# RSA
**Action and Research Centre**

## The Age of Automation

**Artificial intelligence, robotics and the future of low-skilled work**

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September 2017

RSA | **FUTURE WORK CENTRE**

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## About the RSA

The RSA (Royal Society for the encouragement of Arts, Manufactures and Commerce) believes that everyone should have the freedom and power to turn their ideas into reality – we call this the Power to Create. Through our ideas, research and 28,000-strong Fellowship, we seek to realise a society where creative power is distributed, where concentrations of power are confronted, and where creative values are nurtured. The RSA Action and Research Centre combines practical experimentation with rigorous research to achieve these goals.

## About the RSA Future Work Centre

This report is produced by researchers in the RSA's Future Work Centre – a programme that aims to bring about a better world of work through a combination of rigorous research and practical experiments. Alongside trends in automation, we are exploring the rise in self-employment, the nature and characteristics of gig work, and the hidden activities of the informal economy. In each case, our work seeks to lead the debate by digging behind the headlines, unpicking the nuance of debates and canvassing views from across the political spectrum. We believe that good work for all is an achievable goal – one that can only be realised through radical but pragmatic interventions. Over the coming year, the RSA will publish further content with ideas on how to boost economic security, meaning and dignity in every workplace.

## Acknowledgements

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# Foreword

'The Age of Automation' is an important and timely contribution to the growing debate about the impact of technology on work. It encourages us to look behind the lurid headlines of a workless future and beyond the polarised debates between utopians and doomsayers. Instead it helps the reader to get to grips with the range of technological change possible and the very different ways this might impact on a range of types of work, particularly that which tends to be classified as low skilled.

Ben and Fabian's report offers an interesting analysis, namely that we are worrying too much about technology but not actually investing enough in is potential. It concludes with a wide ranging and aggregately radical set of recommendations which will, I hope, spur further projects by the RSA.

In my recent Review of Modern Employment for Government I focussed primarily on the current problems facing the labour market, and particularly those struggling in its lower reaches. But inevitably technology featured. One reason we need a fairer and more robust framework for gig work is that the technology underpinning it could be – indeed is being – applied to more and more types of employment. Equally, new organising platforms – sometimes called 'worker tech' – offer opportunities for contract and self-employed workers to develop forms of organisation and mutual support.

Looking further ahead, we also argued for an approach to technological R and D which emphasised the interaction of machines and humans and an approach to employability which could, in a fast changing labour market, better enable people to carry skills and competencies from one job and area of life to another.

The foundation for the whole Review was set by our commitment to good work, or as we put it the goal that 'all work is fair and decent with scope for fulfilment and development'. I have been pleased to see how widely that goal has resonated.

As this report argues, if we are not to succumb to pessimism or determinism we must keep in mind that technological progress must also be human progress. The mixture of rigour, pragmatism and idealism is the hallmark of the RSA's best work. This report meets that expectation fully.

**Matthew Taylor**
Chief Executive, RSA

# Summary

**A new machine age beckons**

Public interest in artificial intelligence (AI) and robotics is gathering steam – and for good reason. Recent years have seen the emergence of machines that can diagnose cancers as accurately as pathologists, detect fraudulent financial transactions in a matter of milliseconds, produce coherent news stories for media outlets, shuttle goods and pallets within complex distribution warehouses, trade stocks and shares in financial markets, and perform case research for the legal industry. The breadth and depth of accomplishments expands by the day.

It is therefore unsurprising that fears have grown in tandem about what AI and robotics might mean for workers. It is four years since the University of Oxford published its landmark study predicting that 35 percent of UK jobs could be made obsolete by new technology. But since then, anxiety about automation has only become more acute. Alarming newspaper headlines such as *'Robots will destroy our jobs – and we're not ready for it'* and *'Robots will take a third of British jobs by 2030'* are now common. So too are the warnings from esteemed technologists and economists, such as Elon Musk, Mark Carney and Bill Gates.

But are we right to be worried? Are humans destined for the scrapheap as some suggest, or will we find new jobs and niches in a world saturated by machines? These are the questions we sought to answer in our study on AI and robotics. In doing so, we have tried to broaden the conversation out from an almost exclusive focus on the number of jobs that might be lost, to look at how the nature and substance of jobs are likely to change. This means examining the potential impact of technology on recruitment, pay, progression and productivity, as well as whether it will make jobs more or less fulfilling and purposeful.

Our research has paid particular attention to low-skilled workers, who have naturally faced greater economic challenges than most. Nearly a third of elementary workers (which includes waitresses and cleaners) have household incomes below the poverty line, as do 22 percent of process, plant and machine operatives. Prospects for progression are also minimal. Barely 1 in 10 workers who were low paid at the beginning of the last decade had escaped low pay by the end. Added to this is the growth of non-standard forms of employment such as temporary work, agency arrangements and zero hour contracts, which afford fewer rights and protections.

**Job availability: reasons to be hopeful**

Will AI and robotics make matters worse? They will undoubtedly cause the loss of some jobs, whether it is picking and packing robots that usurp warehouse workers, or algorithms that take the place of professionals in

financial services firms. But there are several reasons to question claims of mass automation (at least in the short-medium term):

- **Technical limitations** – Despite impressive advances in the capability of machines, there are still many things they cannot do. As entrepreneur and technologist Gary Marcus recently put it: 'Robots fall over while opening doors, prototype driverless cars frequently need human intervention, and nobody has yet designed a machine that can read reliably at the level of a sixth grader, let alone a college student.'[1]
- **Task vs job automation** – In most cases, AI and robotics will automate individual tasks rather than whole jobs. And because jobs usually encompass a range of functions, the automation of one task means workers will be able to pivot into new roles. No machine can wholly substitute for retail assistants, care workers, hotel receptionists, warehouse workers or building labourers. These occupations are more likely to evolve than be made obsolete.
- **Technology complements and creates** – AI and robotics will not just substitute for workers. They will also complement them and create new tasks not previously done by humans. Examples include robotic systems used by overburdened care workers to help lift patients, algorithms that enable doctors to recommend more appropriate treatments, and chatbots that provide call centre workers with partially automated responses to speed up customer support.
- **New jobs will emerge** – Some of the fastest growing occupations in the UK are in the technology industry. The number of pro-grammers has grown by 40 percent since 2011, while the ranks of IT directors have doubled over the same period. Tech jobs alone are unlikely to replace those lost to machines, but they will spur job creation in ancillary sectors. The Berkeley economist Enrico Moretti estimates that every new job in the tech sector has the potential to generate five complementary jobs elsewhere.
- **Demand will be recycled** – Automation must also be looked at through a macro lens that accounts for feedback loops. One of these is the phenomena of shifting or 'recycled' demand. Rising productivity caused by new machines may lead to a lowering of prices, thereby freeing consumers to spend money in the same sector or another part of the economy. In cases where demand is elastic (ie goes up and down with prices), automation may not lead to aggregate job losses.

While we do not wish to dwell on automation estimates, which are often misleading and superficial, our RSA/YouGov poll of business lead-ers indicates that 15 percent of private sector jobs in Britain have the potential to be fully automated in the next decade. However, we found wide variation among our respondents, with a fifth (22 percent) saying

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1. Marcus, G. (2017) *Artificial intelligence is stuck. Here's how to move it forward*. The New York Times, 29 July.

they see zero prospect for job automation in the business they work for. Thirty-eight percent predict a low impact (between 1-15 percent of jobs automatable), 27 percent a medium impact (between 16-30 percent of jobs automatable), and just 13 percent a high impact (more than 31 percent of jobs automatable).

Regardless of their estimates, most studies reveal a technological bias against low-skilled and low-paid workers. Yet some sectors will be more affected than others. While retail and logistics stand out as highly automatable industries, the picture is markedly different for sectors that are bound up in person-to-person interaction. Just 4 percent of business leaders in hospitality and leisure, 2 percent in medical and health services, and 3 percent in education see the scope for high automation among their workforce (although these last two figures should be interpreted with caution given low sample sizes)[2]. This finding is reflected in current job growth rates, with primary and nursery teaching professionals up by 40 percent since 2011, and educational support assistants up 50 percent.

## Job quality: a matter of choices

We conclude that jobs are more likely to evolve than be eliminated, and that new occupations will emerge in the long run, often of a more valuable and 'human-centric' nature. What is less clear is how AI and robotics will change the *quality* of work:

- **Recruitment** – Just as new machines will affect the number of jobs available in the future, so too will they alter the way people access that work. Software is coming on stream that can help recruiters by screening CVs and analysing gestures and expressions during interviews. Some believe these algorithms will entrench existing biases in workforce recruitment, yet others think they could eliminate prejudice. AI is also being used to power on-demand platforms, which have been simultaneously praised for creating jobs and condemned for diminishing worker rights.
- **Pay** – New machines may deskill occupations, thereby lowering barriers to entry and reducing the bargaining power of workers in existing positions. Deep learning algorithms capable of detecting cancers may enable lower skilled nurse practitioners to complete diagnoses that usually take radiologists a decade to train for, with the latter losing out as a result. On the other hand, there is evidence that AI and robotics could boost wages due to sizeable productivity gains, which will generate more absolute wealth that can be shared with workers.
- **Experience** – AI and robotics may pave the way for a 'digital Taylorism', with employers using new tools to control the minutiae of workers' day to day activities. Or technology could humanise jobs and phase out dull, dirty and dangerous work. The LSE's Leslie Willcocks, who has examined the take up of

2. Typically, survey results require a sample of at least 50 respondents to be seen as statistically reliable. Our survey was answered by 37 business leaders in medical and health services and 35 business leaders in education.

technology in companies such as Associated Press, reports that in most cases "we found staff not feeling threatened by automation but instead appreciating having fewer repetitive tasks".

- **Consumer power** – AI and robotics will not only affect people at work but also in the home – as customers, patients, learners and political citizens. The experience of history tells us that technological advances more often than not supercharge living standards, and AI and robotics are almost certain to sustain this trend. Robo-advisory services in finance will open up financial advice to more people, AI in healthcare will improve the detection and treatment of diseases, and algorithms used in education will enable personalised learning.

## Quick to criticise, slow to adopt

The message here is that technology is not predetermined to result in a particular outcome. As a society we have a choice in how to apply AI and robotics and manage their effects. There are choices to be made by developers and engineers in terms of the functionality they imbue in machines, there are choices to be made by employers as to which technologies they purchase, there are choices to be made by HR teams as to whether and how they help staff evolve into new roles, and there are choices to be made by policymakers about the kind of regulatory, welfare and tax system that can maximise the upsides of disruption and minimise the downsides.

These choices, however, are only relevant so long as the technology is being deployed. Indeed, just because a machine can do something, does not mean that it will be bought, integrated and licensed to do so. And herein lies the rub for the UK: while as a society we have been quick to lament the rise of AI and robotics, as an economy we have been slow to adopt these technologies. Sales of industrial robots to the UK fell in the period between 2014 and 2015, with the UK purchasing fewer robots than France, the US, Germany, Spain and Italy. Today the UK has just 33 robot units for every 10,000 employees, compared with 93 in the US and 213 in Japan.

These figures must be seen in the context of our smaller manufacturing base – still the biggest outlet for robotics. But in many sectors the UK has a poor record of investment. Data from the World Bank shows the proportion of UK GDP accounted for by gross fixed capital formation – a measure of investment that includes private and public sector spending – has fallen by 7 percentage points since 1990. Our RSA/YouGov poll finds that just 14 percent of business leaders are currently investing in AI and/or robotics, or plan to in the near future (the figure is just 4 percent for small businesses). Many think that the technology is too costly or not yet proven. For others, concepts such as machine learning, deep learning and cloud robotics appear to be completely new.

Some may view the slow diffusion of technology as the ideal outcome. It will give society time to adjust. Workers can keep hold of their jobs for longer. There will be less need to retrain and shift careers. Business can carry on as usual. Yet it is worth reminding ourselves what business as usual means. The status quo is a largely low-skilled, low-paid, low

productivity labour market that offers too few people the chance to flourish at work. Real median wages are still below their pre-crisis levels – an outcome reflected in our abysmal productivity rates. On average, UK workers are 30 percent less productive than their counterparts in the US. Our problem is not with the number of jobs available today but rather with their quality.

## Accelerating automation on our own terms

The central argument of this report is that the deployment of AI and robotics could help the UK forge a path towards a better world of work. New technologies could phase out mundane jobs, raise productivity levels, open up the door to higher wages, and allow workers to concentrate on more human-centric roles that are beyond the technical reach of machines. This is just as true for low-skilled workers as it is for high-skilled ones. But we cannot be complacent. AI and robotics, if deployed on a large scale, would result in both losers and winners. Some geographic areas, demographic groups, occupations and sectors would be hit harder than others. Economic inequality could rise, geographic disparities could deepen, and demographic biases could become further entrenched.

The challenge, then, is to accelerate the adoption of AI and robotics but in a way that delivers automation on our own terms. Our existing policy framework appears ill-prepared for this task. Our tax system leans too heavily on labour over capital, our welfare structure lacks a sufficient safety net to protect those who lose out to machines, our educational institutions do not do enough to support lifelong learning that would aid career shifts, our inflated housing market prevents people from moving in search of better work, and our investment communities seldom distinguish between supporting benign and malign technologies.

But an alternative path exists. While it is beyond the scope of this study to lay out fine-tuned recommendations, we suggest several interventions that would help bring about inclusive automation. Among our ideas are to:

- Develop an ethical framework to guide the behaviour of AI and robotics engineers
- Encourage VCs and non-profits to invest in benevolent technology that enriches the worker experience
- Establish a Centre for AI and Robotics that encourages greater take-up of innovations among industry
- Create personal training accounts that aid lifelong learning and help workers as they jump from job to job
- Shift the burden of taxation away from labour and towards capital
- Draft a blueprint for a UK sovereign wealth fund that would give every citizen a 'technological inheritance'.

In the frenzy of commentary on automation, it is easy to lose sight of a simple but profound truth: that technology does not arrive out of nowhere, but is humanity's creation to be wielded as we see fit. It would be a tragedy if we were to let a failure of imagination and a dearth of

leadership deny us its gifts. AI and robotics promise to extend lifespans, eradicate famine, tackle climate change, and help us manage an ageing population. If there were a question we should be asking, it is not how can we live with these technologies, but rather how can we live without them?

## Box 1: Key findings from our RSA/YouGov survey of UK business leaders

Business leaders on average believe 15% of jobs in their organisation have the potential to be automated:
- 22% see zero prospect for automation in their business
- 38% predict a low impact (between 1-15% of jobs automatable)
- 27% a medium impact (between 16-30% of jobs automatable)
- 13% a high impact (more than 30% of jobs automatable).

Estimates of high impact automation vary widely by sector:
- 15% of business leaders in retail
- 21% in transport and distribution
- 4% for hospitality and leisure.

The adoption rate of AI and/or robotics is low among UK business leaders:
- Just 14% have already invested in AI and/or robotics, or plan to in the near future
- 20% say they want to invest but that it will take several years before they will 'seriously' do so
- 14% are aware of the technology but believe it is too costly
- 15% are aware of the technology but do not believe it has been properly tested.

Most business leaders take a positive stance towards the arrival of new technologies in their sector (including but not limited to AI and robotics):
- 46% think new technologies are more likely to alter jobs than to eliminate them, and lead to greater prosperity in the long run
- 15% think new technologies will lead to the significant automation of jobs, harming livelihoods in the process.

There is lukewarm enthusiasm among business leaders for radical policy solutions to technological disruption, although surprising backing for some ideas:
- 44% back more priority to vocational education and lifelong learning
- 34% back employee ownership models
- 31% back a Universal Basic Income.

This an abridged account of the full survey results, which can be found in the main body of the report text.

# Introduction

## Automation anxiety

Of all the innovations set to impact the labour market in the 21st century, few have received more attention than robotics and artificial intelligence. Recent books including *Rise of the Robots* (Ford), *Only Humans Need Apply* (Kirby and Davenport) and *Race Against the Machine* (McAfee and Brynjolfsson) predict these technologies will change the face of modern employment, possibly beyond recognition.[3] Whether it is driverless cars or surgical robot assistants, banking 'chatbots' or self-service checkouts, it is now common to hear of how new machines are stepping in for humans at work (a process known simply as 'automation').

The public reaction has so far been a combination of marvel and trepidation – feelings that are reflected in popular culture. TV shows and films such as *Humans*, *Ex Machina* and *Automata* are both feeding off and fuelling interest in the power and possibilities of AI and robotics. Nor have developments escaped the attention of policymakers. Both the UK and US governments have investigated the potential impact of these technologies on the workforce, and earlier this year a new All Party Parliamentary Group was launched to consider the ramifications of AI.[4] Added to these are independent reviews, such as The Future of Work Commission, led by Tom Watson MP, and the Royal Society's Machine Learning inquiry.[5]

Such interest is understandable given the huge sums of money now flowing into these technologies, the definitions of which we unpack in the next chapter. The amount of venture capital funding going into robotics doubled between 2011 and 2015 to $587m, while the number of mergers and acquisitions of AI start-ups went from 11 in 2012 to 78 in 2016.[6] Several of these deals involved UK companies, including DeepMind (bought by Google), SwiftKey (Microsoft) and Magic Pony (Twitter). The global market for robotics and AI-based systems is expected to grow from $58bn in 2014 to $153bn by 2020.[7]

## Four voices on automation

Not everyone is in agreement about the consequences for workers. Internet law and policy expert Robert Cannon believes that "everything that can be automated will be automated", while Amazon CEO Jeff Bezos

3.  Ford, M. (2015) *Rise of the Robots*. Oneworld Publications; Davenport, T. H. and Kirby, J. (2016) *Only Humans Need Apply*. Harper Business; and McAfee, A. and Brynjolfsson, E. (2011) *Race Against the Machine*. Digital Frontier Press.

4.  For more information, see http://www.appg-ai.org/

5.  For more information, see http://www.futureofworkcommission.com/

6.  CB Insights (2016) *Robots R' Us* [Research brief] 23 March 2016; and CB Insights (2017) *The Race for AI* [Research brief] 21 July 2017. CB Insights - https://www.cbinsights.com/blog/top-acquirers-ai-startups-ma-timeline/

7.  Cited in Government Office for Science (2016) *Artificial Intelligence: Opportunities and implications for the future of decision making*. London.

claims "It's hard to overstate how big of an impact [AI is] going to have on society over the next 20 years".[8] In stark contrast, the new US Treasury Secretary Steve Mnuchin has said the prospect of significant job automation is "not even on my radar screen". Likewise, the economist Robert Solow has mocked that "the fear of automation is rather like the fear of collision with an enormous asteroid."[9]

Division in opinion is not limited to a handful of public figures. A Pew poll of technology and business experts found a 52:48 split between those who believe AI and robotics will create more jobs than they destroy, and those who think the opposite.[10] There are also widely different estimations of how many jobs are likely to be displaced by new machines. Carl Benedikt Frey and Michael Osborne from the University of Oxford predicted in 2013 that 35 percent of UK jobs had the potential to be automated, whereas more recent studies put the figure at 10 percent (OECD), 5 percent (McKinsey), and 30 percent (PwC).[11]

Yet whether jobs are likely to be rendered obsolete or not is only one dividing line in the complex debate about technological disruption. At least four different camps of opinion on technological change can be discerned, including those who deny it is even happening on the scale widely presumed:

- **Alarmists** – Alarmists believe in an irresistible march of AI and robotics that will lead to the mass automation of jobs, rising inequality and economic strife – unless imminent action is taken. Writers like Martin Ford acknowledge that technology has historically led to new and better jobs in the long-run, but argue that the pace of recent improvements in AI and robotics will mean that 'this time is different': more destruction, less creation.[12] Many, including Ford and the journalist Ryan Avent, are doubtful that upskilling the workforce will help, pointing as proof to a dwindling number of high-skilled jobs.[13] A Universal Basic Income (UBI) is presented as one solution, possibly paid for by a 'tax on robots', as was recently suggested by Bill Gates to much controversy.[14]

- **Dreamers** – Dreamers believe, just as Alarmists do, that new technology will lead to the mass automation of jobs. However, their stance is that this could usher in a utopia of a leisure society where workers are emancipated from the drudgery and dullness of modern work (a 'digital Athens'). Instead of railing against the machines, Dreamers call for greater investment in

8. Robert Cannon quoted in Pew Research Center's AI, Robotics and the Future of Jobs study. Available here: http://www.pewinternet.org/2014/08/06/future-of-jobs/. Jeff Bezos quoted on CNBC news, 31 May 2016. Available here: https://www.cnbc.com/2016/05/31/amazons-bezos-sees-ai-at-early-stages-of-decades-long-trend.html

9. Solow, R. (2013) *The End of Work, Again*. [article] The European, 25 July 2013.

10. Smith, A. and Anderson, J. (2014) *AI, Robotics, and the Future of Jobs*. Pew Research Center.

11. Frey, C. B., Osborne, M. A., and Holmes, C. (2016) *Technology at Work v2.0*; OECD (2016) *Automation and Independent Work in a Digital Economy*; and PwC (2017) UK Economic Outlook: March 2017; and McKinsey Global Institute (2017) *A Future that Works*.

12. Ford, M. (2015) op cit.

13. Avent. R. (2016) T*he Wealth of Humans*. St. Martin's Press.

14. Delaney, K. J. (2017) *The robot that takes your job should pay taxes, says Bill Gates* [article] Quartz, 17 February 2017.

technology and for the productivity gains to be used in pursuit of reducing worker hours (or 'full unemployment'). Alex Williams and Nick Srnicek, two leading leftwing proponents of automation, have, like the Alarmists, called for a Universal Basic Income, as well as for the use of public funds to 'democratically control' how technology develops.[15.]

- **Incrementalists** – Incrementalists believe AI and robotics are sophisticated technologies, but with a long way to go before they make humans obsolete at work. They see the force of technology as a gradual rising tide rather than a fast approaching tidal wave, and believe that new machines are more likely to evolve jobs than eliminate them. For the writers Julia Kirby and Thomas Davenport, AI and robotics will augment the human workforce, giving the mundane to the machines and the purposeful to the people.[16.] It is up to employers and educators to help workers respond by 'stepping up' or 'stepping aside', meaning respectively to find jobs overseeing machines or to find a human-centric pursuit that is resistant to automation, such as in healthcare or education.

- **Sceptics** – Unlike the other three camps, Sceptics claim that recent innovations – including in the realms of AI and robotics – are mediocre compared with past inventions. In their view, the low hanging and richest fruits of technology have mostly been harvested, and only modest innovations remain to be discovered. Among the Sceptics' founding fathers are Tyler Cowen and Robert Gordon, the latter of which has argued that the invention of indoor plumbing was more consequential for mankind than the advent of the internet.[17.] As proof of their claims, Sceptics point to the plateauing of productivity levels around the world, a phenomenon Cowen has labelled 'The Great Stagnation'.[18.]

## Focusing in on the low-skilled

Each of these camps has been tussling for position for at least a decade. Yet the debate has been squarely focused on assessing automation's impact on one group: middle-skilled workers. There is now a broad consensus among all but the most ardent Sceptics that the labour market underwent a form of 'hollowing out' during the 1990s and early 2000s, albeit with a subsequent filling in of middle-skilled jobs as other professions plugged the gap.[19.] According to the Resolution Foundation's analysis, jobs in the middle of the pay distribution, such as secretarial and manufacturing work, fell markedly as a share of total UK employment

15. Williams, A. and Srnicek, N. (2015) Inventing the Future: *Postcapitalism and a world without work*. Verso Books.

16. Giving "the mundane to the machines and the purposeful to the people" was a phrase used by Matt Hancock MP in a speech to the Centre for Policy Studies in 2016. Available at: https://www.gov.uk/government/speeches/technology-innovation-and-the-future-of-the-uk-workforce

17. Gordon, R. (2012) *Is US economic growth over? Faltering innovation confronts the six headwinds*. National Bureau of Economic Research.

18. Cowen, T. (2011) *The Great Stagnation: How America ate all the low-hanging fruit of modern history, got sick, and will (eventually) feel better*. Dutton.

19. Gardiner, L. and Corlett, A. (2015) *Looking through the hourglass: Hollowing out of the UK jobs market pre- and post- crisis*. Resolution Foundation.

between 1993 and 2014.[20] In contrast, there was a large growth in the number of customer service roles and health and social care professionals (eg housing officers and paramedics) – jobs that are known to be less routine.

But what about low-skilled work? Less attention has been paid to jobs like caring, cleaning, driving and waitressing, largely because they embody tasks that demand manual dexterity and complex manoeuvring, which were once thought too difficult for machines to mirror (Box 2 describes our concerns about using the label 'low skilled'). The technology that is coming on stream today is now challenging those assumptions. Advances in modelling 'belief space', for example, has led to breakthroughs in situational awareness and the ability of robots to grasp objects and replicate hand-to-eye coordination.[21] Meanwhile, developments in materials science and the use of air muscles and 'ferrofluids' have made robots more life-like and dexterous. Equally significant has been the emergence of cloud robotics, allowing machines to share data and continually learn from the experiences of others (the next chapter provides a full introduction to AI and robotics).

It is important to understand how AI and robotics might affect low-skilled workers for two key reasons. The first is that they make up a considerable chunk of the UK labour market. While the ONS does not offer a strict definition of low-skilled employment, it does classify occupations by their skill level.[22] This suggests there are 13.9 million low-skilled workers (levels 1 and 2) in the UK, accounting for 45 percent of the workforce.[23] This includes 1.1 million retail assistants, 769,000 care workers, 325,000 teaching assistants, 281,000 waiting staff, 541,000 cleaners and 232,000 taxi and cab drivers. Moreover, the number of low-skilled workers is expected to expand rapidly in the years to come, with as many as 400,000 caring personal service roles set to be created between 2014 and 2024.[24]

## Box 2: Who are you calling low-skilled?

The degree to which work is deemed high-skilled, middle-skilled or low-skilled tends to be based on an assessment of its technical intensity, and the degree to which formal training and qualifications are required to fulfil the role. However, this overlooks the empathetic intensity or emotional intensity associated with many forms of work, including caring, teaching and some forms of retail. It is not within the remit of this report to offer fresh definitions or frameworks for understanding worker skill level, and indeed we are somewhat constrained by the reams of literature and data that use traditional notions of low-skilled work. But we have endeavoured to be mindful of this limitation and will seek to address it more more extensively in future research.

20.   Ibid. Manufacturing, the home of modestly paying, middle skilled jobs, today employs just 10 percent of the UK workforce, down from around a third in the 1970s.

21.   Ross, A. (2016) T*he Industries of the Future*. Simon and Schuster.

22.   The ONS classification can be found here: http://webarchive.nationalarchives. gov.uk/20160106225424/http://www.ons.gov.uk/ons/guide-method/classifications/ current-standard-classifications/soc2010/soc2010-volume-1-structure-and-descriptions-of-unit-groups/index.html

23.   Source: RSA analysis of Labour Force Survey (April-June 2016).

24.   UKCES (2016) Working Futures 2014-2024. Note: personal service roles includes care home workers and teaching assistants.

The second reason is that low-skilled workers already face pressing challenges in the workplace, having been at the sharp end of a slow economic recovery. Thirty percent of elementary workers (which includes waitresses and cleaners) have household incomes that push them below the poverty line, as do 22 percent of process, plant and machine operatives, and 20 percent of workers in care and leisure occupations.[25] Low pay is in turn reflected in a dearth of assets and savings. More than half of all workers in elementary, machine operative, and sales and customer service roles have £1,000 or less in gross financial wealth, leaving them vulnerable to the slightest of setbacks such as an illness or bereavement.[26]

This is just the static picture. Equally troubling is the lack of dynamism at the bottom end of the labour market, with too few workers seeing any progression in pay or skill level. According to the Social Mobility Commission, barely 1 in 10 workers who were low paid at the beginning of the last decade had escaped low pay by the end.[27] Added to this is the growth of non-standard forms of employment such as temporary work, agency arrangements and zero hour contracts, which afford fewer rights and protections. According to the OECD, almost all the aggregate increase in employment in the UK between 2007 and 2013 was owed to contingent work of this kind.[28] As many as 1 in 7 care workers and 1 in 4 waiting staff is on a zero hour contract.[29]

Neither are the problems that beset low-skilled workers solely of a financial kind. Just as many jobs are low paid and characterised by volatility, so too do many lack meaning and purpose. Others still constrain the autonomy of workers and leave them with little space to use their initiative and talents. The recent exposés of worker mistreatment in retail and ecommerce warehouses may be at the extreme end of bad practice, but they are indicative of a broader disregard for agency and dignity in low skilled jobs.[30] Only 21 percent of process and plant operatives are satisfied with their involvement in decision making at work, while an underwhelming 59 percent of elementary workers (eg warehouse workers) are satisfied with their sense of achievement.[31]

The low-skilled are not one homogenous group. The experiences of teaching assistants and childcare minders will vary considerably from those of warehouse operatives and kitchen staff, as will the satisfaction of workers *within* these occupations. We should also be mindful not to exaggerate the levels of insecurity facing these workers. The rise of gig work– where people find small jobs through online platforms or apps – has been rapid but still only 3 percent of UK adults have engaged in this work.[32] Most of the workforce including low-skilled workers continue to be employed in conventional jobs that pay a predictable wage.[33] What

25. RSA analysis of FRS/HBAI (2015/16). These figures are derived after housing costs are taken into account.
26. Source: RSA analysis of Wealth and Assets Survey (WAS) Wave 4.
27. Social Mobility Commission (2016) *State of the Nation 2016*.
28. Stewart, H. (2015) *Temporary and part-time jobs surge promotes inequality, says OECD*. The Guardian, 21 May.
29. Source: RSA analysis of Labour Force Survey (April-June 2016).
30. See for example Jenkins, C. (2016) *JD Sports Investigation* [news report] Channel 4 News, 22 December.
31. Source: RSA analysis of Workplace Employment Relations Survey 2011.
32. Balaram, B. (2017) *Good Gigs: A fairer future for the UK's gig economy*. London: RSA.
33. Taylor, M. et al. (2017) *Good Work: The Taylor Review of Modern Working Practices*.

we can say with some certainty, however, is that for too many people in today's labour market, work is far from a labour of love.

## Friend or foe?

The question this report asks is whether AI and robotic technologies will add further pressure to an already ailing workforce, or whether they will be a welcome reprieve by boosting the quality of work and raising levels of pay and productivity.

On the surface, the answer is obvious: machines are becoming more sophisticated and this can only mean the displacement of workers and the driving down of wages. It is easy to imagine driverless cars pushing the UK's 232,000 taxi drivers out of business, just as it is easy to picture self-service checkouts diminishing the need for many of the country's 1.1 million retail workers. A glance at media headlines also foreshadow a gloomy future. *'Millions of UK workers at risk of being replaced by robots'* and *'Robots to steal 15 million jobs in the next 15 years'* are typical of the pessimistic captions that regularly appear in national newspapers.

There are several reasons to doubt these sweeping claims, however. Number one is that the UK enjoys the lowest unemployment rate in a generation. More people want to cut their hours than want to work more hours, suggesting that work is plentiful in many occupations and sectors.[34] Moreover, history is littered with claims that new machines would make humans obsolete in the workplace, only for these to be dashed as new jobs and occupation types emerged. Positive employment gains have been made in the UK in more than three quarters of the years since 1971, in spite of technological advances.[35] One need only look at day-to-day technologies – self-service checkouts, ATMs, automated customer helplines – to see their limitations and the interdependency of human and machine.

As with every topical issue, there is more to the sensational headlines and snappy statistics than first appears. Through this report we hope to clear up inaccuracies and enrich people's understanding of the impact of AI and robotics – both the opportunities and the threats. What is the technology capable of and how has it evolved in recent years? How are low-skilled workers in different occupations and sectors likely to be affected? Will AI and robotics even be adopted at the rate some suspect? And what can the government, employers, educators and regulators do to prepare the workforce of today and tomorrow for any disruption?

We hope to add particular value by:

- **Capturing the views of employers,** whose voices are often missing from debates on technology, yet who are ultimately the ones who buy and deploy it.

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34. Source: RSA analysis of According to the Labour Force Survey (2016 Q4). The underemployment rate is 8 percent and the overemployment rate is 10 percent.

35. Source: RSA analysis of ONS employment time series. Positive employment gains have been made in more than three quarters of years since 1971. Years with negative employment growth = 10 of 44. Share of years with negative employment change = 22.73 percent. Share of years with positive = 77.27 percent.

- **Looking at how technology affects the quality of work as well as its quantity**, such as what it means for pay, productivity, progression and agency.
- **Discussing the value of technology as it relates to broader societal challenges**, including an ageing society, climate change and rising pressures on public services.
- **Setting out policy and practice prescriptions that extend across the technology lifecycle**, from the point at which machines are conceived to the time they are deployed in workplaces.

Our starting point is to state clearly that the trajectory of AI and robotics is not predetermined, but rather can be moulded to suit our own ends. A common theme we will return to in this report is that we do have choices as a society over how we marshal technology for the benefit of workers. Developers can choose what features they code into software. Employers can choose which types of robots or AI systems they purchase. Regulators can choose what constraints to put on industries and employers. Educators can choose which skills and qualities they want to develop in the workforce of the future. And the government can choose how it sets its tax and welfare regime to ensure those who gain the most from technological disruption support those who stand to lose the most.

We firmly believe there is such a thing as **automation on our own terms,** and we hope the rest of this report spells out a positive vision for how this can be achieved.

# Understanding AI and robotics

## Lifting the lid on AI and robotics

Artificial intelligence and robotic systems can be found in every corner of our economy. Example uses include:

- **Cancer detection** – A deep learning algorithm developed by Stanford University is capable of diagnosing cancerous skin lesions as accurately as a dermatologist.
- **Media reports** – The Associated Press recently adopted machine learning software that can produce 3,000 corporate earnings reports every quarter.
- **Construction** – A robot called the Semi-Automated Mason (SAM) can lay up to 1,200 bricks a day, compared with the 300 to 500 a human bricklayer is capable of.
- **Utility repairs** – HiBot USA uses a combination of robotics and AI to predict the likelihood of pipe failures, based on factors such as surrounding soil type and land topography.
- **Parcel delivery** – Starship Technologies has developed a wheeled robot that can deliver parcels autonomously, and is now being trialled with logistics companies worldwide.
- **Patient care** – Japan's Tokai Rubber Industries has developed the RIBA robot, which is being used in health care to lift and move humans up to 175 pounds in weight.
- **Fraud detection** – Fraugster is a startup that uses machine learning algorithms to spot fraudulent behaviour in financial transactions in as little as 15 milliseconds.
- **Housing inspections** – Technology company ASI Data Science has created algorithms to predict where unlicensed landlords operate, helping to prevent the exploitation of vulnerable tenants
- **Online shopping** – Many retailers use machine learning algorithms to learn customer preferences and offer personalised recommendations

The breadth of applications for AI and robotics is clearly vast. But before we can ascertain what these machines will mean for the workforce, first we need a better understanding of how they function and how they are likely to evolve in the future. What does artificial intelligence mean in practical terms? How does it relate to other concepts such as 'deep learning' and 'machine learning'? What constitutes a robot? And how significant are innovations such as 'cloud robotics' and 'serpentine robotics'?

Here we attempt to lift the lid on these machines, beginning by separating out artificial intelligence from robotics, which are two overlapping but distinct technologies.

## Introducing artificial intelligence

Artificial intelligence is complicated to define, but generally refers to tasks performed by computer software that would otherwise require human intelligence. And by 'software' we mean a bundle of algorithms that follow a series of steps to arrive at an action or conclusion.

There are two broad types of artificial intelligence: general AI and narrow AI. **General AI** refers to holistic systems that have equal or greater intelligence to humans, and which can complete all manner of tasks, from playing chess to greeting customers in a shop to creating works of art. Aside from the most ardent of optimists like sci-fi writer Vernor Vinge and entrepreneur Elon Musk, most experts believe we are several decades away from seeing machines that can pass for humans. The fundamental block is that general AI demands an understanding of how intelligence works, yet this is an enormous puzzle that will keep research labs occupied for some time to come.[36]

Considerably more progress has been made in the second field of **narrow AI**, which is sometimes referred to as 'weak AI'. These are systems that can perform discrete tasks within strict parameters, for example:

- Image recognition – used in self-service desks at passport control, and automatic name tagging on Facebook photos.
- Natural language processing – used in voice recognition for AI assistants like Amazon Echo and Google Home.
- Information retrieval – used in search engines.
- Reasoning using logic or evidence – used in mortgage underwriting or determining the likelihood of fraud.

These tasks can in turn be grouped into three categories of intelligence: **sensing**, **reasoning** and **communicating**. The technology journalist Kris Hammond uses the example of voice assistants like Apple's Siri and Google's Assistant to demonstrate how AI systems often combine different functions: first they deploy speech recognition algorithms to capture what people are asking ('sensing'), then use natural language processing to make sense of what the string of words mean and identify an answer ('reasoning'), and finally relay this answer to users using natural language generation ('communicating').[37]

## AI winters that came and went

But how did artificial intelligence systems get to this point? The concept of thinking machines has existed in serious form since Alan Turing and his contemporaries developed the first sophisticated computers in the 1940s. The Dartmouth College convention of 1956 is often cited as the landmark moment when computer scientists came together to pursue

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36. See for example Marcus, G. (2017) *Artificial general intelligence is stuck. Here's how to move it forward*. New York Times, 29 July 2017. Carey, S. (2016) *DeepMind cofounder says general artificial intelligence remains "a long way off"* [article] TechWorld, 6 December.

37. Hammond, K. (2015) *The AI Ecosystem*. [article] ComputerWorld, 11 May.

artificial intelligence as a field in its own right, powered by leading thinkers such as Marvin Minksy.

Despite early enthusiasm and significant funding, however, initial progress in developing AI was disappointingly slow. DARPA, which had pumped millions into university departments during the 1960s, became particularly frustrated at the lack of headway in machine translation, which it had hoped would turbocharge its counter espionage capabilities. Meanwhile in the UK, a 1973 government commission on AI led by James Lighthill raised grave doubts that the research field was going to evolve at anything but an incremental pace.[38.] The result was that government funding in both countries – and across the developed world – was drastically curtailed.

The rise and fall of AI in the consciousness of policymakers and the public continued throughout the 20th century. A new development would trigger a wave of enthusiasm and a surge in funding, only for interest to plunge and resources to dry up as promised innovations failed to materialise. As many as four 'AI winters' can be identified since the genesis of the movement in the 1950s. Trigger happy funders and sensational media reporting were partly to blame for inflating the AI bubbles, but so too was the research community's overzealous predictions. Even the subdued Marvin Minsky was caught claiming in 1970 that "[within] three to eight years we will have a machine with the general intelligence of an average human being".[39.]

## The green shoots of an AI spring

Progress was slow partly because of the approaches researchers were using to develop software. Most AI applications of the 20th century took the form of expert systems, which are based on a series of painstakingly developed 'if-then' rules that can guide basic decision-making (picture a decision-tree with multiple branches). While expert systems are useful for dealing with a contained task – say, processing cash withdrawals under the bonnet of an ATM – they struggle with requests that cannot easily be codified in rules. For example, it is very difficult to write rules that determine whether a human-like object is a mannequin or a real person, or whether a dark pattern on an MRI scan is a tumour or benign tissue. These instead rely on 'tacit knowledge' that is hard to articulate.

It is only when new approaches to artificial intelligence were deployed that significant breakthroughs were made – not least thanks to **machine learning** techniques. Rather than having to write rules from scratch, machine learning works by 'training' algorithms using existing data that is often labelled (eg images denoted as mannequins or humans, and MRI scans labelled as malign or benign tumours). Working backwards, the algorithms then detect a pattern and create a generalised rule to make sense of future inputs. Machine learning algorithms are now being used in multiple domains, from detecting fraudulent transactions in banking to helping HR teams screen CV applications during employee recruitment.

While machine learning has been powering achievements in AI for the last decade, the spotlight in the last two years has turned to one of its

38. Lighthill, J. (1973) *Lighthill Report: Artificial Intelligence, a paper symposium.*
39. Wadhwa, V. (2016) *The amazing artificial intelligence we were promised is coming, finally.* The Washington Post, 17 June.

subdomains: **deep learning**. Deep learning systems are made of 'artificial neural networks' that have multiple layers, with each layer given the task of making sense of a different pattern in images, sounds or texts. A first layer may recognise primitive patterns, such as the outline of an object in an image, whereas a second layer may be used to identify a band of colours in that image. Data is fed through multiple layers until the point where the system can cluster patterns into distinct categories, say of objects or words. According to a King's College London study, deep learning techniques more than doubled the accuracy of brain age assessments when using raw data from MRI scans.[40.]

Other important approaches to AI include supervised learning, reinforcement learning and transfer learning:

- **Supervised learning** – Algorithms can be trained at their outset in one of two ways: through supervised or unsupervised learning. Supervised learning means that algorithms are fed labelled data, which they draw patterns from to come up with a generalised rule to make sense of future data. Most machine learning and deep learning algorithms are trained using a supervised process. Unsupervised learning is when an algorithm is fed unlabelled data and spots patterns of its own accord. Example uses include population segmentations used by marketing companies, and some cybersecurity software.
- **Reinforcement learning** – Whereas some algorithms are written or trained only once, reinforcement learning uses positive feedback mechanisms to continuously tweak and improve algorithms as they are used. Recommendation systems in online retail are an example of reinforcement learning in action. Every time a consumer purchases a product – a book, a record or an item of clothing – an algorithm automatically adjusts to factor in these behaviours when making future recommendations.
- **Transfer learning** – Transfer learning involves taking an algorithm that was developed in one domain and modifying it for use in another, without having to start from scratch and source huge reams of original and labelled data. Transfer learning has been used to repurpose algorithms that were originally deployed to read print media to subsequently read text on social media.

To clarify, the above approaches to AI are not necessarily mutually exclusive, and can often be used in combination.

## Introducing robotics

What about robotics? As with artificial intelligence, there is not a common definition of a robot, but for the purposes of this report we deem them to be physical machines that move within an environment with a degree of autonomy. While tractors, construction diggers and sewing machines have moving parts that complete manual tasks, they require human oversight for long periods (if not continuously) and therefore do not fall under our definition of a robot. In contrast, picking and packing

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40.  Emerging Technology from the arXiv (2016) *Deep-learning Machine uses MRI scans to determine your brain age.* [article] MIT Technology Review, 12 December.

The Age of Automation

machines in warehouses and 'carebots' that lift and carry patients both fulfil tasks with partial autonomy, and would therefore be classed as robots by our reckoning.

The word robot first emerged in a 1921 science fiction play written by Karel Capek, which told the story of a society that produced human clones to be its slaves, only for the robots to overthrow their masters. Robotics remained the preserve of science fiction until the 1950s, when the first industrial robotics company called Unimation was formed. It invented a ground-breaking 4,000 pound robot arm that could pick up and drop down items based on pre-programmed commands, making it ideal for moving heavy and hot items in factories. The Unimate robot had its first outing at General Motors in 1961, where it was used to transport hot pieces of die-cast metal and weld them to car body parts.

Not long afterwards in 1969, pioneering roboticist Victor Scheinman developed the Stanford Arm, the first electrically powered and articulated robot arm. It was seen as a breakthrough in robotics because it operated on six axes, giving it greater freedom of movement than previous single or double axis machines.[41.] The Stanford Arm marked the beginning of the articulated robot revolution, which transformed assembly lines in manufacturing and spurred the launch of several commercial robotics companies including Kuka and ABB Robotics. Over the years, articulated robots have taken on evermore functions, from welding steel, to assembling cars, to adding finishes to white goods. The International Federation of Robotics puts the current number of industrial robots at 1.6m globally (note this also includes other robotic types including Cartesian robots).[42.]

## Breaking free of their cages

The world of robotics remained focused on articulated arms for most of the 20th century. Yet just as with the field of AI, the picture began to change at the turn of the millennium. Honda's ASIMO robot was unveiled in 2000 as one of the first humanoid machines that could walk on two legs, recognise gestures and respond to questions. Three years later, KIVA Systems (now Amazon Robotics) was established to supply mobile robots that could shuttle goods and pallets within complex distribution warehouses. The early 2000s was also the period when autonomous vehicles moved from lab testing to road trials. Particularly symbolic was DARPA's Grand Challenge of 2004, a first of its kind prize that offered a £1m award to anyone who could navigate a 142 mile course with an autonomous vehicle.[43.]

While varying in their functions, size and setting, each of these robots have one characteristic in common: mobility. Whereas the articulated robots of the 20th century were firmly rooted in one place and often enclosed behind screens, the robots of the 21st century have broken free of their cages. One driving factor has been the symbiosis of AI and robotics, with sophisticated software giving physical machines the wherewithal to deal with unanticipated surroundings and events. Reinforcement

41. Chirgwin, R. (2016) *Obituary: Victor Scheinman, inventor of the "Stanford Arm" factory robot*. [article] The Register, 22 September.
42. International Federation of Robotics (2016) *Executive Summary World Robotics 2016 Industrial Robots*. IFR.
43. DARPA (2014) *The DARPA Grand Challenge: Ten Years Later*.

learning, for example, means that robots can now mimic and learn from human co-workers. Furthermore, storing data in the cloud means robots can share learning and pool experiences with other robots in a network, be they retail humanoid robots such as Pepper or the autonomous driving cars of Waymo.

Advances in robotics can also be traced to innovations in hardware. Improvements in sensors are giving robots the visual awareness necessary to navigate unstructured environments. These sensor capabilities have been matched by a rich and growing pool of data on the physical world, including new 3D image datasets such as ScanNet and 3D maps of streetscapes gathered by fleets of cars in real-time.[44] Materials science has also come on leaps and bounds. Better materials such as silicone and spider silk make for sharper looks, while 'mechanical hairs' made of piezoelectric transistors are as sensitive as human skin.[45] Added to this are improvements in hydraulic pumps, which offer minimal friction and allow for remarkable levels of control.[46]

The result is that robots are no longer confined to factories but can be seen roaming settings as diverse as hospitals wards, shop floors and city streets. Yet even in factories, robots continue to evolve. The latest machines, dubbed 'cobots', are designed to work in tandem with human workers, for example by picking components out of bins, removing defective items from product lines, and fulfilling simple tasks such as screwing, gluing and soldering. They are also extremely simple to reprogramme, making them attractive for businesses with smaller batch runs, and have torque sensors which immobilise the machine in the event of human contact. Research by MIT undertaken in partnership with BMW found that robot-human teams were 85 percent more productive than either working alone.[47]

So what is the overall picture in 2017? A look at the landscape of robotics suggests there are five main types of physical machine now in existence:

- **Articulated robots** – Stationary robots whose arms have at least three rotary joints, and which are typically found in industrial settings. Cobots are the latest iteration of articulated robots. Examples include Baxter, a reprogrammable robot that is 'trained' simply by moving its arms in the desired motion, rather than via programming.
- **Mobile robots** – Wheeled or tracked robots that can shuttle goods and people from one destination to the next. Self-driving cars are the pinnacle of mobile robot capability, while Tesla is planning to launch trials for autonomous long-haul trucks. Mobile robots can undertake more specific functions, including Amazon Robotics' small orange machines that move pallets in warehouses, and Starship Technologies' wheeled droids that can deliver parcels in urban areas.

44.  Knight, W. (2017) *A massive new library of 3D images could help your robot butler get around your house*. [article] MIT Technology Review, 24 April.
45.  McKinsey Global Institute (2017) op cit.
46.  Patil, S. (2016) *15 Latest developments in robotics field*. [article] TechStory, 27 May.
47.  Hollinger, P. (2016) *Meet the cobots: humans and robots together on the factory floor* [article]. Financial Times, 5 May.

- **Humanoid robots** – Robots that have a physical resemblance to humans and which seek to mimic our abilities. SoftBank claims its new Pepper robot is the first to be able to recognise human emotions and adapt its behaviour accordingly, while RIKEN's Robear has been engineered to lift and carry patients in healthcare. Other humanoid robots have taken on therapeutic functions, such as NAO, which uses simple gestures and games to support the development of autistic children.
- **Prosthetic robots** – Robots that can be worn or handled to give people greater strength, including disabled people or workers performing hazardous jobs. The HULC is a hydraulic exoskeleton that supports soldiers carrying heavy weights on expeditions. Another exoskeleton, suitX, gives paraplegics the strength to walk. Although these machines may not appear 'autonomous' (recalling our earlier definition of robots), under the bonnet many have sophisticated software to sensitively gauge and adjust the level of assistance wearers should receive.
- **Serpentine robots** – Snake-like robots made up of multiple segments and joints that can move with extreme dexterity. Because of their ability to traverse difficult terrains and move through confined spaces, serpentine robots have found uses in industrial inspection and search and rescue missions. HiBot USA has developed a pipe inspection robot that can glide through decades-old piping to assess the extent of deterioration and to determine, in concert with AI software, whether a replacement is necessary.

## What does the future hold?

It is impossible to predict how these two technologies – artificial intelligence and robotics – will develop over the coming years and decades. Deep learning algorithms may hit an impasse in their capabilities, while humanoid robots could turn out to be a flight of fancy. Some have already suggested that an AI bubble is inflating in Silicon Valley, with machines that are more artificial than intelligent.[48.] But what we can say with some certainty is that these technologies will continue to progress in one way or another, as they have done since their genesis in the 1940s and '50s. Several factors lead us to this conclusion:

- **Computing power** – Since the 1970s, the number of transistors that can fit into the same space on computer chips has doubled every two years – a rule known as Moore's Law. As computing power continues to grow, including through the recent introduction of nanometer transistors, it will open up pathways for more sophisticated AI and robotic systems. While there are indications Moore's Law may be waning, engineers believe considerable computer power gains are still to be made in the improvement of chip design and by creating chips especially for machine and deep learning algorithms.[49.]

48. Baciu, A. (2016) *Artificial intelligence is more artificial than intelligent*. [article] Wired, 7 December.

49. Simonite, T. (2016) *A $2 Billion Chip to Accelerate Artificial Intelligence*. [article] MIT Technology Review, 5 April.

- **Data capture and storage** – Data is the raw material that fuels the engines of AI and robotic systems. Thanks to the advent of the internet, the digitalisation of records and files, and the boom in social media communication, the global pool of available data that machines can train on is colossal. Every day 2.5 exabytes of data are produced, the equivalent of 530,000,000m songs and 250,000 US libraries of congress.[50] The world's stock of data is doubling in size every year, partly due to the spread of internet-connected devices.[51] One estimate suggests the number of IP-enabled sensors worldwide will reach 50bn by 2020.[52]

- **Common infrastructure** – It was once the case that every research lab and tech company would develop its own proprietary hardware and software. The picture is very different today, with common infrastructure emerging that means robotic and AI technology need not be created from scratch. For example, open source robotic operating systems such as ROS and BrainOS allow developers to experiment with robotics at low cost, bringing down the barriers to entry.[53] Google's TensorFlow, meanwhile, is an open source library of machine learning code that enables users to easily incorporate AI features like speech recognition and natural language processing into their software programmes.

- **Research investment** – A fourth driving factor is the large amount of investment flowing into research and development. In 2015, the US government's investment in unclassified R&D in AI-related technologies was approximately $1.1bn.[54] The EU has set up a public private partnership to strengthen Europe's robotics industry, with $700m of public funding.[55] The number of higher education institutions with AI and robotics departments is also expanding. There are now 100 departments in Chinese universities that specialise in automation, while there are approximately 34 UK universities offering courses in AI.[56] Investment is also very active in the private sector, with as many as 85 AI venture capital funds in operation.[57]

This chapter has summarised the key developments in artificial intelligence and robotics, and highlighted how these tools are being put use to use in fields as diverse as healthcare, finance, hospitality and utility repair. But what impact will these technologies have on workers? Will the likes of self-driving cars and picking and packing robots lead to huge job losses, or are these fears unfounded? The next chapter investigates the ramifications of these technologies in more detail.

50. Khoso, M. (2016) *How much data is produced every day?* Northeastern University.
51. Evans, P. and Forth, P. (2016) *Navigating a world of digital disruption.* Boston Consulting Group Perspectives.
52. Ibid.
53. Wood, L. (2016) *Service robots: The next big productivity platform. PwC.*
54. Networking and Information Technology Research and Development Subcommittee (2016) *The national artificial intelligence research and development strategic plan.*
55. For more information see: https://ec.europa.eu/digital-single-market/en/robotics-public-private-partnership-horizon-2020
56. Ross, A. (2016) *The Industries of the Future.* Simon & Schuster UK.
57. Corea, F. (2017) *Unsupervised Investments (I): A Guide to AI Investors.*

**Figure 1: An overview of robotics**
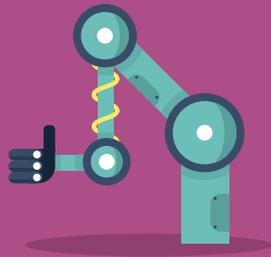


**ARTICULATED ROBOTS**

Stationary robots whose arms have at least three rotary joints, and which are typically found in industrial settings

CAR MANUFACTURING
ADVANCED SURGERY

**ASSISTANCE ROBOTS**

Robots that may be worn or handled to give people greater strength and mobility

PROSTHETICS
STROKE THERAPY

**HUMANOID ROBOTS**

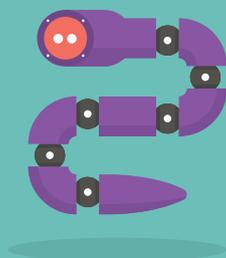Robots that have a physical resemblance to humans and seek to mimic our abilities

LIFTING PATIENTS IN CARE
CUSTOMER SERVICE ROLES

**MOBILE ROBOTS**

Wheeled or tracked robots that can shuttle goods and people from one destination to the next
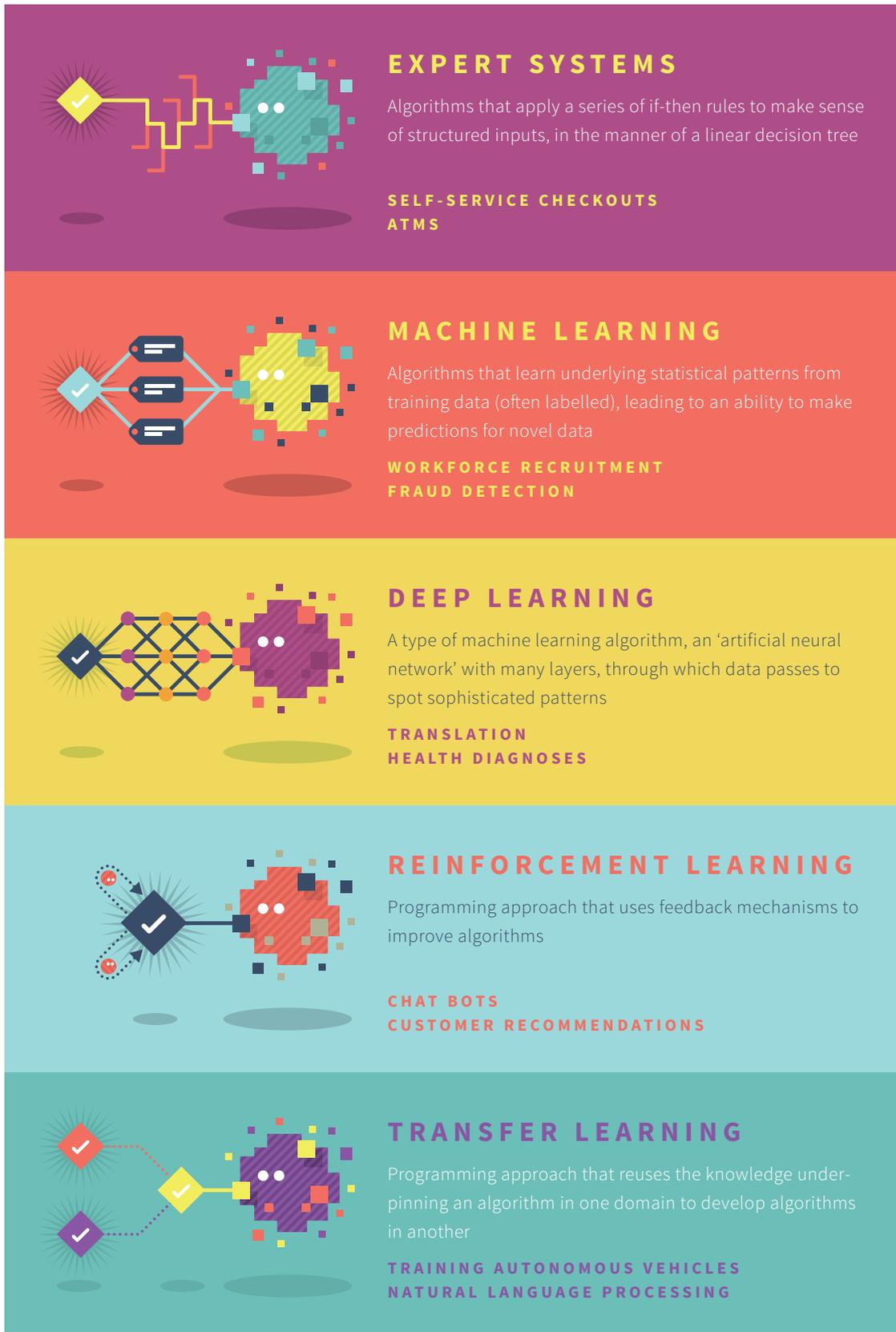
PARCEL DELIVERY
SECURITY SERVICES

**SERPENTINE ROBOTS**

Snake-like robots made up of multiple segments and joints that can move with hyper dexterity

INDUSTRIAL INSPECTION
SEARCH AND RESCUE

**Figure 2: An overview of artificial intelligence**



# EXPERT SYSTEMS

Algorithms that apply a series of if-then rules to make sense of structured inputs, in the manner of a linear decision tree

**SELF-SERVICE CHECKOUTS
ATMS**

# MACHINE LEARNING

Algorithms that learn underlying statistical patterns from training data (often labelled), leading to an ability to make predictions for novel data

**WORKFORCE RECRUITMENT
FRAUD DETECTION**

# DEEP LEARNING

A type of machine learning algorithm, an 'artificial neural network' with many layers, through which data passes to spot sophisticated patterns

**TRANSLATION
HEALTH DIAGNOSES**

# REINFORCEMENT LEARNING

Programming approach that uses feedback mechanisms to improve algorithms

**CHAT BOTS
CUSTOMER RECOMMENDATIONS**

# TRANSFER LEARNING

Programming approach that reuses the knowledge under-pinning an algorithm in one domain to develop algorithms in another

**TRAINING AUTONOMOUS VEHICLES
NATURAL LANGUAGE PROCESSING**

# The five dimensions of automation

## Introducing the five dimensions

Whether it is deep learning algorithms that can diagnose cancers in healthcare, machine learning software that can speed up recruitment practices in HR, or mobile droids that can deliver parcels to and from distribution centres, there is a sense among many that new machines are set to usurp humans from the workplace.

But of course, this is not the first time automation has drawn breaths of anticipation. Beginning with the industrial revolution in the late 18th and early 19th centuries, the world has seen a steady stream of new technologies come into play that have altered the nature of work. The spinning jenny, the flying shuttle, interchangeable parts, assembly lines, agricultural mechanisation and the personal computer are just some of the inventions that have replaced human labour over the years. The American professors Erik Brynjolfsson and Andrew McAfee draw a useful dividing line between two broad periods of automation: a first machine age where new technologies substituted for physical tasks, and a second machine age where cognitive activities became the focus of automation.[58.]

In this chapter, we explore how automation might play out in the future, drawing upon historical experience to give us clues. In doing so, our analysis extends beyond the traditional focus on job quantity to encompass matters of job *quality*. We believe the latter is a significant omission in recent studies on automation, with too many commentators fixated on estimating the number of jobs that could be displaced, at the expense of understanding how the remaining jobs will evolve. Not only are automation estimates an almost impossible exercise to get right, they distract observers from the way new technology will transform other aspects of the worker landscape, such as recruitment practices, wage growth, worker bargaining power, productivity levels, the degree of monitoring at work, and exposure to dull, dirty and dangerous tasks.

Figure 3 groups these variables into five dimensions of automation, which the rest of this chapter explores in turn.

58. McAfee, A. and Brynjolfsson, E. (2011) op cit.

**Figure 3: The five dimensions of automation**



**2. RECRUITMENT**
AI and robotics could improve or impede people's access to jobs (e.g. through platforms that connect people to opportunities, or algorithms that screen applicants prior to interview)

**3. PAY**
AI and robotics could boost or supress wages (e.g. tech that deskills jobs could reduce bargaining power, but a rise in productivity could open the door to wage hikes)

**TASK VS. JOB AUTOMATION**

**1. JOB AVAILABILITY**
AI and robotics could eliminate or transform jobs, at the same time as creating new roles and moving demand around the economy

**SHIFTING DEMAND**

**NEW JOB TYPES**

**ENGINEERING BOTTLENECKS**

**5. CONSUMER POWER**
AI and robotics may reduce the price of goods and improve the quality of services (e.g. enhancing health care diagnoses or reducing the cost of financial advice)

**4. EXPERIENCE**
AI and robotics could increase the quality of work or diminish it (e.g. harmful and mundane tasks could ebb away, or monitoring in the workplace could grow)

## #1 – Job availability

**Three reasons to be hopeful**

In 2004, the US academics Frank Levy and Richard Murnane published a book called *The New Division of Labor*, which speculated about the kind of tasks and jobs that might be off limits to machines. In the second chapter entitled 'Why People Still Matter', they suggested that self-driving trucks may one day be able to operate in structured environments, thanks to cameras and sensors that can capture sensory input. But they were doubtful autonomous vehicles would ever cope with busy streets or a task like turning in heavy traffic. "Articulating this knowledge and embedding it in software for all but highly structured situations are at present enormously difficult tasks… Computers cannot easily substitute for humans in [jobs like truck driving]".[59.]

Levy and Murnane are two brilliant economists, but their inaccurate forecast reminds us to be careful when trying to ascertain what can and

59.  McAfee, A. (2010) *Where the silicon meets the road*. Andrew McAfee blog, [blog] Available here: http://andrewmcafee.org/2010/11/mcafee-google-autonomous-car/

cannot be automated.[60.] Indeed, thanks to the developments outlined in the last chapter, including machine learning and cloud robotics, new machines are beginning to encroach on non-routine activities that were once thought the sole preserve of humans. Amazon's robots can scurry pallets around busy warehouses, soft gripping robots can pluck and bag delicate fruit harvests on farms, and machine learning algorithms can identify breast cancer with 89 percent accuracy – a better record than most pathologists.[61.] Faced with examples like these, it is hard not to agree with the likes of Martin Ford that humans are destined for the scrapheap.

Yet there are several reasons to be sceptical of such claims. The first is that **there are still many things that machines cannot do**, and which seem unlikely for them to master in the near future. Artificial intelligence and robotic systems struggle with open-ended conversations, they do not have hunches, they lack taste and cultural awareness, they have no strategic vision and cannot lead, opinions are beyond them, they cannot improvise, and by their very nature they are not authentic. While an IBM computer was able to beat Garry Kasparov at chess in 1997, there are still no machines that can ably tie a shoe lace, open doors, or turn the page of a book.[62.] Researchers at Berkley University found it took their towel-folding robot ten hours to produce a stack of twenty-five towels (a new commercial robot called Laundroid takes three to ten minutes to fold a single item).[63.] This is what has become known as Moravec's Paradox: high-level reasoning requires low computation, but low-level sensorimotor skills demand huge computational resources.[64.]

A recent study by McKinsey canvassed the views of technology experts to identify which work activities, out of a set of 2000, have the greatest scope for automation. High on the list were tasks that hang on processing or collecting data, and operating machinery in predictable environments. In contrast, tasks such as interfacing with stakeholders, being creative, planning, managing and developing people, and applying expertise to decision-making are all estimated to be significantly less susceptible to automation. These findings are roughly mirrored in Carl Benedikt Frey and Michael Osborne's seminal University of Oxford study, which identified three groups of tasks – or 'engineering bottlenecks' – that remain difficult for machines to master:[65.]

- **Social intelligence** – The ability to negotiate and persuade, to respond to the emotional cues of others, and to impart knowledge.

60. Some technologists and economists continue to question whether self-driving cars will become mainstream. However, their doubts relate less to what is technologically possible and more to the regulatory obstacles, moral dilemmas and logistical hurdles (eg who cleans taxis or helps less able passengers in and out of cars?) See for example Welch, D. and Coppola, G. (2017) *Self-driving taxis could have a vomit problem* [article] Bloomberg, 13 July.

61. Bergen, M. (2017) *The AI Doctor Orders More Tests*. Bloomberg Businessweek, 8 June, and Butler, S. (2017) *If EU workers go, will robots step in to pick and pack Britain's dinners?* The Guardian, 25 February.

62. Robots exist that can fulfil these functions but with great difficulty. See for example: https://www.youtube.com/watch?v=HWglGMLa0yA

63. Kolbert, E. (2016) *Our automated future*. The New Yorker, 19 December.

64. For more information see: https://en.wikipedia.org/wiki/Moravec%27s_paradox

65. Frey, C. B., and Osborne, M. A. (2013) *The future of employment: how susceptible are jobs to computerisation?* Oxford Martin Programme on Technology and Employment.

- **Complex manipulation** – The ability to deftly handle, move and control objects in a variety of settings, using fine muscle control.
- **Creativity** – The ability to conceive of novel ideas and to create art and design that pushes cultural boundaries.

Some dispute the idea that competencies like creativity and social intelligence are beyond the remit of machines. Historian Yuval Noah Harari points to software that can write symphonies exquisite enough to dupe listeners into believing they are human made.[66] Others point to the robotherapy chatbot Ellie, which has been designed by researchers at the University of Southern California to study facial expressions and voice patterns, and elicit responses from patients. Yet many of these technologies offer only *shallow* forms of automation. 'Deep creativity' means pushing the boundaries of artistic endeavour rather than replicating symphonies of the past, while 'deep communication' means not only disseminating knowledge but helping others make sense of it, as well as engaging in open-ended and imaginative dialogue.

A second reason why the extent of automation may be less severe than some expect is because **jobs are multifaceted and made up of a basket of tasks**, only some of which are automatable. Hotel receptionists have to meet and greet customers, pick up and drop off keys, check bookings on a computer system, and move heavy bags through busy walkways. It is feasible that one of these tasks could be computerised, for example through automated check-in systems, but the result would most likely be an evolution of the job as new tasks fill the void. And even were all of these tasks automatable, it is difficult to see a *single* machine switching between them seamlessly as a human receptionist would. As one Nasa scientist put it, humans have an edge in being a "150 pound, non-linear, all-purpose computer system".[67]

The tendency of technology to automate tasks rather than whole jobs is often cited as a reason why the spread of ATMs in the 1990s did not lead to the significant loss of jobs in bank branches.[68] Because cash dispensing was only one function of bank tellers, theory has it they were able to pivot into customer-facing roles and fulfil more unstructured tasks such as processing mortgage applications or answering queries about managing accounts and transactions. Looking at automation through the lens of tasks rather than jobs, the OECD estimate that only 10 percent of UK jobs are at risk of full displacement.[69] However, they also calculate that a further 25 percent of jobs could see roles change considerably as AI and robotics chip away at routine functions.

The third reason to be sceptical about claims of mass job displacement is that technology results in more than just worker substitution (see Box 3). **AI and robotics will also complement what humans do**, enabling people to achieve more and do better work. A good example is the use of ceiling-based modular robots in domiciliary care, where partially automated devices help overburdened social care workers lift patients out

66. Harari, Y. N. (2015) *Homo Deus: A brief history of tomorrow*. Harvill Secker.
67. Cited in Went, R., Kremer, M. and Knottnerus, A. (2015) Mastering the Robot. The Future of Work in the Second Machine Age. Amsterdam University Press.
68. For more information see https://www.bba.org.uk/news/statistics/abstract-of-banking-statistics/statistical-abstracts
69. OECD (2016) op cit.

of bed and in sitting positions (the next chapter provides a more detailed case study). Another example is the use of AI platforms in call centres. The airline KLM uses a chatbot to generate partial responses to customer queries on social media, which are then edited, refined and elaborated on by human agents in the team. Ten percent of messages are sent without alteration, most of them answers to basic questions.[70.]

Alongside substituting and complementing, AI and robotics will *create* work in their own right. This means machines fulfilling tasks that have never been done by a salaried human previously, or at least only by a minute fraction of the workforce. A case in point are the new concierge service bots coming onto the market for older people with low level care needs. ElliQ is an elder care assistant that can remind people to take their medicine, set up video chats with family and friends, and recommend physical exercises depending on how sedentary a person has been. Given that none but the wealthiest of individuals have carers on hand 24/7, this device cannot be seen as encroaching on human turf. Another example is the use of AI in agriculture to predict crop yields and determine where pesticide should be sprayed. These are not skills that farmers or their workers would ever profess to have, and thus machines should be seen in this context as creating value without displacing labour.

| Box 3: Three ways technology impacts work | | |
|---|---|---|
| Form | Impact | Examples |
| Substituting | Removing people and replacing them with a machine | ▪ Unmanned self-service checkouts<br>▪ Autonomous machines on assembly lines |
| Complementing | Allowing people to achieve more or do better quality work | ▪ Voice activated robots that help carers lift patients<br>▪ Chatbots that produce partial responses for call centre staff |
| Creating | Doing work that was never previously done by humans | ▪ Elder care AI assistants that keep older adults active<br>▪ AI in farming that predicts crop yields and determines where to spray pesticides |

**Job displacement: How many, who and where?**

What does all of this mean for job availability in the round? Recall the predictions of various studies that have explored the consequences of automation. Frey and Osborne forecast that 35 percent of jobs in the UK have the potential be fully substituted, while the OECD put the figure at 10 percent and McKinsey closer to 5 percent. Most recently, PwC bucked the increasingly conservative stream of estimates with a higher prediction of 30 percent.[71.] The reason why these estimates vary is because of methodological differences, for example with McKinsey using their own raft of experts to review the capabilities of machines, and the OECD viewing automation through the lens of tasks rather than jobs.

Rather than try to repeat another extensive estimation exercise, we chose instead to speak directly with employers about the prospects for job automation. They are the ones who ultimately buy and deploy new technology, and are therefore better placed than experts to determine

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70. Caffyn, G. (2016) *How KLM uses artificial intelligence in customer service.* [article] Digiday UK, 4 October.
71. PwC (2017) op cit.

its impact in the short-term, at least within their own organisation. Our RSA/YouGov survey found that **business leaders on average believe 15 percent of jobs in their organisation have the potential to be fully automated within 10 years.**[72] This is a significant proportion and on a par with PwC and Frey and Osborne's studies, if we take into account their timelines were around twice as long. However, as Figure 4 shows, we found wide variation among respondents, with a fifth (22 percent) saying they see zero prospects for job automation in their business.

Regardless of the overall figure of automation, **most studies reveal a technological bias against low-skilled and low-paid workers.** The OECD calculates that 44 percent of workers with less than a high-school degree hold jobs made up of many highly automated tasks, compared with 1 percent for the college-educated.[73] Similarly, Deloitte estimate that UK jobs paying less than £30,000 are five times more vulnerable to displacement than jobs paying £100,000 or more.[74] These figures are given greater impetus by the numerous media stories of new technologies emerging in low-skilled occupations, whether it is robots that can flip burgers, delivery drones that can automate parcel delivery, or automated floor cleaners operating in hospitals and hotels.

**Figure 4: Business leader estimates of the proportion of jobs in their organisation that could be fully automated within ten years**
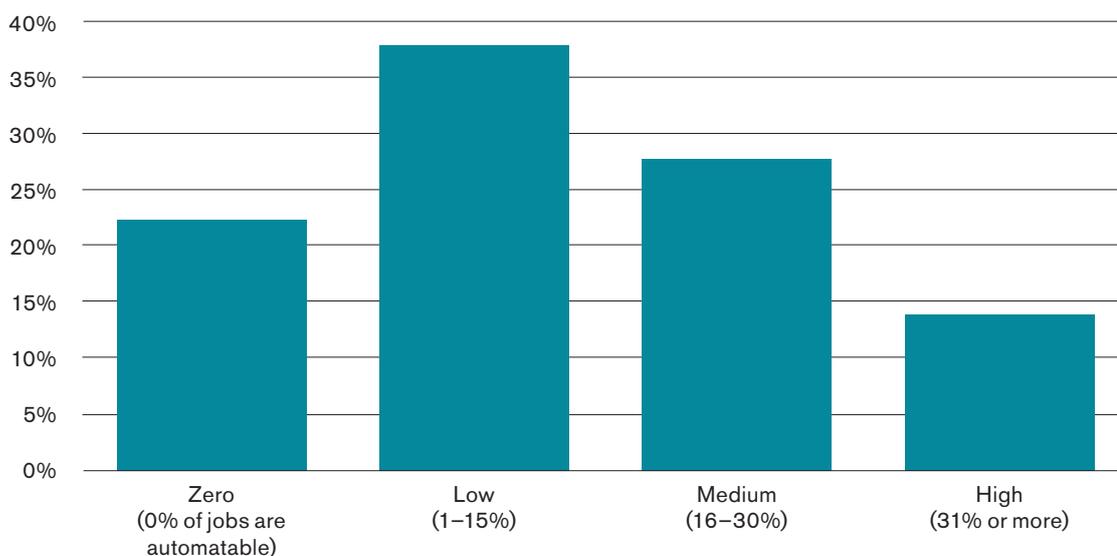


Source: RSA/YouGov survey of 1,111 UK business leaders (Fieldwork conducted 10-18 April 2017)

While these are gloomy forecasts for low-skilled workers, it is important to note that some sectors will be more affected than others. In nearly every study of AI and robotics, including our own, two low-skilled sectors emerge as likely to bear the biggest brunt of automation: retail

72. This mean figure was calculated by taking the midpoints in our variable options (eg 7.5 percent when the option to respondents was between 6-10 percent of jobs), multiplying these by respondent answers, and then dividing this grand figure by the total number of respondents (minus those who said 'don't know).

73. OECD (2016) op cit.

74. Deloitte (2016) *London Futures. Agiletown: The relentless march of technology and London's response.*

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and logistics. Figure 5 shows that 15 percent of retail business leaders see considerable potential for job automation in their organisation (defined as more than 31 percent of jobs being automatable in the next 10 years), as do 21 percent of business leaders in transportation and distribution. In terms of middle and high-skilled jobs, both finance and manufacturing are seen as having high numbers of jobs that could be displaced by machines. Indeed, a recent US study by two MIT economists estimates that the deployment of one extra industrial robot (ie in manufacturing) per thousand workers reduces the employment to population ratio by 0.18-0.34 percentage points.[75.]

**Figure 5: Share of employers who think a high level of jobs in their organisation will be automatable in the next 10 years, by sector**
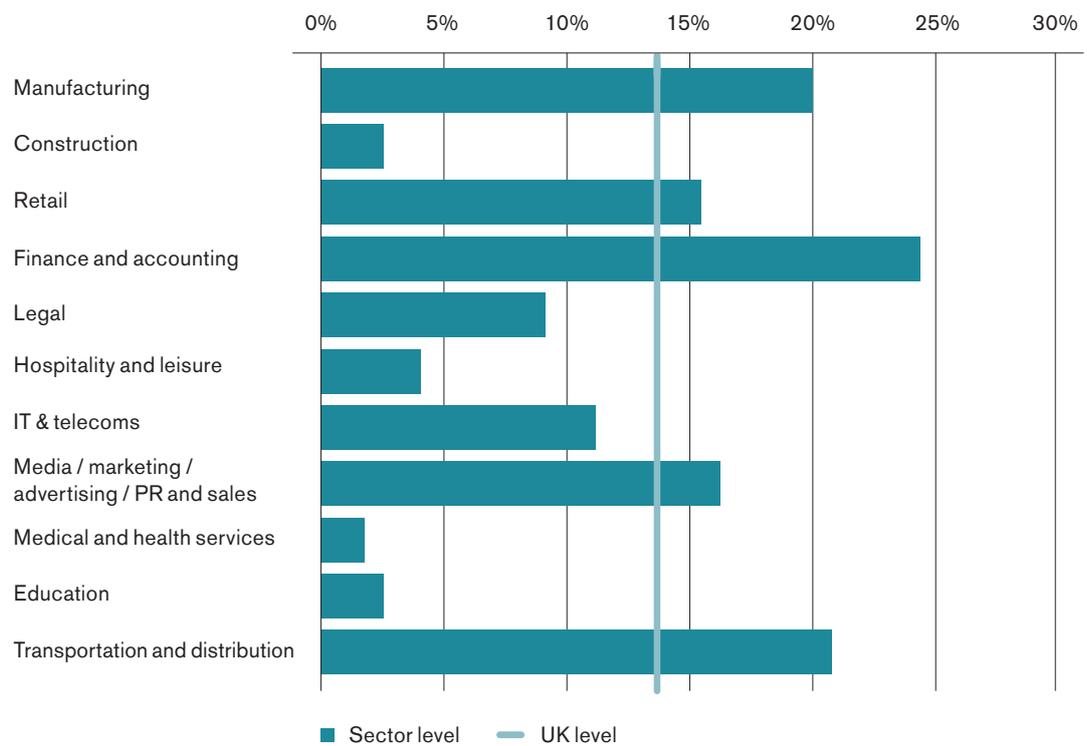


Source: RSA/YouGov survey of 1,111 UK business leaders (Fieldwork conducted 10-18 April 2017)[76.]

Yet the picture is markedly different for sectors that are bound up in the delivery of experiences and person-to-person interaction. Just 4 percent of business leaders in hospitality and leisure, 2 percent in medical and health services, and 3 percent in education see the scope for high automation among their workforce (although these last two figures should be interpreted with caution given low sample sizes).[77.] This echoes Frey and

75. Acemoglu, D. and Restrepo, P. (2017) *Robots and Jobs: Evidence from US Labor Markets*. NBER Working Paper No. 23285.
76. Some of these figures should be interpreted with caution given low sample sizes. Typically, survey answers are only considered statistically reliable with a sample size greater than 50. 36 business leaders in the legal sector answered our survey, 37 in medical and health services, 35 in education, and 49 in transport and distribution.
77. Typically, survey results require a sample of at least 50 respondents to be seen as statistically reliable. Our survey was answered by 37 business leaders in medical and health services and 35 business leaders in education.

Osborne's research, which finds many low-skilled but human-centric jobs have little to fear from machines. Mental health and substance misuse social workers rank fourth of 702 on their scale of automation-proof jobs, while healthcare social workers rank eighth. The number of human-centric jobs is already growing at pace in the UK. Primary and nursery teaching professionals are up by 40 percent since 2011, educational support assistants are up 50 percent, and nursery nurses and assistants are up 25 percent.[78]

Why are human-centric jobs less automatable? Because they require competencies that are currently very difficult for machines to replicate, such as empathising, forming authentic relationships and communicating in open ended dialogue. Each of these sits under the broad skillset of 'social intelligence', which, as noted earlier in the chapter, has been identified as a bottleneck for AI and robotics engineers. Figure 6 shows the relative importance of this skillset to different low-skilled occupations, alongside creativity and manual dexterity. See the Appendix for a full explanation of our methodology.

**Figure 6: Importance of "bottlenecks to automation" to selected low-skilled occupations**
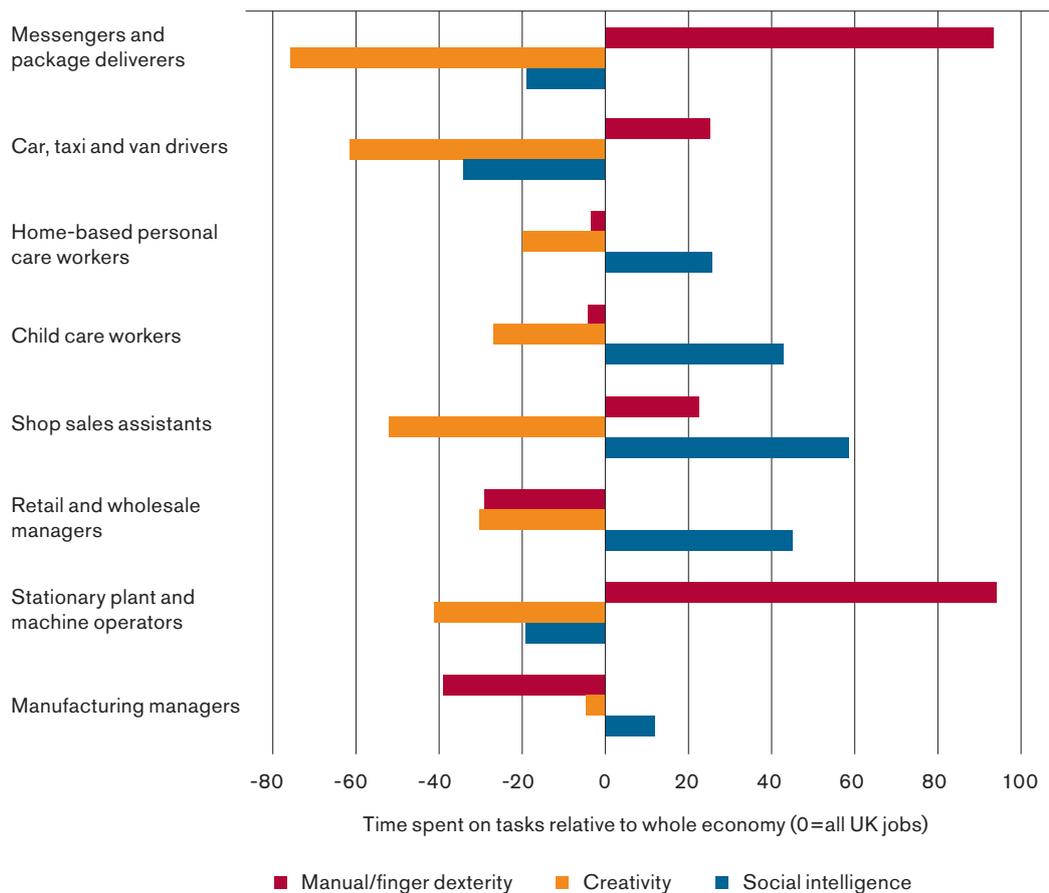


Source: RSA analysis of OECD PIAAC data

78. Source: RSA Analysis of Labour Force Survey.

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**New jobs and recycled demand**

An analysis of the impact of AI and robotics on job numbers would not be complete without considering the macro ramifications, beyond changes at the firm level. One of these is the potential for new jobs to emerge as a result of the arrival of these new technologies. Many of these will be directly related to AI and robotics, such as roles in monitoring and repairing technology, engineering machine learning and deep learning algorithms, or reviewing and improving cybersecurity measures. Some of the fastest growing occupations in the UK are tech-centric, such as programmers, whose number has risen by 40 percent since 2011, and IT directors, which have more than doubled in number over the same period.[79]

Many commentators are understandably dubious about the claim that new occupations will emerge to replace those that dwindle in size and importance. An investigation in 2013 by PwC found that just 6 percent of all UK jobs that year were of a kind that did not exist in 1990, while an OECD study found that only 0.5 percent of the US workforce is employed in digital industries that emerged during the 2000s.[80] However, some new occupational types have gained a significant foothold in the labour market, such as IT business analysts and systems designers, the number of which has shot up by 31 percent between 2011-16.[81] Furthermore, AI and robotics are likely to create new *tasks* that will subtly reinforce jobs, such as personal trainers using sophisticated monitoring software to create tailored fitness regimes.

We should also recognise the multiplier effects of job creation. While it is true that new tech-centric occupations and sectors are unlikely to replace all the jobs lost to AI and robotics, their creation will spur the formation of additional jobs in ancillary sectors to serve their needs. The Berkeley economist Enrico Moretti estimates that one additional job in the 'tradeable' industries of a given US city results in 1.4 jobs in the local non-tradeable industries (where tradeable means products and services that can be exchanged over distances). Because they command higher earnings, every new job in the tech sector is estimated to generate five complementary jobs elsewhere.[82] Note that this multiplier dynamic plays out strongest in city areas.

Alongside new jobs, a second macro ramification of AI and robotics will be **shifting or recycled demand**. This is a well-documented phenomenon whereby rising productivity caused by new machines leads to a lowering of consumer prices, thereby freeing consumers to buy more of the product in question or to spend money in another part of the economy. One of the best examples of recycled demand can be found in the transformation of the 19th century garment industry. It is estimated that 98 percent of the labour required to weave a yard of cloth was automated as a result of new technologies, yet the number of textile weavers actually

79.  Source: RSA analysis of Labour Force Survey.

80.  Frey, C. B. (2015) *New job creation in the UK: which regions will benefit most from the digital revolution*. PwC; Berger, T. and Frey, C. B. (2016) *Digitalisation, Deindustrialisation and the Future of Work*. OECD.

81.  Source: RSA analysis of Labour Force Survey.

82.  Moretti, E. (2010) Local Multipliers. *American Economic Review*, Vol. 100, No. (2), pp. 373-77.

grew for a period because prices fell and demand was elastic.[83.] The same effect played out after the introduction of ATMs in the US, which reduced the cost of running branches and bank services, leading banks to open more branches and take on new staff.[84.]

There is no reason why the same phenomenon will not occur in the wake of AI and robotics automating jobs and tasks. A case in point comes from the legal industry. Despite many fearing that AI will shrink the number of entry-level legal jobs, an investigation by The Economist found that the number of legal clerks in America grew by 1.1 percent on average per year between 2000 and 2013.[85.] The authors speculate that the introduction of software, which was capable of analysing large volumes of legal paperwork, led to falls in the cost of legal services, which in turn raised demand for legal clerks. In the same vein, robo-advisory services may heighten demand for financial advisors, while machine learning-powered health diagnostic systems may counterintuitively lead to greater demand for health practitioners.

The rest of this chapter explores the impact of AI and robotics on other aspects of the worker landscape: recruitment, pay, experience and consumer power.

## #2 – Recruitment

Just as new machines will affect the number of jobs available in the future, so too will they alter the way people access that work. Several start-ups have developed software aimed at transforming who and how organisations recruit. Arya uses algorithms to source potential hires partly based on their social media history, Entelo applies machine learning techniques to spot individuals who may be on the cusp of switching jobs, and Ideal. com has developed shortlisting software that can screen candidates' CVs based on the role and requirements of the employer. Last year, the consultancy firm Deloitte began using a new algorithm to tap into a more diverse talent pool.[86.] Alongside academic results, the system will take into account entrenched obstacles candidates have faced, such as growing up in a deprived area.

Other tools focus less on identifying and screening candidates, and more on streamlining the recruitment process. Mya, for example, is a chatbot designed to engage with job applicants before and after interviews. Using natural language processing and generation, it can answer a host of different questions applicants may have, raise final but important queries from the recruiter ("Can you remind us whether you have line management experience?"), and schedule interviews with minimal human oversight. Mya's founders say it can automate up to 75 percent of the recruitment process.[87.] Another innovative tool is qDroid, which is used by Google to automatically draft interview questions based on the attributes it calculates are pertinent to the job. Again, this is based on historic data about the characteristics of successful previous hires.

83.   Bessen, J. E. (2016) *How Computer Automation Affects Occupations: Technology, Jobs, and Skills.* (October 3). Boston University School of Law, Law and Economics Working Paper No. 15-49.

84.   Ibid.

85.   The Economist (2016) Automation and anxiety. *The Economist*, 25 June.

86.   Coughlan, S. (2015) *Firm 'hides' university when recruits apply* BBC News, 29 September.

87.   For more information see: https://hiremya.com/

The attraction to employers of using these machines is clear: they promise faster hiring times, lower costs and better job matching. But what do they mean for workers? One concern is that shortlisting software may exacerbate biases if it is trained on data that reflects previous hiring decisions. A Carnegie Mellon study looking at the use of algorithms in job adverts found that men were significantly more likely than women to be shown adverts for highly paid jobs when browsing Google's internet search engine.[88.] On the other hand, algorithms could eliminate prejudice if they are tuned to give weight only to the qualifications and experience of candidates, rather than their age, gender or class. One AI tool called RAI is expressly designed to help employers reach their diversity targets.

To focus solely on traditional HR practices, however, would be to ignore the way AI is changing the very meaning of recruitment and what it means to be employed. The expansion of the gig economy – where people find atomised tasks through online platforms and apps – has only been made possible thanks to increasingly sophisticated algorithms. Uber, for example, relies on AI to predict hotspots of passenger demand, while Deliveroo depends on it to orchestrate the complex pick up and delivery routes of its riders.[89.] The rapid rise of gig working patterns, which the RSA estimates 3 percent of the UK workforce are now involved in, has been a major point of contention, with many fearing that workers are being exploited.[90.] This may well be true for some, but we should also recognise how these platforms and the algorithms underpinning them have made it easier to access work and on hours of people's choosing.

## #3 – Pay

What about the impact of AI and robotics on pay? To the extent that automation leads to job losses, it will of course wipe out people's pay packets. But it may also reduce the wages of those who remain in work. In a survey undertaken earlier this year, a third of US experts agreed that IT and automation are a central reason why median wages have been stagnant in the US over the past decade.[91.] Only 20 percent disagreed. Technological alarmists point to the basic laws of supply and demand in setting wages. AI and robotics, they say, will flood the labour market with a cheap supply of mechanical labour, which will in turn reduce the bargaining power of human workers. American mathematician and philosopher Norbert Wiener observed as much in the 1950s:

> "Let us remember that the automatic machine is the precise economic equivalent of slave labour. Any labour which competes with slave labour must accept the consequences of slave labour".[92.]

Furthermore, new machines may deskill occupations, thereby lowering the barriers to entry and reducing the negotiating position of workers in existing jobs. Higher skilled professionals are likely to bear the brunt

88.   Spice, B. (2015) *Questioning the Fairness of Targeting Ads Online*. Carnegie Mellon University.

89.   O'Connor, S. (2016) *When your boss is an algorithm* [article]. Financial Times, 8 September.

90.   Balaram, B. (2017) op cit.

91.   For more information see www.igmchicago.org/surveys/robots

92.   Cited in Dunlop, T. (2017) *Putting lipstick on the robot*. The Guardian, 12 April.

of this disruption. For example, deep learning algorithms capable of detecting cancers may enable lower skilled nurse practitioners to complete diagnoses that usually take radiologists a decade to train for, with the latter losing out as a result. Yet AI and robotics may also serve to deskill already low-skilled jobs. In its recent investigation of the warehousing industry, the LA Times reported that Amazon workers were now surrounded by machines giving them precise instructions for every manner of task, reducing the scope and need for initiative. This includes scanners that tell workers how big a size of box to use, and small machines that produce exactly the right amount of tape for packing.[93]

On the other hand, there is evidence that AI and robotics could lead to a boost in wages – not least because of productivity growth, which generates more absolute wealth that can be shared with workers. A 2015 study looking at the use of robots across 17 countries found they raised labour productivity by 0.36 percentage points annually over the period 1993-2007.[94] They also lifted wages and total factor productivity. Overall, this productivity boost was equivalent to the contribution of steam technology between 1850 and 1910.[95] Looking forward, McKinsey estimates that automation from AI and robotics could raise productivity growth globally by 0.8 to 1.4 percent annually. Another consultancy, Accenture, believes that AI could increase labour productivity in the UK by 25 percent by 2035.[96]

There is good reason to believe low-skilled workers will benefit just as much as high-skilled workers. Indeed, what makes the latest advances in AI and robotics distinct from previous innovations is the sectoral breadth of their application, going beyond manufacturing (where productivity has been rising for decades) to low-skilled sectors that have historically suffered sluggish productivity growth, such as care and retail. A recent IPPR investigation found that low skilled sectors in the UK – including retail, accommodation, food and admin services – are 29 percent less productive than the economy as a whole, and are also less productive than their equivalents in Western Europe.[97] Assuming new technologies can raise productivity in these laggard sectors, whether through robots in social care or self-service checkouts in retail, then low-skilled workers will be set to benefit, so long as employers share the gains and there is significant support for in-work learning.

A final consideration when thinking about the impact of new technology on pay is Baumol's cost disease. This refers to the phenomenon whereby productivity and wage rises that occur in one sector of the economy can lead to wage rises in another, even if the second sector has experienced no equivalent productivity growth. The reason is because wages have to rise across the economy to prevent workers leaving their jobs for the lead sectors, and partly because workers in the lead sectors have greater spending power to channel elsewhere. This is why the pay of

93.  Kitroeff, N. (2016) *Warehouses promised lots of jobs, but robot workforce slows hiring* Los Angeles Times, 4 December.
94.  Graetz, G. and Michaels, G. (2015) *Robots at work*. Centre for Economic Performance.
95.  Ibid.
96.  Purdy, M. and Daugherty, P. (2016) *Why artificial intelligence is the future of growth*. Accenture.
97.  Thompson, S. et al. (2016) *Boosting Britain's Low-Wage Sectors*. IPPR.

teachers and hairdressers has risen throughout the post-war period, despite the former teaching roughly the same number of students and the latter serving the same number of clients as 50 years ago. Thus, even if low-skilled sectors do not see dizzying productivity gains as a result of AI and robotic adoption, continued productivity growth in high-skilled sectors like advanced manufacturing and finance should lift wages across the board.

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**Box 4: Hollowing out and progression**

Most economists agree that recent waves of technology, combined with the offshoring of manufacturing activity to East Asia, has led to a hollowing out of the UK labour market, with middle-skilled jobs such as machinists, secretaries and administrators falling as a proportion of the workforce. Most also agree that there has been a subsequent 'filling in' thanks to jobs growth elsewhere. However, there is a risk that within individual occupations and sectors, the automation of middle-tier jobs could remove rungs on progression ladders. Both the retail and accommodation/food services industries already have limited progression prospects, owing to a large number of entry level jobs and small number of management positions. Further research is required to understand the impact of automation on occupational mobility.[1]

1.  Analysis by the Resolution Foundation in 2014 found that 41 percent of workers in supermarkets are "stuck", meaning they had never earned above low pay over the decade 2003-2012. D'Arcy, C. and Hurrell, A. (2014) Escape Plan. Resolution Foundation.

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## #4 – Experience

Worker experience is another domain often overlooked in popular commentary on automation. Yet the quality of work is no less important than the quantity of it. For some, AI and robotics will lead to a kind of digital Taylorism, with employers using new tools to relieve staff of responsibilities and control the minutiae of their day-to-day tasks.[98] Recall the story of the warehouse workers whose initiative had been compromised by machines that automate microscopic decisions, down to the types of boxes they use. In logistics, predictive algorithms are being used to direct the routes of delivery drivers metre by metre, while in retail, a Silicon Valley startup called Percolata is using a combination of shop sensors and sophisticated algorithms to calculate the performance metrics of individual workers and apply this to create store schedules with an optimal mix of staff. The company says its algorithm can boost sales by 10-30 percent.[99]

Artificial intelligence could also lead to an unhealthy degree of monitoring in the workplace. Existing technology already allows for a degree of surveillance, for example with GPS systems in cars and RFID tags on worker clothing that can be used to track the whereabouts of staff.[100] But AI may take this to another level of intensity. It was reported earlier this year that 'sociometric badges' powered by machine learning are being used by employers to analyse the speed, tone and volume – but not the

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98.  O'Connor, S. (2016) op cit.
99.  Ibid.
100.  Federal Ministry of Labour and Social Affairs (2016) *White Paper: Work 4.0.*

content – of their employees' voices, with a view to analysing workplace interactions.[101] Another start-up, Veriato, has developed software to log staff behaviour on office computers, including browsing history, email messages, keystrokes and document use. This data is then crunched by an AI system to create a productivity baseline for the company and flag where individuals may be performing poorly.[102]

Yet just as with our discussion on recruitment and pay, AI and robotics could quite as easily be a boon for worker experience. First and foremost, these technologies could humanise jobs, phasing out mundane tasks and opening space for more intellectually stimulating work. McKinsey estimates that only 2 percent of the average worker's time is spent on creative tasks, and 9 percent on social and emotional reasoning.[103] In contrast, 67 percent is spent on 'recognising known patterns', which is hardly the makings of a fulfilling job. Indeed, while we must take seriously the risk of technological unemployment and disruption, there are some types of work that we should not mourn the loss of. As the CEO of one robotics' company put it, "Does anyone write on their resume that they're skilled at walking down hallways without bumping into things and they know how to ride elevators?"[104]

Leslie Willcocks at the LSE has been studying the impact of automation at a firm level for several years, and his findings are worth heeding. In one investigation, he reported on how Associated Press had deployed new software to automate corporate earnings reports, allowing the company to produce 4,700 reports per quarter, up from 300 when humans wrote them. But rather than feeling threatened by these machines, the company's journalists were 'positive about the reframing of their job responsibilities' away from mundane, highly-structured assignments.[105] In another study, Willcocks looked at the experience of a major gas and electricity utility, which had installed software to verify meter readings submitted by household residents. This led to a quarter of back office admin being automated, with humans left to work on the 'really unusual' reading cases that required more investigation.

While Willcocks focused on white collar workplaces, the scope for AI and robotics to humanise low-skilled jobs may be just as expansive. Algorithms in healthcare could allow entry-level nurses to play a more active role in diagnosis, partially autonomous trucks could lower accident rates for HGV drivers (assuming humans are still behind the wheel), and robots in social care could allow caring staff to spend more time comforting patients and less time lifting them and preparing their meals. Over the years our labour market has shifted away from agriculture towards manufacturing and then onto services, and at each point more workers have been relieved of the three 'ds' of dull, dirty and dangerous jobs. There is every reason to believe this trend will continue with further advances in AI and robotics.

Finally, it is worth considering how new machines might lend greater agency to workers, in the sense of having more control over how they

101. Gilligan, A. (2017) *Bosses track you night and day with wearable gadgets*. The Times, 15 January.
102. Greenwald, T. (2017) *How AI is transforming the workplace*. The Wall Street Journal, 10 March.
103. McKinsey (2017) op cit.
104. Wood, L. (2016) op cit.
105. Lacity, M. C. and Willcocks, L. P. (2016) *A new approach to automating services*. LSE.

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access and manage work. Two promising uses of AI stand out in this regard. The first is French-based Bob Emploi, a new AI platform that uses anonymised public employment data from the French government to deliver custom recommendations to job seekers so they can improve their job search strategy.[106.] The platform is planning to install a new 'skills recommendation' feature that will recommend which skills are likely to help job seekers land roles in specific industries and occupations. The other platform is WorkIT, which uses the power of IBM's Watson computer to help workers of Walmart find out about their rights and the policies of the supermarket.[107.] The Resolution Trust and Bethnal Green Ventures' partnership on WorkerTech is exploring similar solutions to empower UK workers.[108.]

## #5 – Consumer power

The fifth dimension in the landscape of automation is consumer power. AI and robotics will not only affect people at work but also in the home – as customers, patients, learners and political citizens. The experience of history tells us that technological advances more often than not supercharge living standards. In the last 250 years, global income per head has grown ten-fold, while in the most advanced economies it's closer to a twenty times increase.[109.] If we take into account technology's impact on the quality of the goods we consume, real income per head is estimated to have grown by anything between 40 and 190 times.[110.] Technology's effects on living standards were particularly noticeable in the postwar period, when television ownership went from 19 percent of households in 1955 to 96 percent in 1975, and when washing machine ownership jumped from 18 percent to 70 percent over the same period.[111.]

AI and robotics are almost certain to sustain this trend. For example, according to Boston Consulting Group, the operating cost of a robot welder in the car industry has plummeted to $8 an hour, versus $25 an hour for human welders.[112.] As the industry uses more robotic welders to produce cars, these savings are likely to be passed onto consumers in the form of lower prices. The Bank of America estimates that advanced robotics and AI could cut labour costs by 18-33 percent across all industries by 2025.[113.] Recall also the bricklaying robot (SAM) which can lay up to four times as many bricks as the average human bricklayer. Deployed in the right way, this could speed up home building and possibly reduce prices for homebuyers. In other cases, AI and robotics will open up goods to people that were once out of reach. Robo-advisory services in finance, for example, are cheap enough to be used by most high street savers,

106.   For more information see https://www.google.org/helping-prepare-for-the-future-of-work/

107.   Berfield, S. (2016) *Labour group gets IBM's Watson to help Walmart workers*. [article] Bloomberg Businessweek, 14 November.

108.   For more information see: https://bethnalgreenventures.com/2016/11/17/introducing-workertech-using-technology-to-boost-low-wage-workers/

109.   Lent, A. (2012) *Generation Enterprise*. London: RSA.

110.   Nordhaus W. (1997). "Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggest Not." in. In T. Bresnahan &and R. Gordon (eds) *The Economics of New Goods*. Chicago: University of Chicago Press.

111.   Lent, A. (2012) op cit.

112.   Sirkin, H. L. et al. (2015) *How robots will redefine competitiveness*. BCG Perspectives.

113.   Beijia, M. (2015) *Robot revolution – Global Robot and AI Primer*. Bank of America Merrill Lynch.

unlike traditional financial advice which comes with an average price tag of £150 per hour.[114.]

AI and robotics could be equally transformative for the delivery of public services, with gains being felt both in cost savings and quality improvements. Whether it is DeepMind's partnership with Moorfields Eye Hospital to improve detection of common eye diseases, or IBM Watson's work with cancer centres to provide more tailored drug treatments, the scope for new machines to transform health outcomes appears vast. In education, too, AI promises to amplify the work of teachers and trainers. Knewton is a new tool that helps teachers create tailor-made lessons for every student, by monitoring how they respond to different content and learning materials – be it games, videos or literature.[115.] Local authorities are also set to gain. Aylesbury Vale District Council is today trialling Amazon's Alexa personal AI assistant as a new way for local residents to make requests, such as setting up council tax payments or applying for business permits.

Then there is the prospect of greater leisure time. The first household machines emancipated people (predominantly women) from home-based duties. One estimate suggests that the time spent on household chores fell from 58 hours per week in 1900 to 18 in 1975.[116.] It may be that the latest domestic robots reduce this figure even further. According to the International Federation of Robotics, 3.7m such machines were sold in 2015, including for vacuum cleaning, lawn-mowing and window cleaning.[117.] But it is in terms of working hours where the greatest opportunity for time-saving lies. Contrary to popular belief, the number of annual hours worked per employee has fallen in the UK since 2000, as it has in most developed countries.[118.] While AI and robotics may not bring the working week down to 15 hours – as John Maynard Keynes once speculated – it holds out the hope of workers gaining at least some extra leisure time, assuming we make the right choices as a society.

## A matter of choices

In this chapter we have reviewed the potential impact of AI and robotics on the workforce, with a particular slant towards the low-skilled. Our findings suggest that, while a significant proportion of jobs could be fully displaced by new machines (15 percent of private sector jobs over the next 10 years, according to our YouGov poll), grim predictions of mass automation and widespread economic strife do not stand up to scrutiny. Machines are still incapable of performing many tasks, and very few can comprehensively automate whole jobs. Occupations are more likely to evolve than be eliminated, and new ones will emerge in the long run. Low-skilled workers will probably face the greatest disruption, but sectors vary significantly in their automation potential and we are likely to see a continued growth in human-centric roles in health care, social care and education.

114.  Williams, A. (2017) *FCA prepares for the march of 'robo advisers'*. Financial Times, 11 April.

115.  See: www.knewton.com/

116.  Lent, A. (2012) op cit.

117.  International Federation of Robotics (2016) *Executive Summary World Robotics 2016 Service Robots*. IFR.

118.  See the OECD's statistics on average annual hours actually worked per hour: http://stats.oecd.org/Index.aspx?DataSetCode=ANHRS

What is less clear is how AI and robotics will modify the quality of work, in terms of the other dimensions we considered. As we have seen, these technologies could lead to greater productivity, open up the door to higher wages, phase out mundane work in favour of more intellectually stimulating vocations, and create a level playing field in terms of recruitment – for the low-skilled as much as anyone else. Yet these technologies could just as easily be used to deskill jobs, strip workers of their bargaining power, put downward pressure on wages, amplify monitoring and standardisation of work, and bake biases into recruitment. In this chapter we have documented the experiences of Amazon warehouse workers, Deliveroo riders, Associated Press journalists and Walmart supermarket staff – each of whom has engaged with technology on different terms and with different outcomes.

The point is that technology is not predetermined to achieve a particular result. Algorithms and robots do not have objectives of their own, but are directed by humans. Indeed, the sense of technology being a passive tool to be wielded as its owners see fit is possibly one reason why a high proportion of business leaders in our survey said they neither agreed nor disagreed that technology would lead to particular consequences; they rightfully conclude that nothing is guaranteed (see Figure 7, although note that business leaders were asked about technology overall, which includes but is not limited to AI and robotics).

**Figure 7: Business leader attitudes about the impact of technology on work ('The introduction of technology tends to…')**
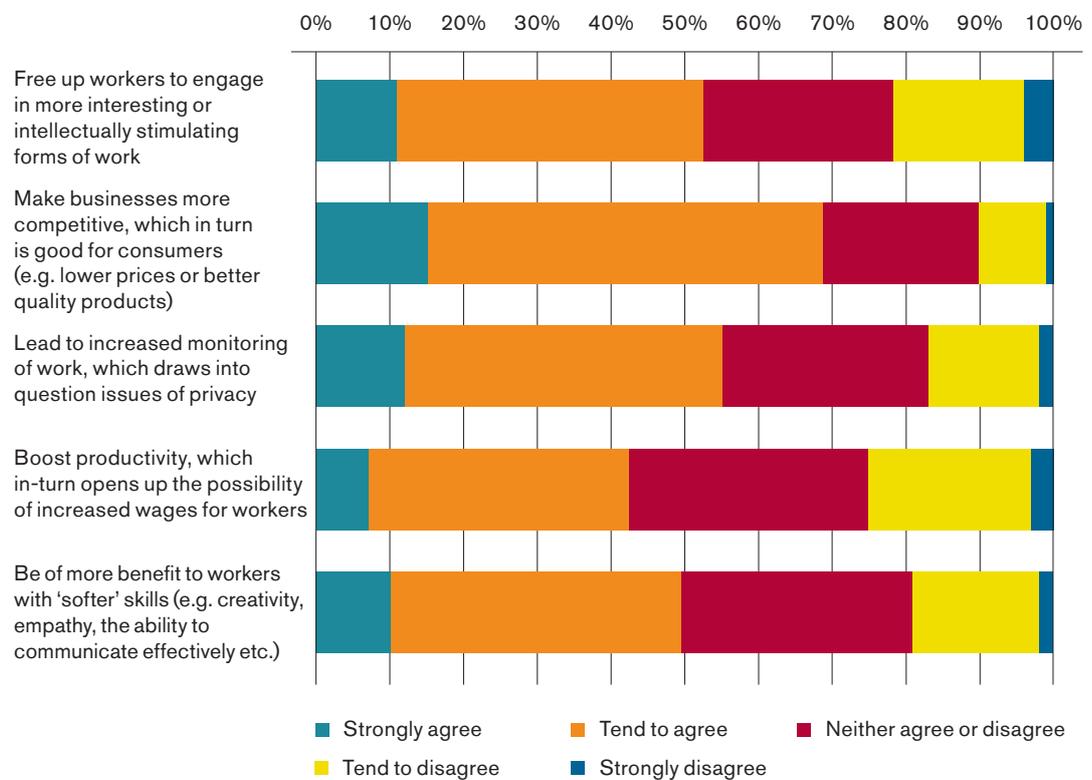


Source: RSA/YouGov survey of 1,111 UK business leaders (Fieldwork conducted 10-18 April 2017)

The good news, therefore, is that as a society we have a choice in how to apply AI and robotics and manage their effects. There are choices to be made by developers and engineers in terms of the functionality they imbue in machines, there are choices to be made by employers as to which technologies they purchase, there are choices to be made by HR teams as to whether and how they help staff evolve into new roles as machines take on certain tasks, and there are choices to be made by policymakers about the kind of regulatory, welfare and tax system that can maximise the upsides of disruption and minimise the downsides.

In the following chapters we will look at the extent to which AI and robotics are being adopted in the UK, and what the government and others can do in practice to ensure their impact is carefully managed. Before doing so, we look briefly at how this technology is currently playing out in three sectors: social care, retail and logistics.

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# Sector case studies

Here we take a closer look at what AI and robotics could mean for three sectors where a large proportion of the workforce is low-skilled. The purpose of this granular analysis is to paint a more vivid picture of what machines are capable of, and to reveal the subtle and often counterintuitive consequences of automation that tend to be overlooked in mainstream debates.

## Social care

The social care sector is home to child care workers, home-based personal care workers, mental health support officers and drug and rehabilitation therapists, among others. These occupations are often seen as the most difficult for machines to automate because of the high degree of human interaction involved. Nurses in adult social care, for example, will spend much of their day persuading their patients to exercise or to eat, and will use careful communication to understand what may be troubling them. Our analysis of the OECD PIAAC database confirms these suspicions, revealing that a high proportion of the time allocated to social care roles is spent on tasks demanding social intelligence and, to some extent, manual dexterity (eg in lifting patients).

However, this hasn't stopped AI and robotic engineers from seeking to automate duties performed in social care. Among the machines currently being developed are:

- **Assisting robots** – Humanoid robots like Pepper and Pearl can read and respond to basic human emotions. They promise to help patients by answering questions, guiding them across buildings, and encouraging them to undertake exercise. Some, like RIKEN's Robear, are also designed to lift patients. The latest version is equipped with torque sensors and more precise actuators to allow for softer movements.
- **Monitoring systems** – Systems like IBM's MERA are being deployed in homes and care homes to monitor older people and pick up on early signs of distress. AI technology is used to build up a 'contextual understanding' of a normal day (eg the times people get up and go to bed, and when they have their meals), and raise alerts with carers when anomalies arise.
- **Autistic support** – A specially made robot called Bandit, developed by the University of Southern California, has been used to improve the emotional development of autistic children, for example teaching them how to share through repetitive games. According to the University, the robots are less intimidating than people because they repeat their behaviour with consistency.[119.]

119.  Taylor, H. (2016) *How robot therapists can fill a gap in health care*. CNBC.

- **Administration** – In 2016, Harrow Council signed a 10 year partnership with IBM Watson to develop an AI-powered personal budget tool. It promises to 'learn from user behaviour' to help patients manage their care budgets more effectively and recommend more suitable support providers. It can also reportedly predict future health risks based on historic data.

These and related technologies have clear potential to substitute for workers. The transport robot TUG, which moves medicine, food and other supplies in health settings, could replace some of the work of porters. Equally, robot assistants like Pepper may one day fill in for humans in helping patients find their way around care homes. Yet we have to question whether it is desirable for social care workers to retain such roles. Moving objects around a building or reminding patients to take their medicine do not make the best use of people's talents. Robots and AI systems may allow social care workers to become more attentive to the needs of patients and more absorbed in the core act of caring.

A good example is the use of robots in domiciliary care. With support from Innovate UK, **Three Sisters Care** in London is working with Designability, Bristol Robotics Laboratory, Shadow Robot Company, Telemetry and the Smart Homes & Buildings Association to develop a ceiling-based modular robot to be installed in the homes of its patients. Called the CHIRON project, the devices will mean that only one care worker will be required to lift a person rather than two (see Box 5 for more details). Three Sisters CEO, Jobeda Ali, says this will enable her workforce to do more human focused work: "If I don't have to send a person to do a transfer job [lifting], I can send them to have a cup of tea and a chat. This is a much better use of their time than carrying patients or cooking meals".

Jobeda says that far from wanting to cut her workforce, the use of machines will allow her to plug vacancies and manage staff churn. "One of the reasons I got involved in this robot pilot is because I realised there just aren't enough people to serve the needs of the care market. The use of these modular robots could effectively double the power of my workforce". The company Skills for Care estimated in 2016 that 6.8 percent of roles in the adult social care sector were vacant, giving an average of approximately 84,000 vacancies at any one time.[120.] Jobeda believes that inventions like the one Three Sisters is building will not only help to fill these gaps, but relieve care workers of backbreaking work and make their profession more "technical in nature".

Many of the aforementioned technologies also offer a novel function that does not duplicate the existing responsibilities of social care workers. A case in point is the phone-based app Lifegraph, which monitors vulnerable patients with mental health conditions. Its developers claim that the software can detect a mental health episode a full month before a person requires hospitalisation – not a skill that any social care worker has ever professed to have.[121.] Other inventions such as exoskeletons are

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120.  Skills for Care (2016) *The state of the adult social care sector and workforce in England*. SfC.
121.  Taylor, H. (2016) *How your smartphone could predict and prevent your next nervous breakdown*. [article] CNBC, 9 December.

complementary to social care workers. Cyberdyne Inc, for example, has developed Hybrid Assistive Limbs (HALs) that can magnify the strength of caregivers and prevent injuries to their lumbar backs.[122.]

<div style="border:1px solid; background:#9fd4d4; padding:1em;">

**Box 5: The CHIRON project**

CHIRON is a two year project funded by Innovate UK. It strives to design care robotics for the future with a focus on dignity, independence and choice. CHIRON is a set of intelligent modular robotic systems, located in multiple positions around the home. Among its intended uses are to help people with personal hygiene tasks in the morning, get ready for the day, and support them in preparing meals in the kitchen. CHIRON's various components can be mixed and matched to enable the customer to undertake a wide range of domestic and self-care tasks independently, or to enable a care worker to assist an increased number of customers.

The vision for CHIRON is to move from an 'end of life' institutional model, widely regarded as unsustainable and not fit for purpose, to a more dynamic and flexible market that offers people greater choice in the care sector when they require it.

The CHIRON project is being managed by a consortium led by Designability. The key technology partners are Bristol Robotics Laboratory and Shadow Robot Company, who have considerable expertise in conducting pioneering research and development in robotics. Award winning social enterprise care provider, Three Sisters Care will bring user-centred design to the core of the project. Smart Homes & Buildings Association will work to introduce the range of devices that will create CHIRON and make it a valuable presence in people's homes.

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## Retail

Unlike care, retail is seen by many as sitting squarely in the crosshairs of new machines. According to PwC's analysis, 44 percent of wholesale and retail jobs are at high risk of automation.[123.] Our own poll finds that 15 percent of business leaders in retail think their organisation has a high number of jobs that could be displaced in the coming decade (30 percent or more). This matters for three reasons: (i) retail is a major employer, home to 1.1 million retail assistants; (ii) retail jobs can be found in every corner of our country, including within low income communities; and (iii) retail jobs often act as a gateway into the labour market for young people and marginalised groups such as the disabled.

Recent innovations in the sector appear to substantiate claims of impending disruption:

- **Automated inventory management** – AI systems are being deployed to monitor stock inventory and more accurately predict fluctuations in consumer demand. IBM's Watson Commerce Insights tool gives retailers real-time performance data on products, allowing them to take action to prevent over and under

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122. See www.cyberdyne.jp/english/products/Lumbar_CareSupport.html
123. PwC (2017) op cit.

stocking in shops.[124.] Elsewhere, a startup called Simbe has created the Tally robot to audit shelves and spot misplaced items.[125.]

- **Chatbot retail assistants** – New chatbots are promoted as a means to enrich the consumer experience. The North Face's customers can search for items on their website through natural conversation with an AI interface. Similar innovations are appearing in physical stores. MindMeld provides conversational tools to retailers include UNIQLO, allowing customers to ask questions they typically would of shop assistants, such as the whereabouts of items.[126.]

- **Enhanced search engines** – Excitement is growing among retailers about image-based search engines underpinned by deep learning algorithms. Rather than writing terms that describe a product, customers can take a picture of an image and the algorithms will find matching items. ASOS, John Lewis and Nordstrom are all reportedly developing apps or website functionality to power visual search.

- **Automated e-commerce design** – Marketers will be familiar with A/B testing to determine the hit rates of different website designs and brand messages. AI promises to turbocharge this process through evolutionary algorithms that continually test and refine content using feedback data. The Italian lingerie company, Cosabella, worked with the startup Sentient to rapidly test alternatives for its website, resulting in a sales uplift.[127.]

The impact of these technologies could be severe. Self-service checkouts may eventually rid many cashiers of jobs, while inventory management systems might one day eradicate the need for store managers. However, there are several reasons to doubt such fears. Number one is that some technologies are still a way from delivering on expectations. One senior call centre director writes: "The day when chatbots handle all customer queries and contact centre agents are completely replaced is a very far off day".[128.] Similarly, a recent investigation into self-service checkouts found that they took consumers longer on average to make a purchase than going through a traditional kiosk, and continue to be undermined by shoplifters.[129.]

Another factor is that some of this technology will augment workers rather than displace them, as we saw with social care. On the marketing side of retail, new AI systems are emerging to help sales teams find leads within client companies, and then to tailor messages so they are more likely to resonate. LeadGenius can pick out top decision-makers with

124.   See www.ibm.com/watson/commerce/
125.   See www.simberobotics.com/
126.   Hook, L. (2016) *Retailers look to artificial intelligence to bag sales.* Financial Times, 22 November.
127.   Ibid.
128.   Ibid, and Davey, N. (2017) *Could chatbots ever completely replace human agents?* Mycustomer, 11 May.
129.   Hamacher, A. (2017) *The unpopular rise of self-checkouts (and how to fix them).* [article] BBC future, 10 May.

buying responsibility across a range of companies.[130.] Another startup, Chorus, can analyse the content of sales calls to highlight topics that repeatedly crop up, or particular pain points that are emphasised.[131.] In some bricks and mortar stores, AI systems are being used by employees to answer customer queries more accurately, rather than have customers directly interact with chatbots. Holm is an application designed to be used by assistants so they can better match customers with clothing items.[132.]

What about the potential for AI and robotics to shift trade from retail stores to online? If innovations such as image search engines and sophisticated recommendations take off, this could move more spending online and take away jobs from the high street. Again, however, this fear deserves closer inspection. Evidence from both the US and the UK indicates that job losses in retail may be compensated for by job gains in the warehouses that underpin e-commerce. The US economist Michael Mandel estimates that the e-commerce sector in the US has created 355,000 new jobs since the crash, compared with the 50,000 lost in retail.[133.] Our analysis of the UK shows that since 2010, jobs in the retail trade have fallen by 7,000, while jobs in warehousing have increased by 115,000.[134.] The latter jobs are also better paid on average (see Figure 8).

**Figure 8: Pay of retail and warehouse workers compared**
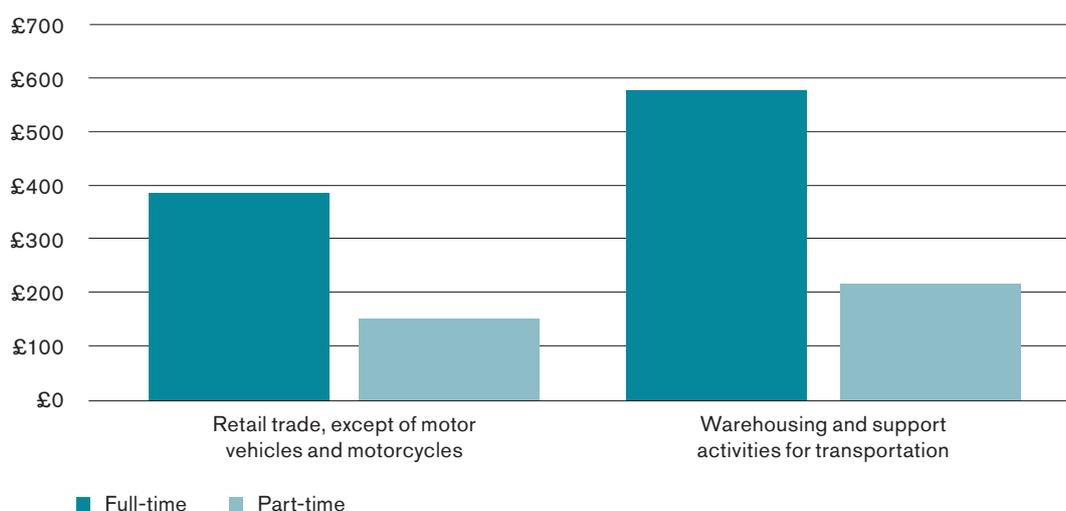


Source: RSA analysis of Annual Survey of Hours and Earnings (ASHE)

Much also depends on the business strategies of retail companies. To the extent that supermarkets, clothing retailers, electronics stores and other outlets prioritise cost savings, we can expect many retail jobs to be lost to AI and robotics. Yet some retailers will pursue a strategy centred on customer experience, with greater emphasis given to person-to-person

130. Faggella, D. (2017) *B2B applications of AI in marketing: Two use cases that matter.* [article] MarTech, 11 July.
131. Ibid.
132. Anderson, G. (2016) *Will AI mobile apps replace associates on Macy's sales floor?* [article] RetailWire, 22 July.
133. Sorkin, A. R. (2017) *E-Commerce as a Jobs Engine? One Economist's Unorthodox View.* The New York Times, 10 July.
134. RSA analysis of Business Register and Employment Survey: open access, 2010-2015.

interaction. A good example is Apple's retail stores, which have multiple staff on hand to create a rich experience for customers. While research on the strategies of UK retail businesses is limited, a recent US study by Cornerstone Capital Group found that no retailers in its analysis pursued a 'convenience' strategy predominantly based on cost, while 35 percent positioned towards an 'experience strategy'.[135.]

## Logistics

The logistics industry encompasses the organisation, storage and movement of goods across supply chains. Even more so than retail, logistics is thought to be on the verge of an automation revolution. Approximately 40,000 robot units were shipped to warehouse and logistics businesses worldwide in 2016 – a figure that is expected to jump to 620,000 by 2021.[136.] Leading the way are companies like Amazon, which is continuously on the lookout for efficiency savings in its sprawling supply chain. Logistics businesses are also being pushed to innovate by consumers who desire ever faster and cheaper (if not free) delivery, and who want items to be shipped at a time of their convenience. Several AI and robotic systems stand out as potentially game-changing for this industry:

- **Warehouse robots** – In 2012, Amazon bought robot maker Kiva Systems for $775m. Its bright orange robots shuttle pallets and product shelving units around warehouses, allowing workers to pick and pack goods without moving through the aisles themselves. Other brands of warehouse robots have since emerged to aid order fulfilment, including Fetch Robotics, Locus Robotics, and Vecna. Many are powered by LiDAR sensor technology, which uses light and radar for navigation.
- **Supply chain management** – Shipping companies must manage extremely complex distribution networks, making sure that goods arrive precisely where they need to while giving an appropriate freight price to wholesalers and retailers. IBM's Watson Supply Chain uses artificial intelligence to determine the optimum route for cargo by crunching live and historic data on weather patterns, port congestion and natural disasters.[137.]
- **Anticipatory logistics** – Anticipatory logistics refers to the process of predicting demand for consumer goods before purchases have been made. This allows logistics firms to improve efficiency and cut delivery times. Ocado, for example, uses algorithms to optimise its warehouse storage structure, meaning popular and soon-to-be popular items are in plentiful supply and in close proximity to its picking and packing teams.
- **Self-driving vehicles** – Several logistics and technology firms are trialling autonomous vehicles for goods delivery. Ocado recently worked with startup firm Oxbotica to pilot the delivery of

135.   Shavel, M. et al. (2017) *Retail automation: Stranded workers?* Cornerstone Capital Group.
136.   Tractica (2017) Warehousing and logistics robots.
137.   Manenti, P. (2017) *Artificial intelligence and future supply chains.* SCM World, 31 January.

groceries in London via a driverless truck called CargoPod. At the haulage end of logistics, Uber and Starsky Robotics are both developing systems for managing autonomous HGVs.

At first blush, the potential for jobs to be displaced in the logistics sector seems considerable. Yet just as with the social care and retail industries, what appear to be impressive technologies on paper are often incomplete and have limited functionality. For example, despite feverish attempts to create gripping robots that can pick up items and stow them neatly into boxes, no machine can yet match the dexterity of humans to do so. The last Amazon Robotics Challenge event, which brought together robotic engineers to compete on a gripping robot challenge, revealed that even the most advanced machines continue to have difficulty handling items that are wrapped in plastic, obscured, or which bend and change shape when moved.[138.]

Humans are also likely to remain in place for 'last mile' delivery in logistics (ie getting packages to the doors of customers). An innovation manager for a major logistics firm in the UK told us that robots would be ill equipped to deliver to gated buildings and high rise apartment blocks – recall that machines can find the simple task of opening a door difficult – or where some interaction has to be made with recipients (eg helping them to install items or finding a neighbour to take in a package). Regarding the prospect of delivery by drone, the innovation manager felt this would be extremely difficult in crowded urban areas, although a possibility for rural locations. He said plans for drone delivery and other zany schemes are more likely to be PR ploys than game-changing innovations with commercial potential.

The logistics sector will also see the emergence of machines that collaborate with human trainers and operators. US based Starsky Robotics is a firm that creates technology to power self-driving trucks, but with a clearly defined role for humans to step in at key moments. Their vision is for HGVs to run on long stretches of highway unaided, and for remote drivers to take the reins of the vehicles in the final furlong of delivery.[139.] The company, which has raised $3.75m from Y Combinator and other investors, expects each office-based driver to monitor and control between 10 and 30 trucks at a time. If a technology like this were to take off, it would ultimately lead to fewer HGV drivers but arguably better quality jobs.

138.   Ackerman, E. (2017) *Aussies win Amazon robotics challenge.* [article] IEEE Spectrum, 2 August.
139.   Korosec, K. (2017) *This driverless truck startup is putting human drivers to work.* [article] Fortune, 28 February.

# Adoption and integration

## Confusing a clear view for a short distance

So far this report has covered mostly technical ground: What do we mean by terms like artificial intelligence and robotics? How have these technologies evolved since their genesis in the early 20th century? What are they capable of in theory? And how might they transform the quantity and quality of work, based on historical experience of past innovations? While each of these questions is critical, an analysis of AI and robotics would be incomplete without a consideration of whether and how this technology is being adopted in practice. Indeed, just because a machine can do something, does not mean that it will be bought, integrated and licenced to do so.

The diffusion of technology across an economy is a drawn out process and far from guaranteed. McKinsey's thorough analysis of historical adoption rates for 25 major technologies found it took between 8 and 28 years from the birth of a commercial innovation to its maximum take-up.[140] One need only look at the experience of the personal computer to see how technology often infiltrates the workplace at a snail's pace. The first – the MITS Altair – was introduced in 1975, soon followed by the Apple computer. But by 1980 still only a million had been sold in the US, and it took many more years before they became a common sight in offices, factories, hospitals and schools.[141] Another case in point is internet of things (IoT) technology, where still only half of UK consumers own an internet-connected device.[142]

What does the data tell us about AI and robotics? Unfortunately there is little available information on the distribution and take-up of AI systems. However, there is data regarding the extent of robotic sales. The International Federation of Robotics (IFR) estimates that worldwide robot sales increased by 15 percent in 2015 to reach over 253,000 – by far the highest number ever recorded.[143] Should this trend continue, the IFR expect the worldwide *operational* stock of robots to grow from 1.63m in 2015 to 2.59m at the end of 2019. Other data, however, suggests a slower degree of diffusion, with wide variation across sectors. Boston Consulting

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140. McKinsey Global Institute (2017) op cit.

141. Knight, D. (2014) *Personal computer history: the first 25 years.* [article] Low End Mac, 26 April. Gizmodo writer Matt Novak has questioned the notion that technology is being adopted at an ever faster rate. His analysis suggests the internet was adopted by the American public at a slower rate than the television and the PC. See: http://paleofuture.gizmodo.com/no-tech-adoption-is-not-speeding-up-1565326373

142. Deloitte UK (2016) *Consumers slow to connect with IoT in the home* [press release] 19 July

143. International Federation of Robotics (2016) *Executive Summary World Robotics 2016 Industrial Robots.* IFR.

Group believe that less than 8 percent of tasks in the US transport-equipment industry are automated today, versus a potential of 53 percent.[144] They also say driverless cars will make up just 10 percent of all vehicles by 2035 – a claim that jars with media depictions of fleets of autonomous vehicles roaming streets in the near future. The UK appears to be a laggard in the adoption of AI and robotics. Sales of industrial robots to the UK actually *decreased* in the period between 2014 and 2015, with the UK purchasing fewer robots than France, the US, Germany, Spain and Italy.[145] In 2015 the UK had just 10 robot units for every million hours worked, compared with 131 in the US, 167 in Japan and 133 in Germany.[146] While this may reflect our different sectoral make-up, UK businesses and public services as a whole suffer from stubbornly low rates of investment. ONS data shows spending on gross fixed capital formation – a measure of investment that includes plant and machinery, software and new dwellings – has barely grown in real terms over the last decade.[147] Going further back, data from the World Bank shows the proportion of UK GDP accounted for by gross fixed capital formation has fallen by 7 percentage points since 1990 (see Figure 9).[148]

**Figure 9: Gross Fixed Capital Formation in the UK (% of GDP)**
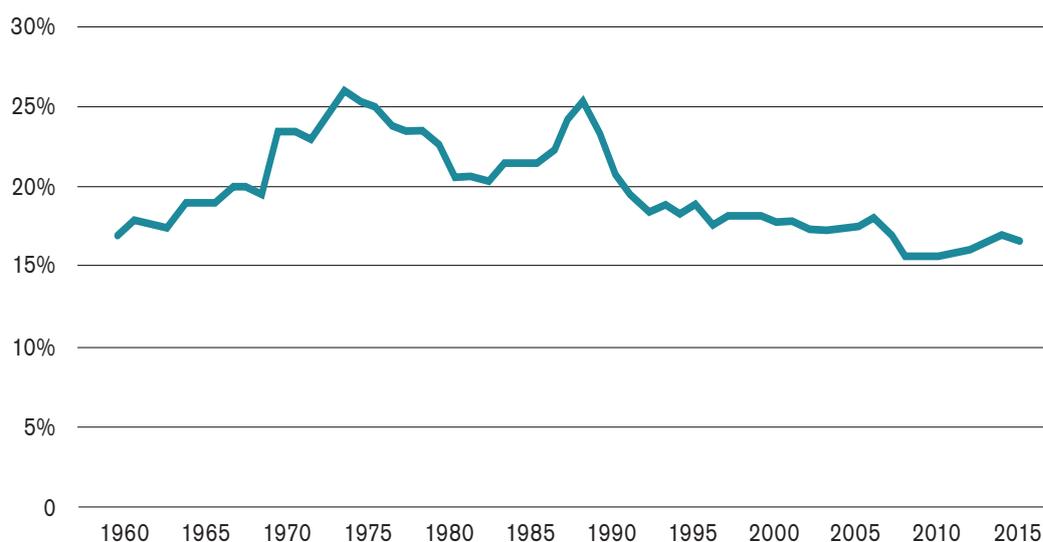


Source: World Bank National Accounts data, and OECD National Accounts data files

For the avoidance of any doubt, we asked the business leaders in our YouGov poll if they were deploying AI and robotics today, or whether they planned to in the near future (see Figure 10). The results speak for

144. Sirkin, H. L. et al (2015) op cit.
145. International Federation of Robotics (2016) *Executive Summary World Robotics 2016* Industrial Robots. IFR op cit.
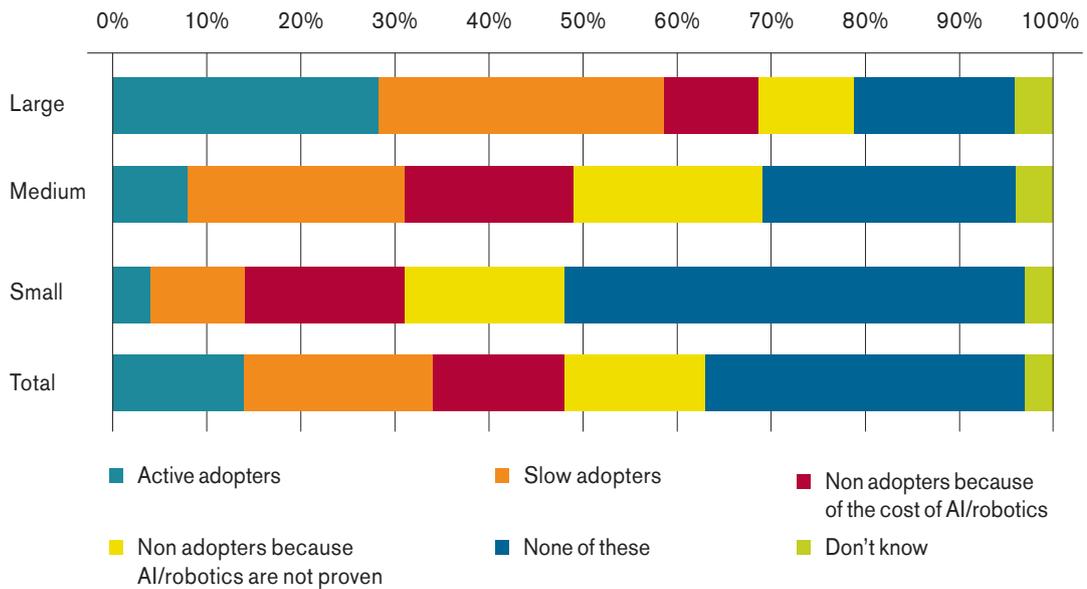146. CEBR and Redwood Software (2017) *Will post-Brexit Britain hinder a robo-revolution?*
147. ONS (2017) *Statistical Bulletin: Business investment in the UK: Jan to Mar 2017 revised results*. Available here: www.ons.gov.uk/economy/grossdomesticproductgdp/bulletins/businessinvestment/jantomar2017revisedresults GFCF = £76,519m in Q1 2008; £78,855m in Q1 2017.
148. Gross fixed capital formation includes public and private sector investment. World Bank national accounts data, and OECD National Accounts data files.

themselves: just 14 percent said they had invested in, or were about to invest in this technology. A further 20 percent said their business wants to invest but that it would take several years to 'seriously adopt' it. The remainder said they either thought it was too expensive (14 percent), not yet properly tested (15 percent), or 'none of these' (34 percent), which we assume includes many who are unaware of the latest innovations. It is also striking that small businesses are considerably less likely than their larger counterparts to have embraced AI and robotics, with just 4 percent falling into this category compared with 28 percent of large firms.

**Figure 10: Adoption rates of AI and robotics by business size**[149.]



- ■ Active adopters
- ■ Slow adopters
- ■ Non adopters because of the cost of AI/robotics
- ■ Non adopters because AI/robotics are not proven
- ■ None of these
- ■ Don't know

Source: RSA/YouGov survey of 1,111 UK business leaders (Fieldwork conducted 10-18 April 2017)

Other research reveals a similar story. A Cisco and Capita survey of business ICT decision makers found that while 50 percent view AI as relevant to their organisation, just 8 percent are currently putting it to use.[150.] For robotics, the figures are 39 percent and 10 percent respectively. A global survey of 3,000 companies by MIT Sloan Management Review found that just 39 percent have an AI strategy in place.[151.] The failure of individual technologies and tech businesses is also telling. Following a poor run of sales, robot manufacturer Johnson & Johnson decided last year to discontinue its Sedasys machine, which was designed to automate the administering of anaesthetics.[152.] Elsewhere, Aethon's robot TUG – a machine that undertakes basic deliveries of medicines in hospitals – was

149. See appendix for full details of the question posed to business leaders.
150. Brown, B. (2016) *Most companies slow to adopt new business tech even when it can help.* [article] Digital Trends, 12 August.
151. Ransbotham, S. (2017) *Reshaping business with artificial intelligence.* MIT Sloan Management Review and BCG.
152. Fecht, S. (2016) *Once-promising robot anaesthesiologist loses its job.* [article] Popular Science, 29 March.

recently reported as suffering low take-up rates.[153] Underinvestment is not limited to the healthcare industry. Market research company TechEmergence reports that 'big box' retailers are also 'extremely slow to adopt cutting-edge technologies'.[154]

What might be holding these and other organisations back? Here we explore four key hurdles to technological adoption: cost and business models; consumer preferences; regulatory concerns; and organisational integration.

## Cost and business models

AI and robotic systems, like all technologies, have fallen in price over time and will continue to do so. The cost of purchasing and deploying a spot welding machine in US car manufacturing fell from $182,000 in 2005 to $133,000 in 2014 (not adjusted for inflation), and is expected to fall further still to $103,000 by 2025.[155] Yet many machines are still out of the affordability zone for organisations, not least small ones operating in tight margin industries. RIKEN's Robear robot, which is used to lift patients in social care, comes with a price tag of between $168,000 and $252,000.[156] Machines to pick soft fruit during harvests can set farmers back around $250,000.[157] On top of this initial outlay are costs associated with maintenance, training and insurance.

Another dilemma for organisations deciding whether to invest in new technology is the prospect of obsolescence. Why invest in a RIBA robot if there are rumours of a more sophisticated caring robot just around the corner? And why plough money into a fraud detection algorithm with 95 percent accuracy if there are expectations one will soon emerge with 99 percent accuracy? These risks are lowered with software as a service (SaaS) agreements, whereby AI software can be licensed on a subscription basis. This 'plug and play' model is also appearing in robotics, with both Saviotic's hotel concierge robots and Starship Technologies' delivery droids operating on rental rather than purchase models. But the prospect of being tied into an expensive contract can still be off-putting for some businesses and public services.

Organisations must also reflect on their wider business strategy, and weigh up the cost of a new technology versus the savings that could be made on staff and efficiency improvements (eg fewer accidents and fewer interruptions in production runs). For organisations employing well-paid and highly-skilled staff, there may be an obvious case for buying in machine alternatives (one reason why the financial industry is bracing itself for significant disruption). However, for organisations operating in low-skilled and low-paid sectors, including care homes, restaurants, bars and some factories, it will continue to be cheaper to employ people. Organisations that expect to change their business model in the

153.  Stanford University (2016) *One hundred year study on artificial intelligence (AI100)*.
154.  Faggella, D. (2017) *Artificial intelligence in retail – 10 present and future use cases.* [article] TechEmergence, 2 May.
155.  Sirkin, H. L. et al (2015) op cit.
156.  Byford, S. (2015) *This cuddly Japanese robot bear could be the future of elderly care* [article] The Verge, 28 April. The cost of Robear may have fallen since the April 2015 report, but it is difficult to find public information on price changes.
157.  The Economist (2017) *British farms learn to work with fewer seasonal migrants* [article] 17 August. See: http://science.howstuffworks.com/baxter-robot3.htm

foreseeable future are also likely to have reservations about purchasing new machines. For example, a care home provider thinking of pivoting into domiciliary care will be wary of investing in robotic hoists and other machines if these cannot be used in a different setting.

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**Box 6: Automation and the National Living Wage**

The introduction of the National Living Wage (NLW) in 2016 was a welcome development for low paid workers, yet its effects on tech adoption remain to be seen. The NLW is currently set at £7.50 per hour for over 25s and is expected by the Office for Budget Responsibility to reach £8.31 by 2020. Rising staff costs could encourage employers to seek out productivity gains through automation. Alternatively, employers may choose to swallow the extra expense via a reduction in profits, or pass on the costs to consumers in the form of higher prices. A survey by the Resolution Foundation in 2015 found that 30 percent of employers affected by the NLW would seek to raise productivity in response, with 20 percent opting to take lower profits and 15 percent planning to reduce the number of their employees or slow down recruitment. This early analysis suggests that minimum wage rises need not necessarily lead to job losses, and may even spur innovation.[1]

1. Resolution Foundation (2015) Half of all employers expect to be affected by the new National Living Wage [press release] 18 November.

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## Consumer preferences

In his book, *Humans are Underrated,* the US journalist Geoff Colvin urges observers of AI and robotics to spend less time analysing what these technologies are capable of, and more time questioning what we want them to do.[158] He asks: "what are the activities that we as humans, driven by our nature or realities of daily life, *insist* be performed by other humans?"

Time will tell where consumer preferences lie, but there are almost certain to be cultural 'no-go zones' where the use of AI and robotics is deemed publically unacceptable. One might expect most people to be unfazed by a fully automated financial advisory service, but less relaxed about receiving a life or death health diagnosis from an AI interface. A recent study by Nesta, however, reveals a more complicated picture. Their survey of the UK public found that more people would be willing to sit in a driverless car where 'you do not need to use the steering wheel' (36 percent) than to get rid of cash completely so all payments would be through digital currencies (28 percent).[159] In another sign that people prefer the human touch in financial transactions, the robo-advisory service Betterment recently began offering the services of human financial advisors for the first time.[160]

Overall, the UK public appears to be less sanguine about the use of new technology than citizens in other countries. Nesta ranks the UK fifth on its 'openness' to new technology among the nine European countries it surveyed, above France and Germany but below Spain and Italy. People under 35, university graduates and Londoners tend to score higher on

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158. Colvin, G. (2015) *Humans are underrated.* Portfolio.
159. Mocker, V. (2017) *Digital Pulse 2017: Which Europeans are most open to trying new technologies?* [article] Nesta, 22 March.
160. Berger, R. (2017) *Betterment adds human touch and raises its fees.* Forbes, 31 January.

the openness scale – but not by a considerable amount. One reason for these cross-country differences may be cultural sensibilities and even religious associations with technology. In Japan, for example, the main religion is Shintoism, a form of 'animism' that believes inanimate objects have spirits. This may explain the country's deep rooted enthusiasm for robotics, and the zeal with which it has embraced machines in the use of a sensitive task like caring.

Beyond cultural and religious dispositions, there may be psychological barriers that hamper take up of AI and robotics. Fascinating research from academics at the University of Oxford and Cornell University suggests that humans are hardwired to distrust any entity that makes moral decisions through rigid calculations of costs and benefits, as machines do.[161.] This way of making decisions – called 'consequentialism' – sits in contrast to rules-based decision-making, in which certain actions are deemed "just wrong", even if they bring about better consequences for all. In the classic philosophical dilemma of a trolley cart hurtling down a track, the decision to refuse to push someone in its path to save five others would be a case of a rule-based approach in action. Thinking of what this means for automation, the researchers write:

> "It may not be enough for us that machines make the right judgements – even the ideal judgements. We want those judgements to be made as a result of the same psychological processes that cause us to make them… Until technology is capable of this feat, any attempts at making ethically autonomous machines will likely be met with suspicion".[162.]

## Regulatory concerns

The third obstacle to AI and robotic adoption is regulation. Earlier this year, the State of California proposed legislative changes that would allow autonomous vehicles to carry passengers without a licensed driver on board, while the US Food and Drug Administration gave the green light to the sale of a 'black box' deep learning algorithm to be used in healthcare.[163.] There are signs that UK regulators are also opening up. The Department for Transport (DfT) has drafted a code of practice for automated vehicles, and the government in partnership with local authorities has given the green light for numerous trials across the country, with a view to the UK being "at the forefront" of this industry.[164.] Elsewhere, the Financial Conduct Authority (FCA) has created a 'regulatory sandbox' to allow the trial of new technologies including AI within financial service products and start-ups.[165.]

Yet the regulatory system as a whole is a large and slow moving juggernaut. While the FCA appears contemplative about the use of AI in financial advice, it may be less comfortable to see algorithms used in offering insurance products, including underwriting. And whereas the DfT

161. Everett, J. (2016) Inference of Trustworthiness from Intuitive Moral Judgements. *Journal of Experimental Psychology: General,* Forthcoming.

162. Everett, J. et al (2017) *Why are we reluctant to trust robots?* The Guardian, 24 April.

163. Brouillette, M. (2017) *Deep Learning Is a Black Box, but Health Care Won't Mind.* [article] MIT Technology Review, 27 April.

164. Burgess, M. (2017) *WIRED's need-to-know guide to driverless car testing in the UK.* [article] WIRED, 24 July.

165. For more information see www.fca.org.uk/firms/regulatory-sandbox

may be enthusiastic about the prospect of autonomous vehicles roving the nation's streets, it has already insisted that a human remains behind the wheel at all times. The EU's new General Data Protection Regulation (GDPR), which comes into force in 2018, brings in new rules that may derail or slow down the spread of AI. This includes a new right for people to receive meaningful information about the logic involved in, and significance and envisaged consequences of, automated decision-making systems that will affect them.[166] New machine learning approaches are likely to jar with this ruling.

AI and robotics will also throw up a host of ethical and legal dilemmas that regulators will have to grapple with, which could in turn stifle or even halt their take-up. Among them are:

- **Discrimination** – Equipped with AI systems, organisations will have greater precision in predicting people's behaviours and the risks they face. This could lead to certain groups being denied access to goods, services and employment opportunities. Insurance companies, for example, may one day be able to use advanced algorithms to determine the likelihood of prospective customers acquiring a disease, making them uninsurable.[167] We have also seen how employers might draw on biased algorithms in recruitment.
- **Privacy** – AI and robotic systems rely on harvesting enormous amounts of data to produce accurate outcomes. This is particularly true of machine learning and deep learning approaches to AI, which use reams of data to train algorithms. But will our privacy be compromised in the process? The use of AI in healthcare diagnostics, for instance, could require public services to open up patient data as a training asset to private companies.
- **Agency** – Agency may take on a different meaning in a world where technology can understand in depth how to influence people's behaviour. There are already concerns in Silicon Valley that sophisticated algorithms are being used to hook consumers on apps and other platforms, as documented by Tristan Harris and his movement, Time Well Spent.[168] More troublingly, it is suspected that AI was used to shape voting patterns in the EU referendum through voter profiling and targeted adverts.[169]
- **Authenticity** – The spread of 'lifelike' AI and robotic systems opens up questions about the sanctity of human relationships. How connected should humans become to machines? And how do we prevent people from being duped into believing that a machine, say an AI chatbot, is a real person? Questions of authenticity are particularly pertinent to the caring industry. A seal-like robot called PARO has proven effective in calming patients with dementia, but some have voiced concern about

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166. Wachter, S. (2017) 'Why a Right to Explanation of Automated Decision-Making Does Not Exist in the General Data Protection Regulation' in International Data Privacy Law, Forthcoming.

167. Wolf, M. (2016) *Good news – fintech could disrupt finance* [article]. Financial Times, 8 March.

168. For more information see: www.timewellspent.io/

169. Booth, R. (2017) *Electoral Commission urged to investigate Farage's Brexit campaign.* The Guardian, 2 March.

outsourcing a sensitive task like care to a machine without a conscience.[170.]

Of course, what matters is not just the action or judgement a machine makes but the context in which it operates, and how the information it supplies is used. It is unlikely that people or regulators will ever be comfortable with a machine acting as sole arbiter in high stakes court cases, but they could add an extra layer of insight to a human judge or magistrate. Likewise, handing over the job of caring for our loved ones to robots is an alarming prospect in its own right. However, their deployment is more likely to be acceptable to society if they are paired with humans, or indeed if we are reminded of the shortage of care workers and the limited time they have available to be truly attentive to vulnerable people. Context and the process by which machines are integrated therefore matter greatly.

There is, however, a more clear-cut risk that will phase regulators: cyber-attacks. Artificial intelligence and robotics are susceptible to malicious hacks and could be overridden with damaging results. The autonomous vehicle industry was given a wake-up call in 2015 when a Jeep Cherokee was paralysed on a highway after two computer scientists hacked its cruise control system.[171.] Elsewhere, Microsoft's Twitter bot, Tay, was abused by internet trolls who trained it to regurgitate racist, sexist and homophobic content. AI and robotics can also be used as tools themselves to penetrate systems, mislead people and scale up fraudulent transactions.[172.] These concerns came out strongly in our YouGov poll, where 76 percent of business leaders said the introduction of new technologies tends to lead to increased cyber security risks, posing a significant threat to businesses (see Figure 11). Regulators will undoubtedly keep a close eye on these dangers and consider when and where to intervene.

## Operational integration

Even when the technology is cheap, consumers are happy to embrace it, and regulators have given their approval, organisations can themselves face internal difficulties in integrating AI and robotics. Occasionally there are physical constraints to contend with. A manufacturer may wish to install a new type of machine, but not have the space to do so. Free moving robots may be stymied by uneven surfaces, platforms, steps and other physical obstacles. In one bizarre case, a security robot in an office building 'drowned' itself when it fell into a water foundation.[173.] These issues are particularly problematic for domestic robots that operate in people's homes, where the owners will be less willing to reconfigure and refurbish their properties than businesses and public service providers. There are also risks associated with vandalism and theft. While the most advanced robots have been trained to operate in complex environments, they may not be prepared for confrontation.

170.   Tergesen, A. and Inada, M. (2010) *It's not a stuffed animal, it's a $6,000 medical device.* The Wall Street Journal, 21 June.

171.   Greenberg, A. (2017) *Securing driverless cars from hackers is hard. Ask the ex-uber guy who protects them.* [article] WIRED, 12 April.

172.   Bell, G., Justice, C., Buffomante, T. and Dunbar, K. (2017) *AI adds a new layer to cyber risk.* Harvard Business Review, 13 April.

173.   Titcomb, J. (2017) *Security robot 'drowns itself' in office fountain.* The Daily Telegraph, 18 July.

**Figure 11: Proportion of business leaders who believe the introduction of new technologies tends to lead to increased cyber security risks, which pose a significant threat to businesses**
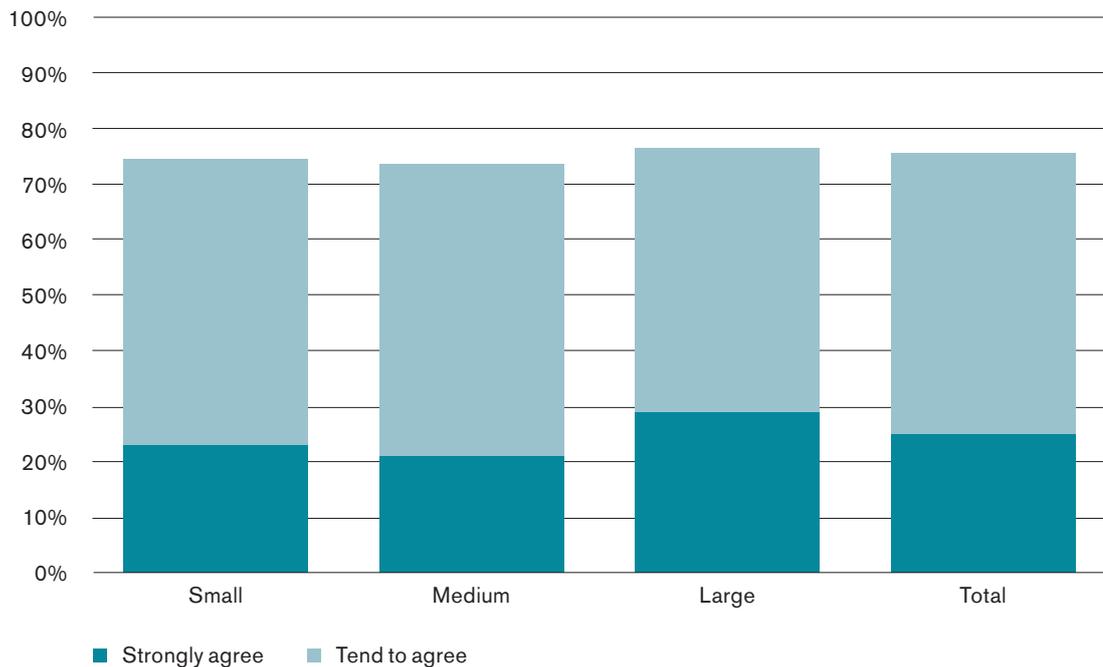


Source: RSA/YouGov survey of 1,111 UK business leaders (Fieldwork conducted 10-18 April 2017)

On top of physical constraints are issues of workforce readiness. A recent survey by Deloitte found that just 15 percent of global executives believe they are prepared to have a workforce "with people, robots and AI working side by side".[174] Staff need training and encouragement to use new technology, while middle managers have to buy into its value and understand what it is capable of. Workers may initially be reluctant to embrace AI and robotics for fear of being usurped or disrupted more generally. A public service health chief we spoke with recalled how his decision to deploy automated transcription software to speed up the write-up of doctors' notes was initially met with resistance from secretaries, until they saw the potential for it to relieve them of a thankless task. Unions may also seek to slow down the adoption of AI and robotics in a bid to protect their members. ASLEF, the UK's trade union for train drivers, warned that the introduction of driverless trains on the London underground could lead to "all-out war" with Transport for London.[175]

Finally, the integration of AI and robotics may be stalled as business models are updated and supply chains are reconfigured. The delivery firm Hermes is currently trialling the use of the Starship Technologies delivery robots for parcel deliveries in 15 minute time slots. However, before this was possible, the company had to develop a new time slot booking application, market this offer to customers, and negotiate with London councils about the use of autonomous robots on local footpaths.

174. Deloitte (2017) *2017 Global Human Capital Trends*.
175. BBC News (2014) *Driverless tube trains: Unions vow 'war' over plan*. BBC News London, 28 February.

Sustainable business models will also be dependent on appropriate insurance products emerging, without which businesses and public services may be reluctant to make investments. Insurance providers may themselves be hesitant to devise new products until it is legally established where accountability for wrongdoing lies. For example, if a cancer-detecting algorithm were to misdiagnose a patient, would culpability lie with the creator of the software, the health service deploying it, or the provider of the data on which it is trained?

In the next chapter we reflect on how these four major barriers to adoption might be lifted, with a view to achieving 'automation on our own terms'. As we will make clear, the slow integration of AI and robotics in our economy should not be viewed as a welcome reprieve from disruptive forces, but rather as a hindrance in our attempt to realise a better world of work.

# Automation on our own terms

### Science fiction vs. economic fact

We began this report by asking what advances in AI and robotics might mean for workers in the years ahead, particularly the 13.9 million people in low-skilled jobs. On the one hand is the alarmist viewpoint that says we are on the cusp of economic disorder. In the near future, some say, automation will be widespread and destructive, individuals and possibly whole communities will be displaced, inequality will accelerate to new heights, and well paid jobs will be few and far between – reserved only for the elites who own or manage the machines. Proponents of this argument point to the growing list of technological achievements, from software that can write news articles and machines that can shuttle goods around warehouses, through to algorithms that can manage logistical supply chains and 'therapeutic' robots used in mental healthcare.

No one is doubting the scale and pace of technological accomplishments, but the notion that AI and robotics will soon destroy large swathes of jobs does not stand up to scrutiny. The UK unemployment rate is 4.4 percent, the lowest it has been since 1971.[176] There are now more people who want to work less hours than who want to work more (see Figure 12), and the redundancy rate is broadly on a downward trajectory.[177] For every article warning of technological unemployment, there is another complaining of skills shortages. Moreover, as our RSA/YouGov survey reveals, just 14 percent of the country's businesses are currently deploying AI and/or robotics, or plan to in the near future. Contrary to colourful newspaper headlines, most employers are not paying attention to innovations in machine learning, deep learning or advanced robotics. The economic facts belie the sensational science fiction.

Does this warrant a collective sigh of relief? Only if we believe the status quo in our labour market is desirable – which it is not. As noted in the introductory chapter, and emphasised in Matthew Taylor's Review of Modern Working Practices, the UK's labour market performs poorly on a number of measures. While work is plentiful, the bulk of it is low-skilled and low-paid, and our productivity levels are abysmal. On average, UK workers are 35 percent less productive than their counterparts in

176. For more information see: www.ons.gov.uk/
177. For more information see: www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/redundancies/timeseries/beir/lms

Germany, 30 percent less than US workers and 9 percent less than Italian workers.[178.] Sluggish productivity growth has in turn been felt in stagnant wages, with real median wages still far below their pre-crisis levels. Workers are getting by on the pay packets of 2005.

**Figure 12: Share of UK workers under and overemployed**
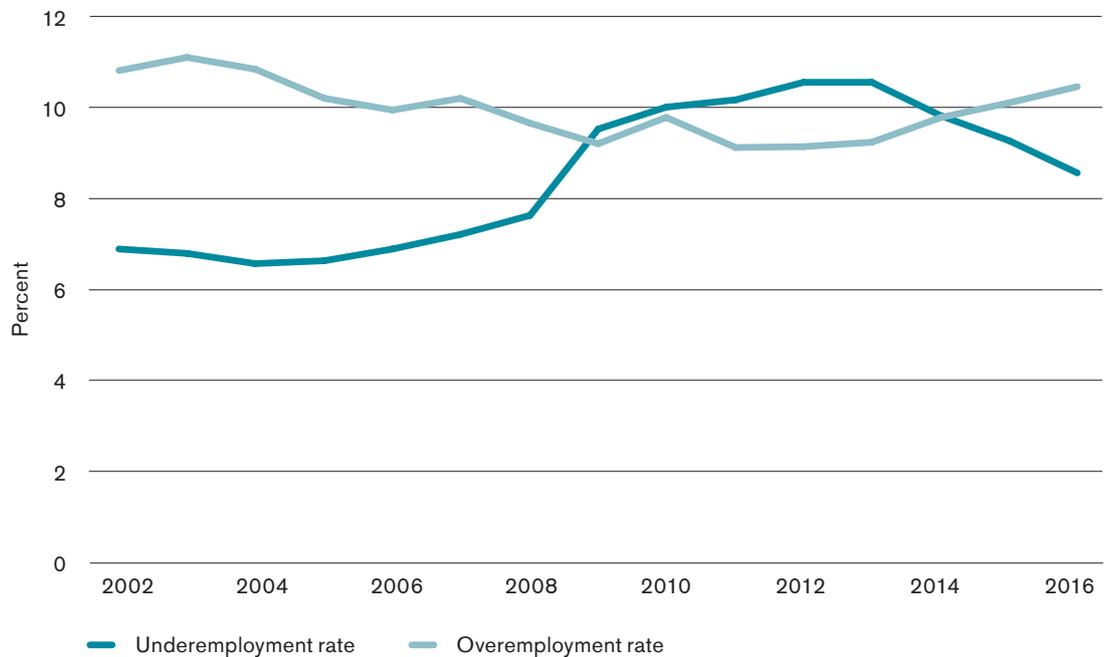


Source: RSA analysis of Labour Force Survey

The central argument of this report is that the deployment of AI and robotics could help the UK forge a path towards a better world of work. These technologies could phase out mundane work, raise productivity levels, open up the door to higher wages, and allow workers to concentrate on more human-centric roles that are beyond the technical reach of machines. This is just as true for low-skilled workers as it is for high-skilled ones. Most of the business leaders who took part in our survey agree with this sentiment, albeit when asked about technology in the round. Nearly half (43 percent) say that new technologies (including but not limited to AI and robotics) will lead to incremental automation and greater prosperity in the long run. Just 15 percent take a negative view that automation will be significant and that technology will harm livelihoods (see Figure 13).

178.   Be the Business (2017) *Top business leaders call on the UK to tackle productivity gap at the launch of 'Be the Business'* Press release, 11 July. Available at: www.bethebusiness.com/wp-content/uploads/2017/07/launch_of_be_the_business.pdf

**Figure 13: Overall attitudes of business leaders towards technology**
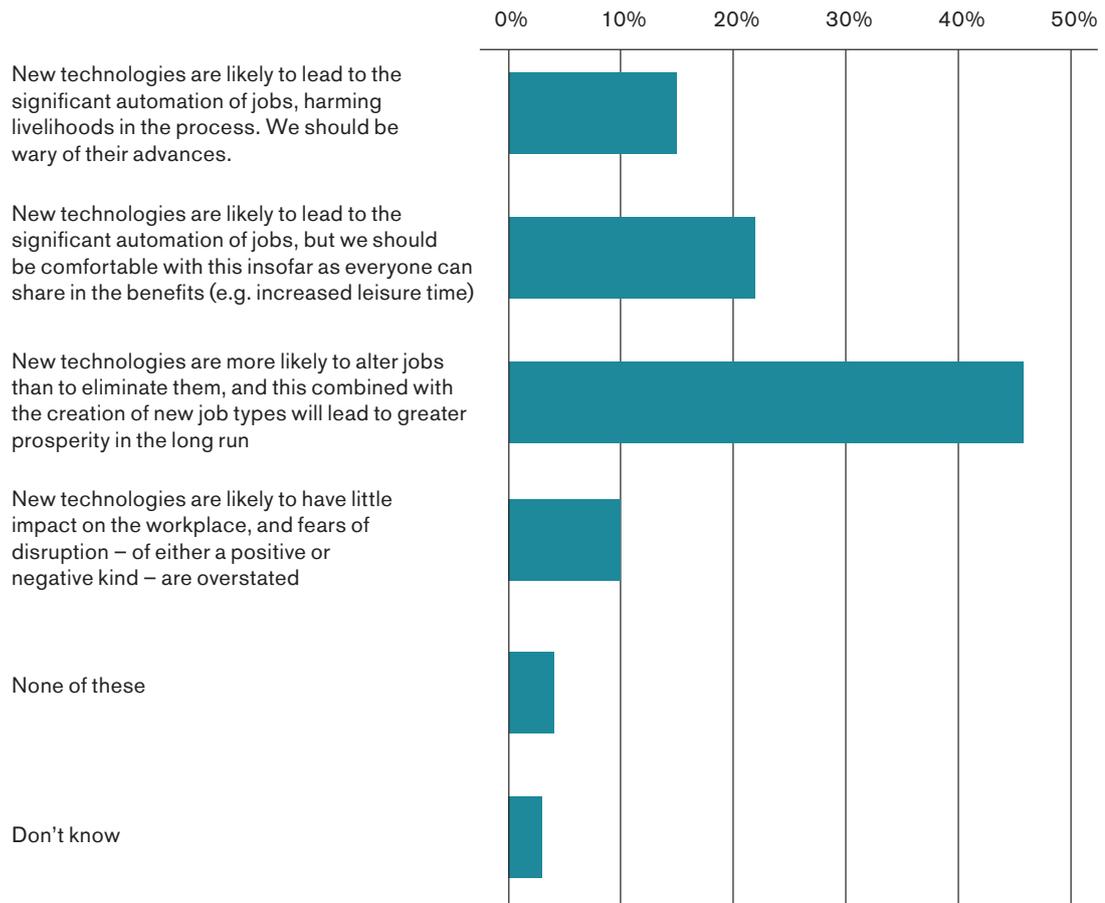


Source: RSA/YouGov survey of 1,111 UK business leaders (Fieldwork conducted 10-18 April 2017)

## Three risks

Yet there is no room to be complacent. As with all innovations, AI and robotics if deployed on a large scale would result in both losers and winners. Some geographic areas, demographic groups, occupations and sectors would be hit harder than others. Drivers in the taxi industry would undoubtedly be rocked by the introduction of self-driving cars, just as builders and labourers would be disturbed by the arrival of robotics on construction sites. While we are doubtful these machines would lead to the heavy loss of jobs, they are almost certain to result in their transformation. And while there are likely to be jobs created to replace those that are ultimately phased out by AI and robotics, people would be required to retrain, shift careers and move home in search of new opportunities.

There are three main risks of embracing AI and robotics unreservedly:

- **A rise in economic inequality** – To the extent that technology deskills jobs, it will put downward pressure on earnings. If jobs are removed altogether as a result of automation, the result will be greater returns for those who make and deploy the technology, as well as the elite workers left behind in firms. The median

OECD country has already seen a decrease in its labour share of income of about 5 percentage points since the early 1990s, with capital's share swallowing the difference.[179] Another risk here is market concentration. If large firms continue to adopt AI and robotics at a faster rate than small firms, they will gain enormous efficiency advantages and as a result could take excessive share of markets. Automation could lead to oligopolistic markets, where a handful of firms dominate at the expense of others.

- **A deepening of geographic disparities** – Since the computer revolution of the 1980s, cities that specialise in cognitive work have gained a comparative advantage in job creation.[180] In 2014, 5.5 percent of all UK workers operated in new job types that emerged after 1990, but the figure for workers in London was almost double that at 9.8 percent.[181] The ability of cities to attract skilled workers, as well as the diverse nature of their economies, makes them better placed than rural areas to grasp the opportunities of AI and robotics. The most vulnerable locations will be those that are heavily reliant on a single automatable industry, such as parts of the North East that have a large stock of call centre jobs.[182]

- **An entrenchment of demographic biases** – If left untamed, automation could disadvantage some demographic groups. Recall our case study analysis of the retail sector, which suggested that AI and robotics might lead to fewer workers being required in bricks and mortar shops, but more workers being deployed in warehouse operative roles. Given women are more likely to make up the former and men the latter, automation in this case could exacerbate gender pay and job differences. It is also possible that the use of AI in recruitment (eg algorithms that screen CVs) could amplify workplace biases and block people from employment based on their age, ethnicity or gender.

There is every possibility that society will prevent AI and robotics from becoming mainstream because the dangers seem to outweigh the benefits. When esteemed figures such as Elon Musk and Bill Gates warn of technological threats, the public and politicians undoubtedly listen. New technologies, including AI and robotics, will always create tensions and present new risks. But it would be a tragedy were we to lose sight of the enormous potential they also have for helping society address its biggest challenges – from managing an ageing population to lengthening lifespans to combating climate change.

179.  Berger, T. and Frey, C. B. (2016) op cit.
180.  Ibid.
181.  Ibid.
182.  RSA analysis of Labour Force Survey data. Workers in the North East are 16 times more likely to work in telesales (call centre jobs) than those in London (0.3 percent v 0.018 percent). Farm workers are more concentrated in the East Midlands than other parts of the UK (LQ = 2.2). Also Scotland (LQ = 1.9).

## Inclusive automation

The challenge, then, is to accelerate the adoption of AI and robotics but in a way that delivers inclusive automation – a kind that acts in the service of workers. How might this be achieved? Many point to Universal Basic Income – an unconditional grant paid to every citizen – as the surest way to give people economic security in an age of automation. The RSA has itself been one of the strongest advocates of piloting UBI in the UK.[183.]
Yet our response to technological disruption must encompass more than an overhaul of our welfare system. It is vital that policymakers, educators, regulators and others look across the lifecycle of technology, and intervene where necessary to encourage a positive outcome at each stage – from developing benevolent machines to equipping young people with modern skillsets. Effort must be made to:

- **Develop benevolent machines** – Programmers, tech companies and their investors should be steered towards developing benign forms of technology.
- **Accelerate the adoption of machines** – Employers should be encouraged to deploy AI and robotics in a way that enriches rather than harms their workforce.
- **Future-proof the workforce** – Educators must prepare future generations with the skills and competencies that will allow them to thrive in an automated economy.
- **Create a modern social contract** – Our tax and welfare systems must evolve so that those who reap the most rewards from automation support those who lose the most.
- **Democratise the ownership of machines** – The ownership of machines and the organisations that deploy them should be expanded so that more people can share in technological wealth.

While it is beyond the remit of this report to spell out fine-tuned policy recommendations, here we take a tour through possible interventions under each of these headings (see Figure 14). Some of these proposals are quick wins that can be implemented with little disruption or financial expense. Others are long-term, ambitious and will demand root and branch reform of our public institutions. There are also likely to be cases where an internationally coordinated response is required to manage the fallout of automation – not least when technology is being developed outside of our national borders. In every circumstance, we should be guided by an overarching principle that it is never too early to begin planning for an economy where AI and robotics are ubiquitous.

183.  Painter, A. and Thoung, C. (2015) *Creative Citizen, Creative State*. London: RSA.

## Figure 14: Achieving inclusive automation through policy and practice
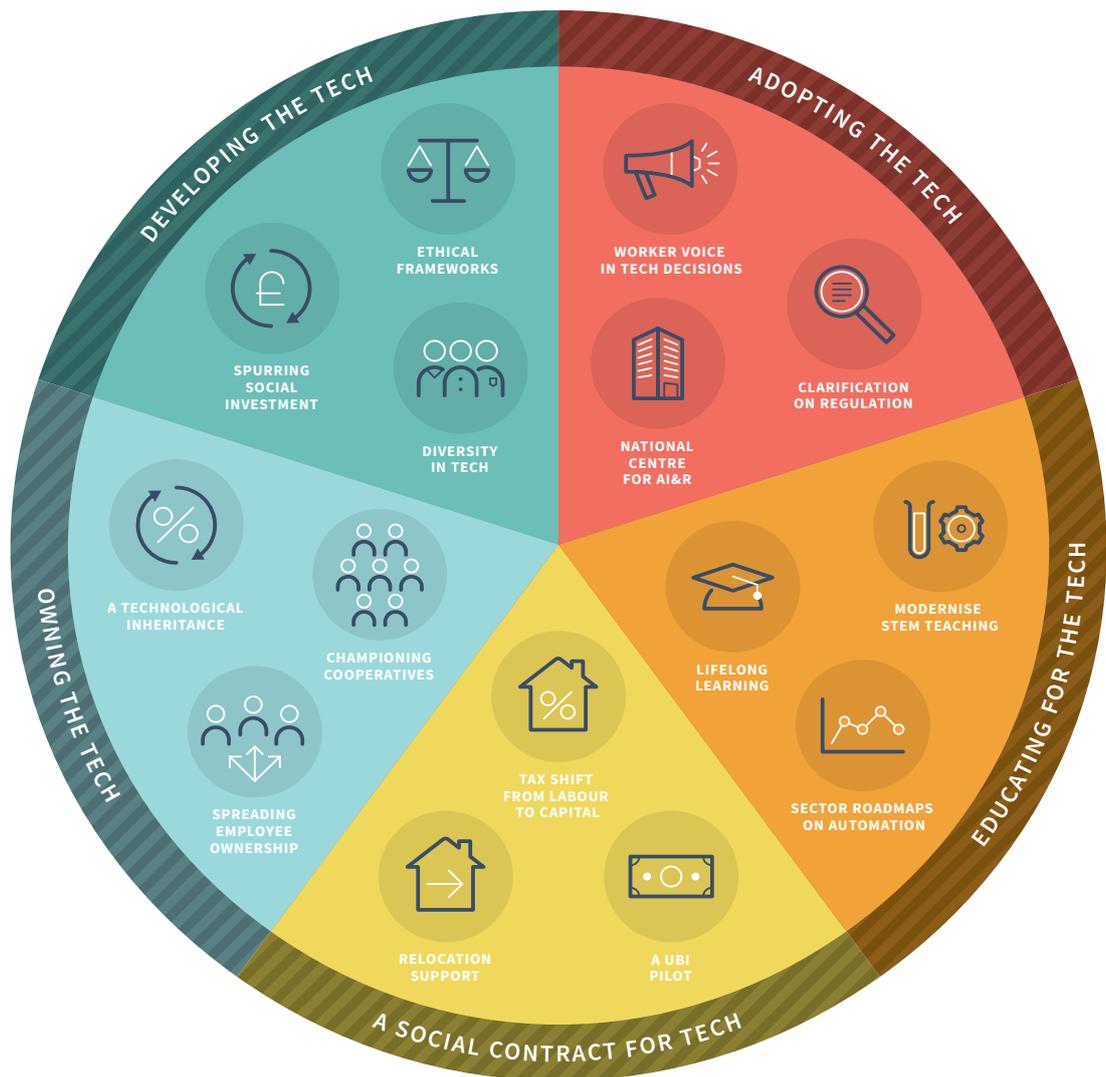


## Develop benevolent machines

The late economist Sir Anthony Atkinson said that "too often technology is discussed as if it has come from another planet and has just arrived on Earth". The reality is that society can and should shape the development of machines, including by eliminating potential flaws as they are being designed. Progressive elements of the tech community should take a lead on drafting and signing up to ethical frameworks that would steer programmer behaviour, as the IEEE has done in the US.[184] Philanthropic foundations and socially conscious investors also have a role to play by funding technologies that have more benign effects on workers. More broadly, careers in the AI and robotics professions must be opened up to wider sections of society, so that technology is built with everyone's interests in mind.

184. IEEE Standards Association (2016) *Ethically Aligned Design: A Vision for Prioritizing Human Wellbeing with Artificial Intelligence and Autonomous Systems.*

We advocate:

- **Establish an ethical framework for AI and robotic engineers** – Several large tech companies – including Apple, Amazon and Google – have committed to creating new standards to guide the development of AI.[185.] A recent EU Parliament investigation has followed suit in recommending the development of an advisory code for robotic engineers.[186.] These efforts should continue, but must not happen behind closed doors. Tech companies should use public engagement methods to canvass opinion on what society considers to be an acceptable and unacceptable use of AI, with a focus in this case on what happens within workplaces. Ethics training should be made a compulsory part of graduate computer science degrees, potentially culminating in a pledge akin to a Hippocratic Oath.

- **Launch a national AI and robotics mission to boost the quality of work** – The amount of funding flowing into the fields of AI and robotics is enormous. Yet much of this comes from private sources such as venture capital funds, and is often aimed at using AI for narrow commercial ends. The government should increase public spending on AI and robotics from its relatively low level (note our departure from the EU may cut off valuable streams of funding from supranational bodies).[187.] Part of this funding should be used to launch a new mission that rewards researchers developing machines that boost the quality of work, for example cobots that augment human labour. The mission could be organised through prize challenges, along the lines of the $4.5m AI challenge just launched by the XPRIZE Foundation.[188.] The UK government should look to partner with likeminded countries on such an initiative.

- **Mobilise the social investment community to sponsor benevolent AI and robotics** – It is not just for the government to invest in socially responsible technology. Philanthropic foundations and non-profits also have a role to play. The Laura and John Arnold Foundation, an NGO based in the US, recently sponsored the development of a new algorithm to be used in criminal court proceedings – one that ignores factors like race, ethnicity and geography to ensure neutral assessments of defendants.[189.] In the same vein, non-profits in the UK should consider sponsoring AI and robotics that enrich the worker experience, such as recruitment algorithms that help employers find and hire workers

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185. For more information see: www.partnershiponai.org/
186. Hern, A. (2017) *Give robots 'personhood' status, EU committee argues*. The Guardian, 12 January.
187. The government earlier this year committed to spending an extra £17.3m on university research in AI and robotics. However, a report from the Science and Technology Select Committee report claims that as much as 80 percent of funding for UK robotic and autonomous system (RAS) research comes from the EU. See House of Commons Science and Technology Committee (2016) *Digital Skills Crisis*.
188. For more information see: http://ai.xprize.org/
189. Livni, E. (2017) *In the US, some criminal court judges now use algorithms to guide decisions on bail*. [article] Quartz, 28 February.

from marginalised groups. A more significant step would be to establish a new social investment fund to back benevolent technology. Google has recently launched a new work initiative to fund tech-based innovations that will help people prepare for the changing nature of work.[190]

- **Open up pathways for marginalised groups to enter careers in AI and robotics** – The tech community lacks diversity. Women make up just 17 percent of IT professionals and only 16 percent of new graduates from IT related courses, compared with 44 percent of new graduates as a whole.[191] The Royal Society estimates that black and ethnic minority groups are over-represented in the 'digital/IT sector' but are under-represented at senior levels.[192] When machines are only built by a small group in society, they will ultimately only tackle the problems of a small group in society. Tech companies should redouble their efforts to recruit a more diverse cohort of programmers and managers, for example by partnering with groups like Code First: Girls and InterTech LGBT.[193]

## Accelerate the adoption of machines

If the UK is to have a higher performing, higher paid labour market, then businesses and public services will need to ramp up their investment in AI and robotics. Particular attention should be paid to raising awareness of new technology among smaller organisations, most of whom lack the resources to investigate how AI and robotics might benefit them. Recall that just 4 percent have embraced AI and/or robotics, compared with 28 percent of large firms. Getting machines into organisations, however, is only half the battle. New technology must be integrated into organisational work practices and culture, which in turn requires workers and middle management to buy into the value of innovation. Accelerating the adoption of machines across the economy and among businesses of all shapes and sizes will demand new institutions, new incentives and new management practices.

We advocate:

- **Establish a National Centre for AI and Robotics** – The government should consider establishing a National Centre for AI and Robotics, or a Catapult centre of the same name.[194] This would be tasked with increasing the diffusion of these technologies throughout the economy, for example by running trade shows where businesses and public services connect with technology firms; informing journalists of new developments to ensure more accurate reporting of AI and robotics; overseeing Knowledge Transfer Partnerships that place AI and robotics

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190. For more information see: www.google.org/helping-prepare-for-the-future-of-work/
191. House of Commons Science and Technology Committee (2016) *Digital Skills Crisis*.
192. Ibid.
193. For more ideas see: Tech London Advocates (2016) Diversity in Tech: A manifesto for London. London: TLA. 60 percent of Tech London Advocates said their company does not work with any external organisations or initiatives to increase their diversity.
194. A government-backed Digital Catapult Centre already exists. However, its remit covers multiple technologies when a more bespoke institution is arguably required.

engineers within firms, particularly small ones; and canvassing the views of businesses so that researchers have a better understanding of their needs. A National Centre could also coordinate the aforementioned national mission to use AI and robotics for the advancement of good work.

- **Encourage organisations to co-create automation strategies with their workforce** – The LSE's Mary Lacity and Leslie Willcocks find that technology is more likely to be integrated in organisations when the C-Suite (the most senior executives) are actively involved in spelling out the benefits, engaging staff in how the technology should be used, and articulating the direct benefits to them.[195.] Wherever possible, businesses and public sector organisations should co-create automation strategies with their employees and the unions, and help workers retrain and pivot into new roles should machines take away some of their workload. Employers should also think carefully about which machines they purchase, as many can achieve the same outcome while having noticeably different effects on workers. Inspiration can be taken from Aviva's decision earlier this year to consult its insurance staff on automation and retrain anyone who feels their job is under threat.[196.]

- **Improve the financial incentives to purchase new technology** – A small but meaningful proportion of businesses (14 percent) say they have not adopted AI and/or robotics because the technology is too expensive. There are several ways the government can make investment more affordable. First, as the CBI has suggested, the Annual Investment Allowance, which writes off 100 percent of qualifying capital expenditure (including tools, equipment and software) against taxable profits, should be doubled to £1m.[197.] Second, Local Enterprise Partnerships should offer to knit together consortia of businesses to buy new machines in bulk with accompanying discounts. And third, the government should look at changing the rules on business rates, so that no plant and machinery investments are included in tax calculations.[198.]

- **Rationalise and clarify data protection rules that impede tech adoption** – The UK government, and where applicable the EU Parliament and Commission, should continue to review data protection regulation to ensure it does not unnecessarily discourage organisations from deploying AI and robotics. Current rules on data management appear ill suited to the use of machine learning algorithms that rely on large datasets. The EU General Data Protection Regulation coming into force in 2018 includes more robust requirements on organisations to gain consent from individuals to use their data. But as the tech company ASI Data Science points out, machine learning is concerned with finding multiple new uses for existing datasets, some of which may not

195.  Lacity, M. C. and Willcocks, L. P. (2016) op cit.

196.  Bacani, L. (2017) *Aviva asks 16,000 staff if their jobs can be done by robots.* [article] Insurance Business UK.

197.  Biggins, C. (2016) *Business priorities for the Autumn Statement.* CBI.

198.  Ibid.

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be apparent when an individual is first asked for consent in the use of their data.[199.]

## Future-proof the workforce

As machines become more sophisticated, so must the UK workforce raise its game. To thrive in an age of automation will require people to do one of three things: play a part in creating the technology, find a way of working alongside it, or identify a niche career that remains beyond the scope of it. Educators need to encourage more students to enrol on computer science and STEM subjects, while simultaneously cultivating the deeper qualities of creativity, entrepreneurialism and overall grit that will help young people navigate their way through a turbulent labour market. In addition, lifelong learning must be given greater prominence and backing, such that adults have the wherewithal to transition between jobs and careers. All of this will require a re-imagination of our educational institutions and the trialling of new training funds.

We advocate:

- **Promote lifelong learning and pilot personal training accounts** – Half of all workers in the lowest socio-economic group have received no training since finishing formal education.[200.] To help more people participate in lifelong learning, the government should consider piloting personal training accounts along the lines of those developed in France and Singapore.[201.] These would provide an annual credit of a few hundred pounds for workers to spend on any training course provided by accredited institutions. To pay for this, the government could reconfigure the Apprenticeship Levy into a wider 'skills levy', as suggested by the CIPD and the Taylor Review. A portion of the funds should be earmarked for marketing, to ensure demand for learning meets supply. In addition, the government should consider redirecting more funding to FE colleges, which are well placed to support lifelong learning efforts among low skilled groups.
- **Experiment with new schooling methods that build soft skills resilient to automation** – Advances in AI and robotics could lead to an expansion in human-centric occupations. A recent study from the US found that the share of the workforce in jobs requiring 'high social skills' grew by 10 percentage points between 1980 and 2012.[202.] To prepare young people for such roles, the government and educators should expand new schooling models that nurture the aptitudes of problem solving, critical thinking and entrepreneurial mindsets. High Tech High schools in the US revolve around project based learning, with each student required to undertake an internship within their community. Similarly, Studio Schools in the UK prioritise the development of

199.  ASI Data Science and Slaughter and May (2017) *Superhuman Resources: Responsible deployment of AI in business.*

200.  Taylor, M. (2017) *Good Work: The Taylor Review of Modern Working Practices.* op cit.

201.  The Economist (2017) op cit.

202.  Greenfield, R. (2016) *Forget Robots—People Skills Are the Future of American Jobs* [article] Bloomberg, 7 December.

emotional intelligence, communication skills and relationship building.[203.]

- **Create sector roadmaps that anticipate and prepare for automation** – The government and sector skills councils should form roadmaps for each major sector to understand the skills and jobs that are becoming more sought after, as well as those which are most at risk of automation. This should be informed through a live and continually updated index showing key developments in AI and robotics, as advocated by MIT's Erik Brynjolfsson. [204.] The sector roadmaps would help schools, FE colleges, universities and other educators to better prepare their students for the offices and factories of the future. At a national level, the UK could follow in the footsteps of Germany's government, which is considering the publication of regular reports on the changing world of work.[205.] Both the sector roadmaps and world of work investigations would require greater collaboration between employer groups, tech companies and educators.

### Box 7: Makers Academy

Makers Academy describes its mission as 'to teach as many people as possible how to create amazing products using beautiful code.' It runs an intensive training course spanning a short period of three months, with the intention that people can switch career into software development without returning to university. The course planners update the curricula after every cohort, and aim to nurture software developers who are as good at collaborating and communicating as they building stable, fast and elegant products. The Academy has trained nearly 1,500 people so far, between one third and half of whom are women. Graduates have found positions in Deloitte Digital, the Financial Times, HSBC and Thoughtworks, among many other organisations.

- **Modernise computer science courses and teaching methods** – The demand for data scientists, programmers and system engineers is growing at pace. Yet 13 percent of computer science graduates are still unemployed six months after graduating, compared with 8 percent across all subjects.[206.] Evidence suggests this is due to a mismatch between what is taught in schools and universities and what is needed by the industry.[207.] The government's new Digital Strategy goes some way towards addressing this problem, with a commitment to create generous new bursaries for computing science teachers that would improve the quality of courses. But there is also a need for more modular and

203. For more information see: https://studioschoolstrust.org/studio-schools/create-framework/

204. Mitchell, T. and Brynjolfsson, E. (2017) *Track how technology is transforming work*. [article] Nature, 13 April.

205. Federal Ministry of Labour and Social Affairs (2016) op cit.

206. House of Commons Science and Technology Committee (2016) op cit.

207. Ibid. The same report reveals that more than 9 in 10 tech businesses say a digital skills gap affects their operations.

fast-evolving training programmes outside of formal education, for example Makers Academy (see Box 7). The government should offer the same subsidies to these fast-track courses as it does to HE computer science courses.[208.] Effort should also be made to link learners with jobs in the technology industry. In this regard, we welcome the government's new Digital Skills Partnership, which will see tech businesses work with local government to help people move into digitally-focused jobs.[209.]

## Create a modern social contract

To the extent that AI and robotics puts downward pressure on wages or eliminates jobs, it will push some workers into financial hardship. This demands a rethink of our social contract, broadly defined as the division of rights and responsibilities between workers, the state and employers. In the medium to long-term, the government should consider the merits of adopting a Universal Basic Income – a modest sum of money paid to every citizen on an unconditional basis. In the short-term, the government must ensure that the welfare system aids labour market flexibility while guaranteeing a minimum level of security for workers. Denmark's 'flexicurity' system is one model to draw inspiration from. A consensus also needs to be built around tax reform. If machines do become more important as a source of income in our economy, it is reasonable to shift some of the tax burden away from labour and towards capital.

We advocate:

- **Make 'flexicurity' a core tenet of a new social contract** – Our social contract must evolve to meet the needs of a changing labour market. Against the backdrop of automation, our ambition should be to give workers a more robust safety net, while retaining the flexibility that encourages employers to take on workers. Much can be learned from Denmark's flexicurity model. Here, employers have greater freewill to hire and fire employees, but workers are entitled to up to 90 percent of their previous salary as they search for jobs, and are supported by a generous training regime co-designed with unions. The result is that a quarter of Danes in the private sector switch jobs every year, arguably leading to better job matching.[210.] Shifting to a model of flexicurity is ambitious: it will demand a restructuring of our institutions (with a bigger role for trade unions), and significantly more money to be spent on education and retraining. However, the potential prize may merit the size of the investment.
- **Launch a meaningful pilot of Universal Basic Income** – Universal Basic Income is often presented as a silver bullet that would help workers survive in the event of large scale job losses. We do not believe this scenario is likely, nor, in any case, that UBI would be the singular solution. However, UBI could be an

208. COADEC recently recommended this policy change. See COADEC (2017) *A Global Britain: From local startups to international markets.*
209. Department for Digital, Culture, Media and Sport (2017) *UK Digital Strategy.* DCMS.
210. Johal, S. and Thirgood, J. (2016) *Working Without a Net.* Mowat Centre.

important weapon in our armoury of policies to manage the modest labour market disruption we can expect from automation. It would allow workers to dive back into learning, give them more bargaining power vis-à-vis employers, and enable them to meet caring responsibilities (so responding to a demographic trend as well as a technological one). The government should put UBI to the test by facilitating a pilot in a UK town or city, along the lines of the experiment in Finland and Holland. The RSA welcomes the recent news that Scotland's devolved government has committed funding to pay for basic income experiments among its local authorities.

- **Move the tax burden away from labour and towards capital** – How might these welfare reforms be paid for? Earlier this year, Bill Gates put forward the suggestion of a 'robot tax', which would charge businesses for deploying machines that displace workers. Yet it is difficult to see this working in practice, not least because it is impossible to distinguish between robots that complement humans and those that displace them. Nonetheless, the government should embrace the underlying principle of shifting the tax burden away from labour and towards capital. This would counteract any increase in the share of national income flowing to capital owners, which is caused as a result of automation. The government must keep the 'employment wedge' – the non-wage costs of taking someone on as an employee – as low as possible. Taxing wealth is notoriously difficult, given the opportunity for capital flight between countries. The OECD recommends recurrent taxes on immovable property as the least harmful to economic growth.

- **Remove the financial obstacles to geographic mobility** – The degree of technological disruption will vary from place to place. While some towns and cities will suffer declining job numbers and falling wages, others will see rising prosperity from the deployment of new machines. It is incumbent on the government to help people move closer to where new and better jobs arise. Particular support should be given to low paid groups who have fewer assets to finance a relocation. Building affordable housing in areas with plentiful jobs must be the priority, however there are other more immediate steps the government can take to aid geographic mobility. One of these is to reduce Stamp Duty, which can discourage or prevent people from purchasing homes in areas where jobs are in greater supply. The government should also undertake a feasibility study of relocation vouchers, a system of subsidising workers as they search for jobs in other towns and cities.

## Democratise the ownership of machines

A final policy consideration is who owns the machines. Whereas the redistribution of wealth requires tough choices on tax changes and is subject to evasion, giving workers ownership over the technology that creates wealth is a cleaner solution that avoids connotations of dependency. A publically owned sovereign wealth fund could be set up to invest in company assets

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and emerging technologies, and channel dividends to every citizen in the form of a 'technological inheritance'. The fund could be built in the first instance by siphoning a percentage of capital stock from every Initial public offering (IPO), possibly underpinned by short-term corporate tax relief so as not to discourage flotations in the UK. Less radical but no less important, the government and business groups should take steps to expand the employee ownership and profit sharing movements, where workers have a direct stake in companies and by extension the machines they are investing in. This also means championing cooperatives where workers fully own and manage their organisations on a one-person, one-vote basis.

We advocate:

- **Draft a blueprint for a UK sovereign wealth fund** – Sovereign wealth funds (SWF) act as collective investment vehicles owned and managed by nation states.[211] Today there are around 80 funds in existence, the majority of which were established after 2000. Through its investments, a UK SWF would give workers a stake in technology and a share in the companies that benefit from automation. One option advocated by a growing number of economists is to form a fund by siphoning a portion of shares listed in every company IPO (it would not have to be limited to technology companies). This could then pay out dividends to every citizen once it has reached maturity, whether in the form of a continuous dividend (as is the case with the Alaska SWF) or a one-off grant (what might be called a 'technological inheritance').[212] The government in partnership with an alliance of civil society groups should begin drafting a blueprint for a UK SWF along these lines.

- **Expand company profit sharing schemes** – A more direct way to spread ownership of machines is by expanding company profit sharing initiatives. This would be of little use to those who lose their job to technology, but it would boost the incomes of the vast majority who remain in post. Only 8 percent of UK workplaces (with 10+ employees) are thought to operate profit sharing schemes.[213] The government could raise this number by improving tax incentives, simplifying ownership frameworks, and establishing new rights. The Employee Ownership Association recommends streamlining employee ownership legal models from five to two.[214] The government could also establish a new 'Right to Own' rule – as the Labour Party has suggested – which would give employees of a company first refusal on purchasing shares up for sale.[215]

211.  For a comprehensive analysis of Sovereign Wealth Funds, see Cummine, A. (2016) *Citizens' Wealth: Why (and How) Sovereign Funds Should Be Managed By The People For The People*. Yale University Press.

212.  Yanis Varoufakis advocates a Universal Basic Dividend along these lines. See Varoufakis, J. (2016) *The Universal Right to Capital Income* [article] Project Syndicate, 31 October.

213.  Lawrence, M. and McNeil, C. (2014) *Fair Shares*. London: IPPR.

214.  For more information see: http://employeeownership.co.uk/wp-content/uploads/The-Impact-Report.pdf

215.  The Labour Party Manifesto (2017) *For the Many, Not the Few*.

- **Champion cooperatives that turn workers into owners** – Whereas employee ownership gives workers a stake in a company alongside directors and shareholders, cooperatives are wholly owned by workers. Each person has one share and one vote, and profits are typically divided equally among staff. Viewed in the context of automation, the advantage of the cooperative model is that workers can keep more of the wealth generated by adopting new machines. At present, just 2 percent of the UK's GDP is accounted for by cooperative activity. Central and local government should look to turbocharge coop growth through practical interventions and financial assistance. This should include providing funding for coop incubators, as New York City Council has done through its new Worker Cooperative Business Development Initiative.[216.]

## Two caveats on policy and practice

Above we have presented a number of policy and practice responses to an age of automation. This includes developing an ethical framework to guide the work of AI and robotics engineers; encouraging non-profits to invest in benevolent technology that enriches the worker experience; establishing a Centre for AI and Robotics that encourages greater take-up of innovations among industry; creating personal training accounts that aid lifelong learning and help workers as they jump from job to job; shifting the burden of taxation away from labour and towards capital, which is becoming an ever greater source of income; and drafting a blueprint for a UK sovereign wealth fund that would invest in emerging technologies, and give every citizen regular dividends or one-off grants in the form of a technological inheritance.

As worthy as some of these ideas are, however, they will not break through into mainstream policy discussions until they are seen to have legitimacy in the public eye. Political history is dotted with U-turns on sensible interventions that did not receive public backing, such as Child Trust Funds, the proposed rise in National Insurance contributions for the self-employed, and more recently the move to reorganise social care payments. While our YouGov poll of business leaders reveals surprising support for some changes – such as 31 percent backing the idea of a UBI and 34 percent supporting greater employee ownership – many minds are clearly wedded to the status quo (see Figure 15). Anyone championing a more inclusive automation must therefore step up advocacy efforts and begin forging new alliances.

A second major caveat when discussing policy and practice interventions is that low-skilled work will always be with us. Implicit in many of the discussions on how to manage automation is an assumption that if only workers can retrain and rise through the ranks, they will stay ahead of machines and see an improvement in their living standards. This is also the conceit that underpins the concept of social mobility. Yet it is of course impossible for all the UK's 13.9 million low-skilled workers to move into higher skilled positions. The task facing policymakers is therefore not to 'save' people from low-skilled work, but rather to make

216.   For more information see: www.workercoop.nyc/initiative

low-skilled work more financially secure and fulfilling in the long run. If education has its limitations, and tax and welfare changes prove too politically unpalatable, then the priority should be to distribute asset ownership more widely.

More broadly, there is a conversation to be had in society about what forms of work we *value* most, which is after all what influences how much consumers are willing to pay for different goods and services. While it is easy for economic pundits and thinktanks to laud the move to a human-centric economy of caring, teaching and creative work, we must also be willing to pay for it.

**Figure 15: Business leader support for different interventions as a means of managing technological disruption**
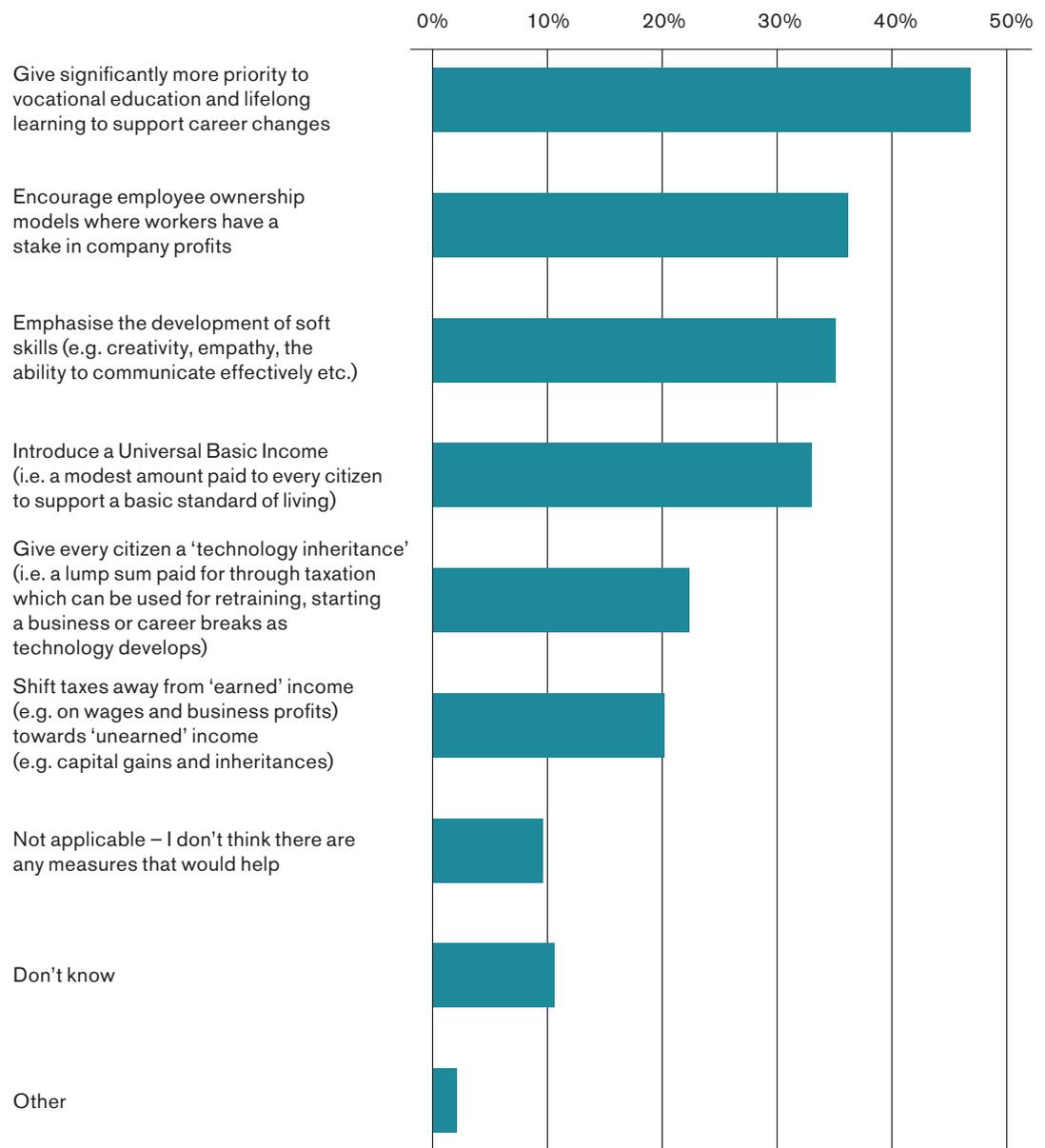


Source: RSA/YouGov survey of 1,111 UK business leaders (Fieldwork conducted 10-18 April 2017)

# Conclusion

This report has argued that AI and robotics could be a blessing to workers rather than a curse. Implemented in the right way, new machines could raise productivity levels, phase out mundane work, boost flagging living standards, and open up the space for more purposeful and human-centric jobs to prevail. Equally, however, the onward march of technology could put downward pressure on wages, lead to greater monitoring in the workplace, and exacerbate economic, geographic and demographic inequalities. The point is that technology is a tool to be wielded by society, rather than an independent force with a mind of its own. Whether or not AI and robotics helps or hinders workers will come down to the choices we make as employers, policymakers, consumers, investors and the wider public.

Yet this debate will continue to be a red herring unless we see a greater take-up of AI and robotics across our economy. The great irony at the heart of the frenzied speculation of whether new technology will lead to mass automation is that very few businesses are even embracing it. Our poll finds that just 14 percent of business leaders in the UK are currently deploying AI and/or robotics, or plan to in the near future. Moreover, sales of industrial robots to the UK decreased between 2014 and 2015, with the UK purchasing fewer robots than France, the US, Germany, Spain and Italy. This mirrors a broader picture of chronic business and public sector underinvestment in capital expenditure, which goes some way to explaining the UK's substandard productivity rates.

The RSA therefore calls for an acceleration in the take-up of this technology, but on terms that deliver an inclusive kind of automation which enriches rather than diminishes worker livelihoods. This cannot be taken for granted, and there are clear dangers of over zealously embracing technology with little regard for the consequences. To ensure AI and robotics continues to work in our favour, we highlight possible interventions that can be made at every point in the technology lifecycle: funnelling more investment into socially beneficial technology; equipping the workers of the future with relevant skillsets; creating a more nimble welfare system that can accommodate greater labour market flux; and scaling up employee ownership models where workers have a stake in company profits – among other ideas.

The RSA and other organisations will continue exploring the impact of AI and robotics on the world of work – and rightly so. But this should not distract us from addressing the social, economic and environmental problems of the here and now. And there are many: a climate that is being irreversibly changed, public services under untold pressure, and the prospect of severe labour shortages as a result of our EU departure. If anything, technology could be one of humanity's most powerful weapons in resolving these issues – whether it is the use of robotics to relieve

our strained social care system or the application of AI to identify new antibiotic treatments. Indeed, while the question on many people's lips is whether we can live with these new machines, a more pertinent one to ask is whether we can live without them.

To find out more about our research, please contact Benedict Dellot at benedict.dellot@rsa.org.uk

# Methodology

## YouGov survey

The RSA commissioned YouGov to conduct an online survey of Britain's business leaders. The survey was carried out between the 10 and 18 April 2017, with a sample of 1111. Respondents were at a senior manager / director level or above. They were required by YouGov to have major decision making involvement or influence in areas including finance, HR, telecoms and business development. The survey data was weighted to be representative of employers relative to their share of employment (ie by number of employees, not by number of businesses).

Figure 9 shows the results of a question posed to business leaders about their take-up of AI and robotics. The options listed in the key are short-hands for longer statements that respondents were asked to choose from. These were:

- **Active adopters** = 'Our business is aware of AI and robotics, and plans to invest in these technologies in the near future, or have already invested in them'
- **Slow adopters** = 'Our business is aware of AI and robotics, and wants to invest, but it will take several years for us to seriously adopt this technology'
- **Non adopters because of cost** = 'Our business is aware of AI and robotics, but will not invest in the foreseeable future mostly because these technologies are too expensive'
- **Non adopters because tech is not proven** = 'Our business is aware of AI and robotics, but will not invest in the foreseeable future mostly because these technologies have not been properly tested'

## Employer consultation

The RSA conducted interviews with senior representatives from public and private sector organisations, including a health care provider, a social care provider, a major advanced manufacturer, a logistics provider and a national supermarket chain. Most of these were interviews conducted on condition of anonymity given the sensitivity of the subject. The purpose was to understand in more detail how their organisations are deploying this technology in practice (if at all), and how their workforce had been affected. We also held a roundtable with employers earlier in 2017 to discuss the same questions as a group.

## PIAAC analysis

Our analysis of the task make-up of different low skilled occupations was based on the Survey of Adult Skills (PIAAC), which contains data on the frequency of tasks that individuals do at work. This was converted into the share of time each individual spends on a task using a modified version of an approach taken by Arntz, Gregory and Zierahn in "The Risk of Automation for Jobs in OECD Countries" (2016).

Indices were then created to reflect the importance of tasks, in terms of the time share all workers in an occupation spend on them relative to the whole economy (all workers in all occupations).

These indices were based on the engineering bottlenecks to automation, identified by Frey and Osbourne and other AI researchers. In other words, the tasks which are perceived by experts as most robot proof.

'Creative intelligence' includes the PIAAC task variables associated with creative problem solving or fine arts. 'Social intelligence' includes the variables associated with social perceptiveness, negotiation, persuasion and assisting and caring. 'Manual dexterity' is picked up in a single variable, relating to the frequency of use of hands or fingers in the workplace.

### a) Time share formula

We re-defined the answers into a work-time scale. The time share for each occupation was then calculated by dividing this unit by the SUM total work-time.

For example:

- Respondents that perform tasks "every day" would receive a score of 1.
- While respondents that perform tasks, "at least once a week but less than every day" would receive a score of 0.5. This was based on the assumption that of those who gave this response there were an equal number of those who worked 1, 2, 3 and 4 days a week, with 0.5 the average of 0.2, 0.4, 0.6 and 0.8.

### b) Indices composition

Creative intelligence: solving complex problems, writing articles, reading professional journals or publications, using advanced maths or statistics, using computer programming language.

Social intelligence: teaching people, selling, advising people, influencing people, negotiating with people, planning others' activities.

## Caveats

Assumptions: people don't perform multiple tasks at multiple times, people spend the same amount of time on different tasks that they perform every day and once a week.

How to interpret scores: a high score on a single index does not necessarily indicate a low automation risk. Frey and Osborne argue that social intelligence and creativity are more resilient to automation than manual dexterity and that jobs that combine these tasks are the most robot proof.

The RSA (Royal Society for the encouragement of Arts, Manufactures and Commerce) believes that everyone should have the freedom and power to turn their ideas into reality – we call this the Power to Create. Through our ideas, research and 28,000-strong Fellowship, we seek to realise a society where creative power is distributed, where concentrations of power are confronted, and where creative values are nurtured.

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