social partners. Such a piloted derogation would initially be limited to a two-year trial period. 'Re-Imagining Work' also proposes the extension of collective bargaining coverage and, eventually, a generally binding collective agreement for the social care sector.

'Re-imagining work' suggests the strengthening of firm level negotiations between the social partners. In order to encourage more self-employment and start-ups, it also proposes the inclusion of self-employed individuals in the statutory pension insurance system, alongside employees. This paper also suggests a Personal Activity Account, as a form of "social inheritance" which can be used for skills development, starting a business or career breaks for personal reasons.

Both the White House paper and 'Re-Imagining Work' are rich in ideas about meeting the challenge of digitalisation. The first paper focuses on digitalisation and Artificial Intelligence as concepts while the second is more concerned about those concepts as they affect the world of work. More than this, however, the two papers differ in tone and culture. The White House paper is fulsome in its recognition of the importance of trade unions (it's hard to imagine the current White House recognising unions' value in this way), but there is little sense of unions helping to shape the ideas in the paper, despite the fact that US unions are engaged in this issue; 'Re-Imagining Work', by contrast, has union ideas and interests running through the document. Leaving aside the importance of trade unions, the White House paper presents digitalisation as something that happens to economies (and by extension, to workers), to which political actors respond; 'Re-Imagining Work' casts the digital agenda as something that workers themselves help to shape. They become active participants, not passive observers, in shaping their own destiny.

'Re-imagining Work's emphasis on security and flexibility is vital. Clearly workers as well as employers need security and workers understand the company's need for flexibility (a concept that can benefit workers too), but flexibility cannot be used as an excuse for exploitation. Unions are important in defining and implementing flexibility at the workplace as an important safeguard against that danger. Similarly, the question posed by 'Re-imagining Work', asking "how can machines help to support and empower people in the way they work" is important, as it can feel that this debate is too often focused the other way around.

Case Study One: the Work of IG Metall

IG Metall is Germany's metalworkers union. The largest union in both Germany and Europe, IG Metall has about 2.2 million members. Moritz Niehaus of IG Metall's "Future of Work" Department has considered the nature of employment in the age of digitalisation, or what is known in Germany as Industrie 4.0.

The term Industrie 4.0 was coined by, among others, Henning Kagermann, Head of the German Academy of Science and Engineering, ACATECH, in light of the fact that, as we have seen, three previous industrial transformations happened before this one. In essence, Industrie 4.0 refers, according to Moritz Niehaus, to "*an integration, a networking of production, all along the value-chain: from the suppliers, throughout the production process, with all its indirect aspects, to the customer. Track it, network it, integrate it, make it totally digital - that's the vision (of Industrie 4.0).*" This means that "*humans and machines interact just as if they were the same. It shall not matter whether they're human or machine, they are all in the so called cyber-physical system…"*

Attitudes towards Industrie 4.0

The debate around digitalisation has provoked concern for the future of employment in many countries. In Germany, there is much less fear than elsewhere. Moritz says the perception in the public sphere is, "something big is coming, but it's not going to hit us so hard that we will have millions more unemployed people. At least that's the perspective here in Germany."

That is not a universal view. There is some fear of the unknown, in Germany as elsewhere. Moritz is also aware that workers in unionised companies or those with strong Works Councils usually face less fear than others. However, Moritz says that, compared to the UK, it might be more difficult to fire workers in Germany, partly for cultural and partly for legal reasons: *"…companies in the industrial sector have a culture of keeping people on board, they don't fire easily. Also because the qualification level in German industry is rather high, people aren't so easily replaceable …. there is a lot of tacit knowledge as well. Also if there is a works council or a high union membership rate on the worksite, then there would be pressure on the company not to fire people. Additionally, the legal situation in Germany needs to be considered; In order to lay off employees with permanent contracts, the company needs to have business related reasons for it. If there is no such proof, the company can still lay off, but subsequently the employees can sue their (former) employer. Then … the company has to prove in a labour court that there is no workplace where this worker could be shifted to within the entire company."*

Industrie 4.0 will bring positives and negatives, in terms of jobs created or lost. One example of an area that could be impacted will be predictive maintenance, which could threaten, or at least will change, the jobs of skilled workers: *"… a worker with 30 years of experience hears that at a machine something sounds wrong, there's a tune in there that's not correct. In the Industrie 4.0 vision this knowledge is supposed*

to become obsolete because of sensors that track the sound, vibration, temperature, etc. of machines. Another example: experienced employees go over a sheet of metal with their hand and they feel little faults. Now, with further digitalisation, the idea is to have high resolution cameras or other technologies that do the job to standardise it…"

Remote maintenance, on the other hand, might provide opportunities: "In Germany there are many factories that build machines, which are then used in other countries… For example at a factory in Portugal where there is down-time because the machine broke… So, in a digitalised industry, somebody in the factory in Portugal goes to the machine with a tablet, films the scene, what's happening there. On the other end of the line there's an expert technician sitting in Germany and she can see the situation, talking via a headset to the mechanic in Portugal. The expert can, for example, draw arrows in the filmed scene that are displayed in Portugal and give some advice, what to do. This reduces downtime and could create employment in Germany – but would also make another expert technician in Portugal obsolete."

Digitalisation will change some skillsets within jobs. Moritz says: *"…Automation is likely to increase and there will be more assistance systems that tell workers what to do. In this way, relatively simple jobs remain or will be created (by de-qualification). This is called the 'polarisation thesis' because there is a very high skilled group of employees who programme those systems, maybe maintain them, set out the algorithms that then define what the other people have to do. But also the 'upgrading thesis' is largely discussed in Germany. Because things are getting more and more complex in a digitalised workplace, low skilled jobs will be replaced partly. Not that they would disappear, but a share will be replaced, and the jobs that remain or will be created are on a higher qualification level."* This points to the need for a skills system that supports those workers in the lower skilled jobs to upgrade.

Union responses to Industrie 4.0

Notwithstanding the fact that many German companies have no union presence, unions are, nevertheless, more influential in Germany than in many other countries and IG Metall has been in dialogue with the Works Ministry with regard to the implementation of industrie 4.0`. An alliance has been formed of the government, big business and unions, and workstreams established. IG Metall is particularly engaged in a work and qualification workstream, from which policy recommendations will be sent to the Federal Government. Moritz argues that IG Metall has brought aspects of employment and working conditions to the debate about Industrie 4.0 because, in Moritz's words, "*at the beginning it was a totally technology driven discourse [with] the vision of networking, computers, robots, automation...and so on, [but] there was not really space for humans in there."* Moritz believes that a success for IG Metall has been to change the nature of the discussion, from one based on technology to one also concerned with work.

This change in narrative has manifested itself in White Paper Work 4.0. According to Moritz, "*the idea was to have a social dialogue about the future of work*". This invited a range of stakeholders, including churches, unions, companies, business

associations and NGOs to make submissions with regard to how they see the future of work, which were then brought together in the White Paper. Moritz says: "*So it's a differentiated view, you have all the statements on the side, which come from business associations or from unions. The paper then tries to sum this input up, how a policy could look in the future".* Moritz believes it to be "*a success, especially compared to the situation in other European countries"* to have a government in Germany under Conservative leadership publishing a paper about the future of work and strongly emphasizing co-determination rights, works councils, trade unions and collective agreements. He says, "*all those things are essential to shape the change*". Moritz is sceptical about many things in the White Paper, such as the stress on flexibility to meet the demands of globalisation and digital markets which, he argues, is not a new argument. Instead, business associations try to liberalise labour protection, such as working time regulations. But the fact that the Christian Democrat led Government of Angela Merkel is addressing this development on a social partnership basis is an optimistic start to build on for unions.

IG Metall is also acting at the regional level to meet the challenge of digitalisation, for example in the Ruhr Valley, a region of traditional industries such as coal and steel. As Moritz told us: "*There are the same problems as probably in northern England … high unemployment and poverty … less and less industry over the last decades - now it's stable, but it's not at a high level*." IG Metall initiated a project bringing together employers, research science institutes and the local office for employment. This led to dialogue, public meetings and press coverage to promote a regional industrial policy, to think about how the Ruhr Valley can prepare itself for change. As Moritz says: "*The goal is not to lose further industrial employment, but to be ahead or, at least, within this development towards the digital industry. For the region, it is important not to experience the same downturn that happened with steel and coal, when industries were just shut down and not replaced. Nowadays, the Ruhr Valley is eager to see the change, be aware of it and shape it because everyone will lose in that region, if they … just stick to old things, as they did in the 60s and 70s, as they have experienced before*."

Moritz believes that works councils improve the implementation of Industrie 4.0 – and there is a great need to improve the application of new technologies: This is illustrated by a survey of attitudes and experiences of digitalisation, carried out last year by the DGB, the TUC's sister organisation. It found 46% of respondents saying that digitalisation had increased their workload, with half of employees saying their workload had remained stable and very few reporting a decrease. Meanwhile, 74% of respondents said that they had no or little influence in the way in which digitalisation is shaping their work.

Moritz said: "*Which is, if you think about it, not surprising. The picker at Amazon or the nurse, who has to document everything digitally now, has no influence over it. But it is fatal … if you can't shape your working conditions: this is a big problem for good working conditions and it would undermine a sense of coherence… When I participate in research networks with engineers from industrial companies and other research institutes, they think about technologically advanced solutions and how to*

implement them. They consider the use of more robots or smart glasses. The attitude among these engineers is rather: 'we develop it, we're smart enough knowing what's best and most productive, and then the works council can implement it with workers…' But that is not a good way to go. In contrast, the real participation of employees and the works council at an early stage would be a big opportunity for German companies. To really let the workforce participate would help employers as well as the employees, I think. The social dialogue could in this case be a real strength of the German industrial relations model in the digital era."

Case Study Two: Airbus Works Council, Hamburg-Finkenwerder

Airbus has four German factories, based in Hamburg, Bremen, Stade and Buxtehude. The largest of those four sites, Hamburg, employs approximately 12,500 people and takes on over 150 apprentices each year. Hamburg is the home to the A320 Family programme, comprising the A318, A319, A320 and A321 aircraft. Structural assembly and equipping of fuselage sections of all four aircraft, as well as final assembly, takes place in Hamburg. This plant is also home to Airbus's A380 major component assembly hall, which houses the structural assembly and the equipping of the forward and complete rear fuselage sections for this new generation of very large aircraft.

Jan Hinz is Vice Chair of the General Works Council of the German civil Airbus factories. Jan is former Chair of the local Works Council in Hamburg. He is also Deputy Chair of the Supervisory Board of Airbus operations, GMBH, and co-chairs the European Airbus Committee, which is a committee of the European Works Council. Jan is a member of IG Metall, the German metalworkers union.

The Implementation of Industrie 4.0 at Airbus, Germany

Jan tells the story of how Industrie 4.0 was implemented at Airbus:

"It was only in 2015 that we first started tackling Industrie 4.0 from a quantum perspective, place at the company level … We are increasingly seeing that Industrie 4.0 is impacting working conditions at the local sites and here we are talking about the future ways of working in the aeronautical industry, at Airbus.

"So back in 2015 we had a meeting of all German Works Councils, including the management. During this meeting we invited representatives from the German Institute of Artificial Intelligence, the Fraunhofer Institute and our union IG Metall, who are researching the impacts of Industrie 4.0. We wanted to get it from the horse's mouth how far we are going to be impacted by Industrie 4.0.

Airbus is a European company and Industrie 4.0 is a very important political issue. It is about getting the development and production on the latest technological level and keeping the topics in Europe. It is very important to get a structure on how to collaborate in the change of work. Therefore, together with the company, the union decided to form a round table to develop the policy. The result is a common explanation for technology, productivity and employment.

It was important to have the Federal Ministry on board, because we have to talk about the whole value chain and all the risk share partners must be part of this effort, and this is why we have ensured that the Federal Ministry was a key part of this."

"We told management that we will play our part, but at the same time we want to make sure that you take care of the defence of the job. Within the scope of this system, the works council is involved in projects that relate to the 'factory of the future'. The first step is to understand which Industrie 4.0 projects exist in the company. When looking at the topics discussed, the works council would then decide where they would get involved.."

Jan gave the example of Exoskeletons – sometimes known as 'wearable robots' and the role of the works council in monitoring their use:

"Exoskeletons are perhaps a way to encourage people who can no longer perform their work and who want to carry it out, even though they can be physically impaired… Thus the Exoskeleton brings positive employment effects and it can also help reduce the disease rates. But the downside is that the Exoskeleton is linked to a system (wearables) that collects data as long as you carry it. It can perhaps prove my movement and "tell" what I do when I wear it… So it's all about how we act and manage data, how to exclude certain things, and what needs to be discussed with the company's management.

"When it comes to the planned projects within Industrie 4.0, we have ensured that they are not carried out in an isolated location outside the company. We have ensured that the locals who are later to work in these projects are involved during the test phases so that they know what to expect and this helps to mitigate their fears. It is also important to know that besides the works council we also have shop stewards (395 in Hamburg) from IG Metall monitoring the way these projects are implemented."

The works council cannot do this alone, according to Jan. The main principle is to "involve colleagues who are affected by the changes".

Jan continues:

"The agreement also states that there is no negative impact on pay or working time during the projects and that jobs are not lost. The employee representatives are very well networked with the politicians in Germany and we are also interested in the fact that Airbus remains a profitable company, in which works councils and trade unions talk about productivity, but a a part of the productivity gains must flow back to the workforce in the form of training etc. When it comes to the successful implementation of Industrie 4.0, colleagues have to be trained on the changed processes. This is fundamental."

How might digitalisation affect Airbus?

Jan believes that if management and works council work together in the agreed structure at Airbus, the "*Industrie 4.0 projects will be implemented well. But it will*

obviously affect the number and different types of jobs. For example, 3D printing will have an effect. Those who work on milling machines and lathes are no longer required in large numbers in the age of 3D printing."

On the other hand: *"...we still have cable trees that need to be connected to the aircraft, which is manual work and it can't easily be replaced. It may be an option in the future that electronic circuits and the cable trees can be printed on top of the skin of the aircraft that may be an option."* If that were to happen, "*colleagues currently responsible for the installation of the cable harnesses must be retrained in order to carry out another activity within the company. And I think this is the responsibility of the company, but this is still something in the future*." Having said all that, "*there will always be a role for manual work*".

Jan believes that in logistics companies like Amazon the number of employees can drop dramatically, since the work of digital solutions is taken over. Jan also believes that large companies have better access to politics. For smaller industries, it can become more difficult to get support. This shows that all works councils must work closely with the trade union federations. Together, Jan believes, we must strengthen small companies. However, in a company like Airbus, things will be quite different. Jan adds: "*We are particularly supported by the strong company law in Germany. In this way, the works councils have a co-determination with the company."*

It is clear that the Airbus Works Council, along with IG Metall, have achieved major successes in protecting the workforce at the company, but does this come at a cost? Is there not a danger of the company inventing jobs that are not necessary in order to keep to the agreement of no job losses as a result of digitalisation? Would that not have a downward effect on productivity, as well as create difficulties for the employee, as workers need to know that the job they are doing is of value if work is to provide them with self-esteem?

Jan believes that a number of things will happen. First, to say that there will be no job losses is not the same as to say that the workforce remains will stay the same. It could be that, as workers retire, they will not be replaced. In Jan's words, "[The baby boomers] will leave the company and so [management] could try to ensure by natural decline to offset that effect on the workforce."

Second, some new jobs will be created in, for example, data management. Jan says: "*We are seeing that a massive amount of data is collected. Not only production data, but personally identifiable data relating to people like me and you. Based on this data, algorithms are created. I think it is absolutely important that human beings, people, manage these algorithms and that they are not managed by robots, because that would be a big risk. So I think it's these over-arching skills, to make sure that the algorithms are managed adequately, and these are high skilled jobs that cannot be replaced."*

A great strength in Germany, of course, is the country's long-standing industrial policy. As Jan puts it: "*I would claim that across the political spectrum it has been*

recognised in Germany that the industrial backbone of the country is key for value creation."

How can the UK learn from Airbus?

Given Jan's belief that Airbus will manage the Industrie 4.0 process so positively, does he have any advice for the UK?

Jan says he is not in a position to distribute advice, but he says that we should reject the doomsayers: *"… there have always been doomsayers who would predict the end of the world when the Industrial Revolution came in. We have always said that there were also changes during Industrie 1.0, etc, and there were changes on a massive scale, but the first step to cope with these changes is to … understand what is going on…. And when we return to the European level, our main focus in Europe is on the quality of our work and the quality of our employees… Quality is everything and that will make us successful in the long run."*

Jan also suggested that management and unions work together to meet this challenge: *"The answer is quite simple: unions and companies need to unite… the United Kingdom has proud tradition of union federation and humanisation at enterprise level …. I think you can only relieve anxiety if you show that management and labour are working in unison and that they know that you are joining together*."

The testimonies of Moritz and Jan show the influence of trade unions in action, grappling with a difficult challenge: how to protect jobs – and even enhance them – in the face of the digital future? Jan's description of the involvement of local people, those who will the working with new digital technology in the years to come, during trial periods – a process which is "geared towards alleviating the fears" that are associated with those technologies – speaks exactly to the idea, described above, of workers shaping their own destinies as digitalisation is introduced.

Of course, not all workers will be in that position. How much say will the picker at Amazon have in shaping his or her destiny? Jan highlighted how large companies have better access to government, and so more influence in the way digitalisation is introduced, so we state clearly here that trade unions are not the only stakeholders that need a greater say in this debate. The representatives of small companies need to be around the table too.

The value of reduced working time during transition phases, and even the sharing of workers between companies during difficult periods, as described by Jan, shows the value of co-determination in action. The White House paper described the benefits of this practice in theory; Jan Hinz of Airbus spoke of how it has worked in practice, to the real benefits of working people at a time of vulnerability and change.

Jan also spoke of how headcount can be reduced through workers not being replaced as they retire. Moritz described evidence of greater work intensity as a result of digitalisation. It may be, if there are fewer jobs in the economy as a result of digitalisation, that we need to think creatively about the lengths of peoples working lives and about the intensity and demands placed on people when they are in work. In both cases, digitalisation could be a help, not a hindrance, if the productivity gains that it provides can be more fairly shared. This is a theme that we return to in the next chapter.

Section seven

What should we do about digitalisation?

It is clear from the evidence presented in this report that the so-called fourth industrial revolution will be transformative, as other disruptive economic and technological breakthroughs were before. We can speculate as to how big or disruptive this change will be, but we cannot know for sure. More than any particular technology, it is the sheer breadth, the pervasiveness of the new technologies coming on stream, which will form the greatest part of the challenge.

However, what we also know is that predictions of the end of the world as we know it are not new. Previous waves of technological change have delivered improvements in living standards. In the midst of a prolonged productivity crisis in the British economy, new technologies could offer an opportunity to revitalize growth across the country, as well as to solve some of our most pressing challenges such as climate change.

That does not mean that all fears about the impact of technology are misplaced. The last wave of technological change – from the 1970s onwards – was accompanied by real disruption for many working people. Industries that had been the mainstay of many local economies disappeared, without thought for what might come in their place, or investment in those who had worked in them. Across the developed world, the share of economic growth going to workers has fallen, and the share going to the average worker fallen still further. Of course, not all of these changes are due to technology – globalization, and the decline of union coverage across most industrialized countries have played a significant role.

But the lesson of the past when it comes to confronting technological change is that while there is no need to panic, there is a need to plan. The final section of this report therefore sets out suggestions for where Trade Union campaigners could focus their attention when it comes to dealing with the impact of technological change, with the aim of kickstarting a broader discussion.

We focus on three aims:

- How the UK can use new technology to enhance productivity, jobs, and wages, particularly in the areas which previous waves of industrial change have left behind;
- Protecting workers and communities whose jobs are most at risk of change; and
- Sharing the rewards of increased productivity.

Taking advantage of the potential of new technologies

A new mission?

New technologies have the potential to deliver huge benefits, including new ways to tackle climate change, to deliver medical advances, and to produce more goods in the UK rather than overseas.

And as the recent conversion to Industrial Strategy by all main political parties recognises, Government has a key role to play in developing and encouraging this kind of industrial growth.

At present, the UK is at risk of falling behind our main competitors in our ability to make the best use of the potential of new technology to help deliver new growth. Our weak productivity figures in part reflect the fact that business investment in the UK remains low, and the prolonged imposition of government austerity means that growth is subdued. While the government has recognised some of this problem with the introduction of a 'National productivity and infrastructure fund' in Autumn 2016, government investment as a proportion of GDP is set to remain below the level seen in the last parliament.[28]

With the UK's strong scientific base, and world leading universities, we should have the potential to be at the forefront of delivering new technologies. Setting an industrial 'mission' to be one of the world's top five digital economies by 2030 could help provide focus for government intervention in this area – and a new spur for investment.

But as Germany has recognised, moving towards a digital economy requires a partnership approach, in which workers, business and civil society get a chance to shape the direction of policy. The first step for Government in this area could therefore be to replicate the German approach, and 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.

Consultation at workplace level will also be vital to ensuring that companies introduce new technology in partnership with workers.

> *"[Policy should] empower worker voice in the workplace through strengthening protections for organising and creating new and innovative ways for workers to make their voices heard"* White House Paper

The Works Council structure in Germany provides a forum for discussion between business and management in which to agree how change will be introduced – leading, for example, to the commitment at Airbus that no jobs will be lost as a result

[28] TUC analysis, see http://touchstoneblog.org.uk/2016/11/autumnstatement-chancellor-goes-little-way-meet-investment-challenge/

of automation. But the UK falls behind in this area: the most recent version of the European Participation Index puts the UK sixth from bottom of the EU28 Member States in terms of workforce participation; only Cyprus, Lithuania, Latvia, Bulgaria and Spain perform worse.[29]

Many unions are already planning how to respond to new technology, including piloting the use of technology agreements in companies in which they have representation, and thinking through how to respond to the challenges of digitalisation. Unite, for example, have been working with the automotive sector to look at the potential impacts of automation and the digital revolution in manufacturing on the future of the industry,[30] as well as the impact of automation on other sectors.

But a more widespread approach is needed. The TUC has long argued for new sectoral bodies that could look at how to drive up pay, conditions and productivity across an industry, with representation from unions and business. These could be given an additional role of considering the impact of new technology on an industry, and what it means for the workforce.

Diversifying the AI workforce

Taking advantage of new opportunities offered by technology will require a skilled and diverse workforce, with widespread evidence showing that more diverse workforces perform better.[31]

But at present, those working in new technologies are overwhelmingly male. A 2015 report from the UK Comission on Employment and Skills found that less than a third of those employed in the UK's digital industries are women;[32] only 16 per cent of computer science graduates in 2016 were female, and only 25% of wider STEM (science, technology, engineering and maths) subject graduates.[33]

These problems are not unique to the UK; a recent report found that just 20 per cent of graduates in computer science across the OECD are women. But if the UK wants to demonstrate ambition in this area, addressing the gender gap in the tech workforce would be a good place to start – perhaps by setting an ambition to get to double the proportion of female STEM graduates being female within the next ten years.[34]

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[29] See 'The Gig is Up!': https://www.tuc.org.uk/sites/default/files/the-gig-is-up.pdf
[30] See for example Unite's work in the automotive sector: http://www.unitetheunion.org/news/unite-conference-to-secure-the-future-of-the-uk-automotive-industry/
[31] See, for example https://economics.mit.edu/files/8851 or http://www.mckinsey.com/business-functions/organization/our-insights/why-diversity-matters
[32] https://www.theguardian.com/technology/2015/jun/09/women-uk-digital-workforce
[33] https://www.wisecampaign.org.uk/resources/2017/02/higher-education-statistics-2016
[34] See 'Hybrid Cars and Shooting Stars, TUC, 2007 – for the TUC's approach to tackling this issue, including our call for a woman Doctor Who - a call that has finally been heeded ten years later.

Protecting workers whose jobs are most at risk of change

Those with higher skills have been the main beneficiaries of technological change, and most predictions of the impact of digitalisation in the future suggest that this pattern will continue.

To make sure workers have the skills they need to take advantage of new opportunities, government needs to focus on those in the workplace now. Two thirds of the 2030 workforce have already left higher education, and it is likely to be these mid-career workers who are most at risk of being left behind in the face of rapid industrial change.

At present, the UK is particularly bad at equipping people with new skills throughout their working lives; IPPR calculate that employer investment in continuing vocational training per employee in the UK is half the EU average and investment in training and learning per employee fell by 13.6 per cent per employee in real-terms between 2007 and 2015.[35] Meanwhile the OECD have shown that spending on out of work training in the UK is less than 40 per cent of the OECD average.[36] This means that the risks associated with losing your job are greater in the UK than elsewhere, as it's less likely you'll get the help you need to train for a different type of work.

Technological change is not the only reason to invest significantly more in adult education, which can bring benefits in terms of higher productivity, and more satisfied employees. While the expansion of apprenticeships is welcome, it's clear that government now needs to go further. Steps could include:

- Setting an ambition to increase investment in both workforce and out of work training to the EU average within the next five years.
- Introducing a right to a mid-life career review, and face to face guidance on training.
- Introducing a new life-long learning account, providing the opportunity for people to learn throughout their working lives.
- Introducing a new targeted retraining programme aimed at those facing redundancy due to industrial change.

[35] https://www.ippr.org/files/publications/pdf/skills-2030_Feb2017.pdf
[36] OECD data from 2011 – the most recent currently available.

To set out a sort of wish list for the UK one would be that we have stronger generic skills across the population more generally. Everybody thinks the digital revolution, high tech skills, STEM [science, technology, engineering, mathematics] skills, we need more scientists and so forth, yes we need those. Yes we need the data analyst, industrial data scientists and the computer programmers, the AI experts, etc. But we also need strong and broad levels or, widespread generic skills and literacy and numeracy and problem solving because that's a way of future-proofing human capital, because you can't acquire those more technical, precise and fast changing skills unless you have a foundation in good generic skills, unless you have that basis. So that's part of the challenge." Alastair Nolan, OECD

"College and career ready skills in math, reading, computer science, and critical thinking are likely to be among the factors in helping workers successfully navigate through unpredictable changes in the future labour market" White House Paper

Sharing the rewards of increased productivity

PwC have estimated that UK GDP will be up to 10 per cent higher in 2030 as a result of artificial intelligence, the equivalent of an additional £232 bn, and equivalent to extra spending power of up to £2,300 a year per household by 2030.[37] The key challenge in dealing with the new wave of technological change is how to ensure that if these benefits arrive they are fairly shared – reversing the trend seen since the 1970s which has seen a larger share of reward go firstly to the owners of capital, and then to the richest workers within the ranks of the employed.

Some have suggested that the risk of large scale unemployment is so great that we should give up on the idea of work at all as the primary means of distributing the gains from productive activity. Advocates of a Universal Basic Income have suggested that this should be funded through a tax on 'robots', as the most effective way of ensuring that those who own capital do not end up with an ever increasing share of the financial rewards from growth.

We are sceptical that this is the right approach at this time. As we set out above, we need more investment in technology, not less. And while there is considerable risk of disruption to jobs from the introduction of new technologies, fears of large scale job losses have as yet been misplaced.

In addition, as a discussion paper on the Universal Basic Income (UBI) published alongside this one argues, there are more effective ways of ensuring that everyone has an adequate income, including reforms to the existing social security system.

[37] https://www.pwc.co.uk/economic-services/assets/ai-uk-report-v2.pdf

Third, we don't need to wait until we have enough robots to tax them to move towards fairer shares of the rewards from work. As we set out below, increasing collective bargaining, a renewed look at the current structure of taxation, and a reduction in working time could help to ensure better quality work for everyone, rather than giving up on work altogether.

Increasing collective bargaining

The best way to protect pay is to encourage collective bargaining, as the evidence suggests that this is the most effective way to both increase the share of wages going to workers in general, and to ensure that this is fairly shared.

There are many sources to back up this argument. As the ILO Global Wage Report, 2016-17, states:[38]

"Collective bargaining can … help in reducing wage inequality within and between enterprises… When collective bargaining takes place at the national, industry and/or branch level in multi-employer settings with coordination across levels, a larger proportion of workers are covered and inequality is likely to be reduced both within and between enterprises… When the collective bargaining system is narrow, taking place at the company or workplace level, the effect is restricted to wage inequality within enterprises. It is thus not surprising that wage inequality tends to be lower in countries with an inclusive system of collective bargaining (Alvarez et al., 2016; Engbom and Moser, 2016)."

As we set out earlier, evidence from the UK suggests that declining trade union membership, following attacks on union rights throughout the 1980s, is likely to have been one factor lying behind the increase in inequality.

Increasing the share of workers covered by collective bargaining agreements will therefore be a critical tool to ensuring that the rewards of technological change are fairly shared. As a first step, government should give unions a right to access workplaces to tell individuals about the benefits of joining a union.

Taxation

While taxing robots is premature, it is right to suggest that the balance of taxation between workers and the companies who employ them could be shifted.

Since 2010 the balance of taxation has been shifted significantly away from corporations. The IFS find that by the end of the parliament, corporation taxes will be a third lower as a proportion of national income than before the crisis. Part of this is due to the fall in North Sea Oil revenues, and therefore taxation, and part due to a fall in banks' profitability (slightly offset by new taxes levied on banks). But a significant reason is the policy of successive cuts to Corporation Tax, set to cost £10.8 billion a year in 2015–16 terms.[39]

It is sometimes argued that ultimately, workers pay the cost of higher corporation tax, in the form of lower corporate investment and lower growth and wages. But at present, there is no sign that corporation tax cuts have encouraged either higher business investment, or led companies to pay higher wages: business investment is

[38] http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_537846.pdf
[39] https://www.ifs.org.uk/uploads/publications/bns/BN_182.pdf

low despite low interest rates, and high levels of corporate profitability, and wage growth is exceptionally weak despite low inflation.

Meanwhile, significant planned cuts to in and out-of-work benefits are set to contribute to a rise in inequality rise over the next five years – with income at the 10th percentile of the earnings distribution projected to fall, while those at the 90th percentile rise.[40]

A shift in resources from working families to the owners of technology is not a theoretical possibility – it is current government policy. Shifts in the rates of current taxes could be a more effective means to turn this around than focusing on taxing one particular form of capital investment.

Working time

Previous technological revolutions have not seen a decline in the number of jobs. But they have seen a reduction in total hours worked. One potential benefit of technological change that should be embraced is its ability to improve the quality of working life.

This report is not about the impact of technology on forms of employment – for example, the rise of platforms, or about the impact of technology on the experience of work, and the rise of surveillance within the workplace (though these will be the subject of future TUC work), and the impact of technology on work intensity is a growing health and safety concern. We should also consider the extent to which robots and forms of artificial intelligence can minimise dangerous, boring, unrewarding work, and offer a chance to consider what good, meaningful work looks like.

But if we are seeking to share the benefits of productivity gains more fairly, we should consider whether they can help deal with the challenges of an ageing population.

In July 2017, it was announced that Britons born between 1970 and 1978 will have to wait until they are 68 to claim their state pension. This rise comes seven years before previously planned and will affect seven million people born between 1970 and 1978, that is, those in the middle of their careers now. The rise was justified on the basis of cost. At present, spending on the state pension is expected to rise from 5.2 per cent of GDP in 2016/17, to 6.2 per cent in 2036/37, and 7.1 per cent of GDP in 2066/67. Under the proposed changes, spending will instead rise to 6.7 per cent of GDP in 2066/67 – a reduction of 0.3 per cent.[41]

But if the boost to GDP from technology is as large as set out by PWC, who predict a ten per cent rise by 2030, the question of how to fund our ageing population could have been answered, and such changes should be unnecessary. Rather than worrying

[40] https://www.ifs.org.uk/uploads/publications/comms/R127.pdf

[41] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/611460/independent-review-of-the-state-pension-age-smoothing-the-transition.pdf

about whether robots will take our jobs altogether, we could concentrate on how whether they can help us to finish our working lives at a time when most of us would choose.

Next steps

We hope that this paper will be the start of a discussion – with Unions, business and government about how best to address the challenges and seize the opportunities posed by the next wave of technological change.

Over the course of the following year we will be developing this work further in consultation with unions, and looking at other aspects of new technology that affect working people, including the rise in surveillance at work, how platform companies are treating their workers, and the potential of digital technology to help trade unions ensure the rewards from growth are fairly shared.

What could government do now?

Using new technology to enhance productivity, jobs, and wages

Set a mission for the UK to be a top five digital economy by 2030

Establish a commission on the future of work, engaging unions, business and civil society in how technology should be introduced

Ensure that workers have a say in the introduction of technology at company and sector level, with new sectoral institutions to bring unions and business together.

Diversify the tech workforce, with a target to double the proportion of female STEM graduates in ten years.

Protecting workers whose jobs are most at risk of change

Focus on older workers and set an ambition to increase investment in both workforce and out of work training to the EU average within the next five years.

Introduce a right to a mid-life career review, and face to face guidance on training.

Introduce a new life-long learning account, providing the opportunity for people to learn throughout their working lives.

Introduce a new targeted retraining programme aimed at those facing redundancy due to industrial change.

Sharing the rewards of increasing productivity

Promote collective bargaining to tackle wage inequality, including by giving unions the right to access workplaces to tell workers about the benefits of joining a union.

Prioritise supporting families, rather than cutting corporation tax.

Consider how the gains from increased productivity could be used to lower the state pension age.

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