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Transformers

How machines are
changing every sector
of the UK economy



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Foreword

Welcome to our new report about the future of business in the UK, which continues our study of the impact of automation and robotics on work and employment. Our research this time shifts the focus from the future of occupations to the outlook for industry sectors.

Using a similar approach and model to our previous research, we have identified those sectors of the economy that are most exposed to the risk of automation and its potential to replace human labour. Our analysis looks at all areas of employment in the UK. The sectors that may be highly vulnerable to rapid advances in technology include some which are big employers today. Our research suggests that the Wholesale and Retail industry has the largest number of jobs at high risk – 2.1 million. This is followed by Transportation and Storage with just under 1.5 million jobs at high risk, and Health and Social Care with 1.3 million.

It is important to understand the limitations of our approach. The model we are using considers what is likely to be technologically possible in the next two decades. It does not consider other key factors: the difficulty of implementing technology in the workplace; social and political resistance; and the relative cost of human labour versus the expense of implementing and maintaining technology. These will act as brakes on the full potential of technology, at least for the time being.

Our work on the automation of tasks and occupations is also just one aspect of the situation. The history of technology in the UK is unequivocally positive, with more jobs being created than destroyed, and new jobs are typically better paid and more highly skilled. However the country cannot rest on its laurels: if the UK is to remain a world leader in technology, strengthening its economy and building vibrant, successful businesses for the future, business leaders, policy makers and educators need to understand the likely impact of automation on the workforce.

We hope that you find this report useful and look forward to your views.



Angus Knowles-Cutler
Vice Chairman, Deloitte LLP



Introduction

All industries will be affected by automation, but in different ways, by different technologies and to different extents. Some of these technologies are mature, and have been in use for many years, whereas others are still experimental and not yet widely adopted, but nevertheless have huge potential for disruption. These technologies are likely to have an impact on many jobs, changing the tasks that people perform and the roles that they fulfil.

Deloitte's previous research has shown that, over more than a century, the tasks that tend to be automated are typically dangerous, repetitive or routine, and this has freed up people to focus on the less routine and value-adding elements of their jobs. Tasks and roles that involve perception, creativity, human interaction, caring for others or other forms of social or emotional intelligence are, for the time being at least, much less likely to be automated.

In November 2014, Deloitte collaborated with Carl Benedikt Frey and Michael Osborne of Oxford University on "*Agiletown: The relentless march of technology and London's response*".¹ In that report, we suggested that 35 per cent of today's jobs in the UK are at high risk of automation in the next 10 to 20 years. Then in autumn 2015 we conducted a new in-depth study of the UK's labour force to understand how these hypothetical models compared with actual changes in the last fifteen years.²

That study painted a positive picture: while technology has potentially contributed to the loss of 800,000 lower-skilled jobs, there is equally strong evidence to suggest that it has helped create nearly 3.5 million new higher-skilled jobs in their place. Each one of these new jobs pays on average nearly £10,000 more per annum than the ones lost. We estimate that this technology-driven change has added £140 billion to the UK's economy in extra pay.

This report takes Deloitte's previous work and extends the analysis by investigating changes wrought by automation at industry sector level. This means that, for the first time, policy makers, educators and business leaders can begin to understand the impact of automation on their sector and make informed investment decisions based on what the future is likely to hold.

Key points from this new research

- All industry sectors have roles that are at high risk of automation and also new roles that are likely to be created as a result of automation.
- The Transportation and Storage, Health and Social Care, and Wholesale and Retail sectors have the highest proportion of existing jobs at high risk of automation.
- The greatest increases in new jobs in the last 15 years have been in the Human Health and Social Work, Education, and Professional, Scientific and Technical sectors. The greatest fall in job numbers has been in Manufacturing.
- The new jobs created in the Professional, Scientific and Technical sector pay significantly more than the new jobs created in Human Health and Social Work or Education.
- While technology is on the whole likely to create more (and generally better-paid) jobs than it destroys, some industries are likely to lose more jobs to machines than the new technologies will create.
- The UK's continued economic and technological success will rest on the ability of political, business, education and public sector leaders to anticipate correctly the future skills requirements and to provide the right education and training for developing them.

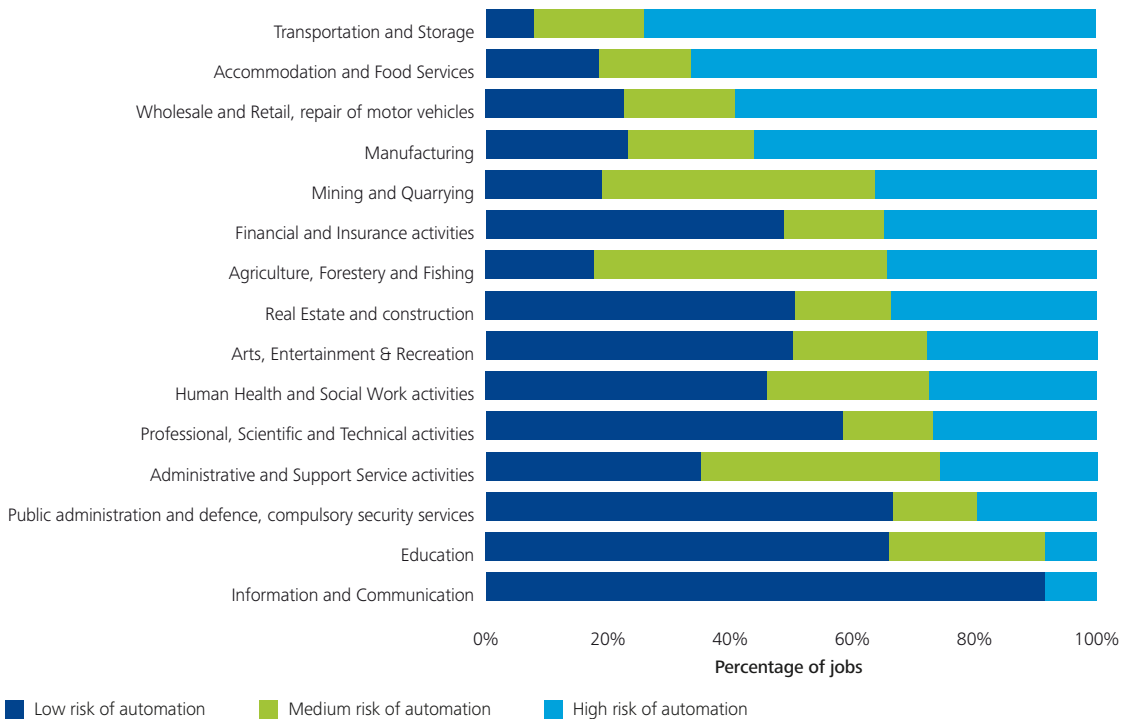
The impact of automation: sector by sector

Using the latest government employment data from the Office for National Statistics (ONS), together with estimates of the probability of computerisation for various standard occupations derived by Frey and Osborne in 2014, a model of the number of UK jobs that are at high or medium risk of automation has been constructed.^{3,4}

Figure 1 shows the probability of automation of occupations by standard industry classification, divided into high, medium and low risk.

Although some industry sectors may have a significant number of occupations at high risk, they do not account for a particularly large proportion of jobs in the UK.

Figure 1. Percentage of jobs at risk of automation in each industry sector

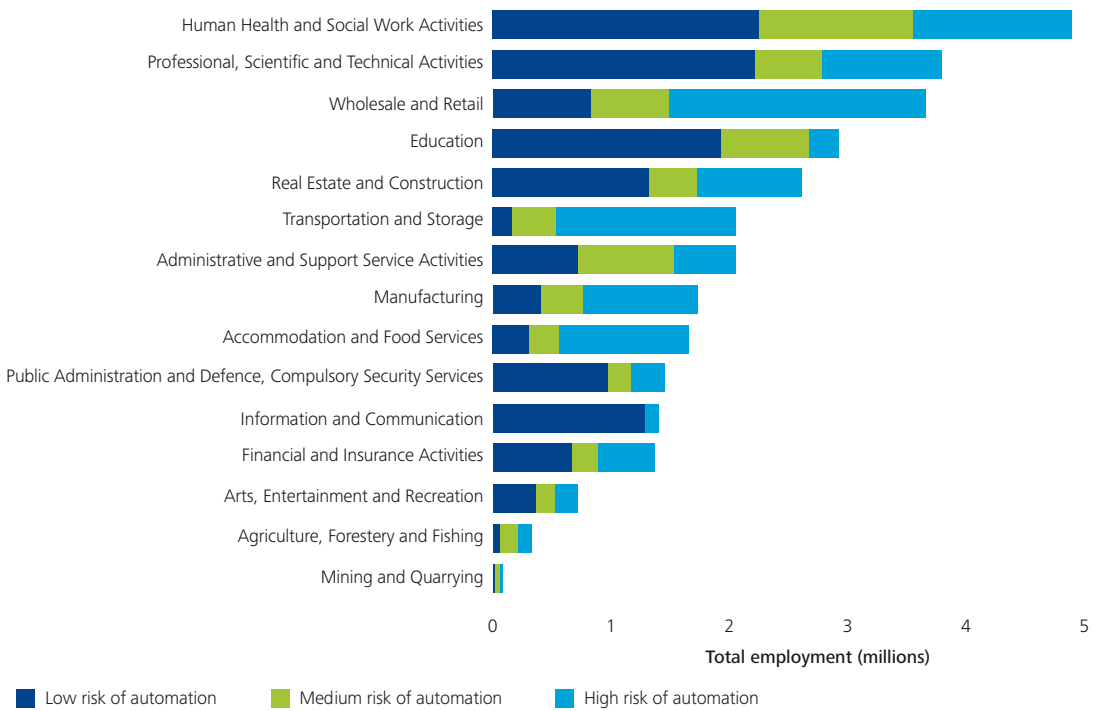


Source: Frey and Osborne, ONS, Deloitte analysis 2016

These sectors therefore have limited impact on the labour market as a whole. For example, the Mining and Quarrying sector currently represents only three per cent of all UK jobs.

Figure 2 shows the relative importance of each industry to the UK labour market, and their associated risk of automation. The industries are ranked by the number of jobs estimated to be at high probability of automation over the next 10 to 20 years.

Figure 2. Total employment by industry, 2015








Source: Frey and Osborne, ONS, Deloitte analysis 2016

For example, the Wholesale and Retail sector has the highest absolute number of jobs at high risk of automation, whereas Mining and Quarrying has the lowest.

Although technology on the whole is likely to create more (and better-paid) jobs than it destroys, some industry sectors are likely to lose more jobs to machines than the new technologies create. Industries in which jobs typically require routine repetitive tasks have seen significant declines in employment in the last 15 years, whereas industries requiring non-routine or interactive tasks have seen substantial net increases in employment.

These patterns can be seen in the decline of traditional manufacturing jobs or in the growth of the Education sector. Figure 3 gives a detailed breakdown of the number of jobs that are at high, medium and low risk of automation, relative to the total number of jobs per sector.

Figure 3. Number of UK jobs (2015) at high, medium and low risk of automation*

	Total number of jobs	High risk	Medium risk	Low risk
Arts, Entertainment and Recreation 	724,000	202,000	159,000	363,000
Agriculture, Forestry and Fishing 	327,000	112,000	157,000	58,000
Accommodation and Food Services 	1,659,000	1,103,000	250,000	306,000
Administrative and Support Service Activities 	2,052,000	528,000	804,000	720,000
Education 	2,919,000	247,000	745,000	1,927,000
Financial and Insurance Activities 	1,368,000	476,000	226,000	666,000
Human Health and Social Work Activities 	4,894,000	1,351,000	1,294,000	2,249,000
Information and Communication 	1,403,000	119,000	**	1,284,000
Mining and Quarrying 	89,000	32,000	40,000	17,000
Manufacturing 	1,733,000	974,000	357,000	402,000
Public Administration and Defence; Compulsory Security Services 	1,455,000	287,000	199,000	969,000
Professional, Scientific and Technical Activities 	3,796,000	1,021,000	560,000	2,215,000
Real Estate and Construction 	2,607,000	882,000	406,000	1,319,000
Transportation and Storage 	2,056,000	1,524,000	371,000	161,000
Wholesale and Retail 	3,656,000	2,168,000	662,000	826,000
Total UK jobs	30,738,000	11,026,000	6,230,000	13,482,000

* Nearest thousand ** Missing data

Source: ONS, Deloitte analysis 2016

Agriculture, forestry and fishing

One of the most surprising growth occupations is farming. In 2014 the UK had more than 165,000 farmers, an increase of over 100 per cent in just ten years.

Farming is in fact one of the founding tech industries. Long before today's widespread fascination with self-driving cars, farmers were using self-driving tractors to seed, spray and harvest their crops using a combination of robotics and GPS technology. In the hills and mountains of Wales, researchers are starting to connect sheep to the Internet of Things, which helps farmers to track and look after their animals remotely. Almost every aspect of agricultural or livestock farming can now benefit from the application of automation or robotics.^{5,6}

This has not led to the expected fall in jobs, however, because farmers have adapted to work with, and not against, technology. The occupation has evolved over decades from tasks requiring predominantly routine manual labour to ones now dependent on higher-level cognitive skills mixed with machinery muscle. The net result is greater efficiency and higher yield to meet ever-growing consumption demand.⁷

Accommodation and food services

San Francisco's Financial District is home to the new high-tech fast food restaurant, Eatsa, which opened in Summer 2015. Although there is a small team of kitchen staff, customers do not interact with them: the entire front-of-house experience has been automated. In the restaurant, customers order their food via tablets and, when their meal is ready, collect it themselves from a small glass compartment. The founders of Eatsa cite the efficiency gains provided by automation that allow them to offer a new experience that combines good quality food, speed and low prices.⁸

But if this is a sign of things to come, why has the number of waiters and waitresses in the UK grown by around a third in past 15 years?

Social resistance to change is likely to be a factor. Human interaction is an integral part of the dining-out experience, and quality of service for many consumers relates to more than simply receiving food promptly and at the right temperature. Nevertheless, where both convenience and low price are demanded, humans are likely to be progressively relegated to scarcer, higher-skilled restaurant occupations that machines cannot (yet) easily replace – such as chefs.

Another factor is pure economics: the cost of labour versus the cost of technology. As long as it costs less to pay people to wait on tables than to buy and maintain robot servers of equivalent functionality and flexibility, ongoing demand for leisure services will continue to be met by a largely human workforce.⁹

Business support services

Technology is replacing humans in many office support functions. For example Deloitte's analysis shows that, compared to 2001, there are 200,000 fewer 'personal assistants and other secretaries'. Other clerical roles have also seen big declines in employment over the same time period, across all industries.

Some of the tasks within these administrative occupations have been steadily digitalised since the introduction of the internet, with email and digital calendars reducing the effort associated with correspondence and organising meetings. For personal assistants, developments in voice recognition technology enable computers to decipher and type up dictation, and experimental 'intelligent personal assistant' initiatives use personal data to predict and respond to an individual's pre-programmed needs.¹⁰ These initiatives are often supported by human labour, but it is expected that in time, aided by machine learning, the technology will become largely self-sufficient.

More recent advances in technology, such as Robotic Process Automation (RPA), are affecting occupations where precision in repetitive tasks is essential, such as book-keeping or managing other financial processes. RPA tools are able to automate key rules-based processes, so they are software robots rather than physical ones, which can access emails, systems and files as well as use pre-built logical rules to deliver outputs. They are typically given the same system access as humans, and are hosted on virtual machines so that their capability can be scaled up or down as needed. Unlike humans, they can operate 24 hours a day, 365 days a year.

Deloitte is deploying RPA within its own shared service centres, using it to automate repetitive but key processes, with positive results. This includes using a “bot” to analyse WIP (Work in Progress) reports. Set-up took less than six weeks, which included defining the process, building the automation and testing it. The manual process (pre-RPA) used up to ten staff. Initially, once RPA was embedded, it was possible to process 80 per cent of cases without human intervention. Over a three-week period the algorithm behind the RPA was updated and improved, and it can now process approximately 97 per cent of cases without human intervention, faster, and to 100 per cent accuracy. This pilot is now being introduced to the rest of the business, with potential to automate further transactional activity across Deloitte’s business support functions.

Human health and social work activities

According to Deloitte’s analysis, since 2001 the single biggest growth occupation in the UK has been care workers and home carers, with 274,000 new jobs. To some extent this runs counter to predictions, since Frey and Osborne forecast that this occupation has a 50 per cent chance of being automated in the next 10 to 20 years. This raises some interesting points around the rate of technological advance, and changing demand for goods and services.

It is a well-documented fact that the UK has an ageing population, and therefore a growing requirement for social care.¹¹ The nature of this occupation currently requires workers to have skills and qualities that cannot yet be easily replicated by machines. Some experimental technology, such as Robear, is being trialled to lift and carry elderly patients, thereby automating certain repetitive, physical elements of the job.¹² However new technology that can detect falls, sense motion, and provide other alerts based on data relayed by sensors from within a patient’s home, is now becoming more widely available and is aimed at helping more people to live independently for longer. Analysing the data relayed from these sensors would enable health care providers to plan and deploy their workforce more effectively, optimising resources, and to offer an appropriate care package at a lower cost but of higher quality.¹³

Manufacturing

Automation in manufacturing has evolved over the centuries, from basic mechanisation using systems such as hydraulics, which have literally taken the heavy lifting out of the production line, to intelligent automation whereby more complex tasks can be completed without human intervention.

Successful firms will be capable of adapting their physical infrastructure and human capital rapidly to exploit changes in technology as manufacturing processes become faster and more responsive to changing global markets.¹⁴

Manufacturing in the UK has a prominent position on the world stage. For example the UK has the second-largest aerospace sector in the world, representing a 17 per cent share of the global industry, with three thousand companies employing a total of 230,000 people.¹⁵

In order to harness productivity and efficiency gains through automation, the industry is taking a coordinated approach to developing their supply chains through a number of supplier development programmes such as Sharing in Growth UK Ltd, which was set up in 2013 to deliver programmes of intensive supplier development over four years.

The scheme provides concentrated business transformation to the suppliers of Original Equipment Manufacturers (OEMs). Among other things, this helps suppliers to invest in new equipment and facilities and at the same time invest in staff training, enabling them to secure higher-skilled roles working alongside new technology.¹⁶

The combination of investment in technology and training and development has resulted in the lead 20 companies in the programme securing more than £1 billion in contracts. The success of Sharing in Growth has meant that the Regional Growth Fund has invested £30 million on top of its original £50 million in the scheme.¹⁷

Retail

Employment in the Wholesale and Retail sector has declined by the second-largest amount (behind Manufacturing), and according to Deloitte's analysis now employs 300,000 fewer people than in 2001. Almost a quarter of the job losses in this industry have affected cashiers and shelf fillers.

The decline in high street retail occupations is likely to have been driven by the trend towards online shopping, as well as the introduction of technology to facilitate self-service in many shops. Online shopping grew by over 16 per cent in 2014 compared to 2013, with approximately 11 per cent of retail revenue coming from internet sales in March 2015.¹⁸ Online retailers often have different employment and property requirements, compared to traditional high street shops.

Many retailers have leased (or bought) warehouses in strategic locations, to optimise efficient distribution of their goods across the country.¹⁹ Initially, employment at these warehouses would have been undertaken primarily by humans. However, improvements in robotic dexterity and cognitive capability mean that robots can now organise and prepare stock for shipment. Some organisations have adopted technology in their warehouses very effectively, optimising automation and machine-human collaboration.²⁰ These robots either rearrange the shelves in neatly-packed rows or bring them over to human workers, who stack them with new products or retrieve goods for packaging.

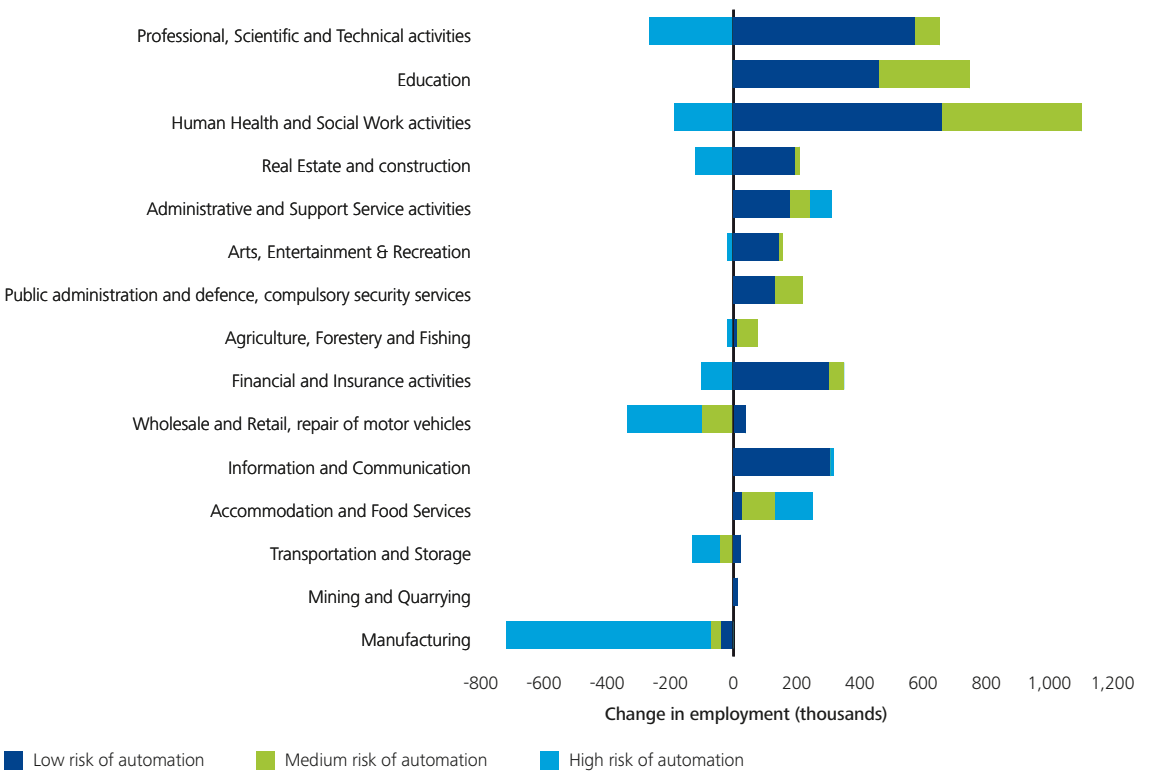
Traditional shop-based retailers have embraced new technology and data analytics to reduce labour costs and optimise price points. Technology, in the form of self-service check-outs, have been widely adopted and significantly reduce the need for cashiers in store. However, while automation has helped retailers address the efficiency challenge in many areas of the business, service remains an important differentiator, particularly in-store.

Retailers also make good use of data collected through loyalty schemes and other sources to understand the preferences of shoppers at an individual level and en masse.²¹ This helps them to make informed decisions about store locations, staffing levels and stock, as well as delivering highly personalised and largely automated advertising campaigns.

How has the number of employees changed over the last 15 years?

Figure 4 shows the disruption in each industry in context, by comparing the relative growth (or shrinkage) of each sector's share of UK employment. Manufacturing's share of UK employment has fallen most, and the largest increases are in Human Health and Social Work, and the Education sectors.

Figure 4. Absolute change in employment by sector, 2001-2015

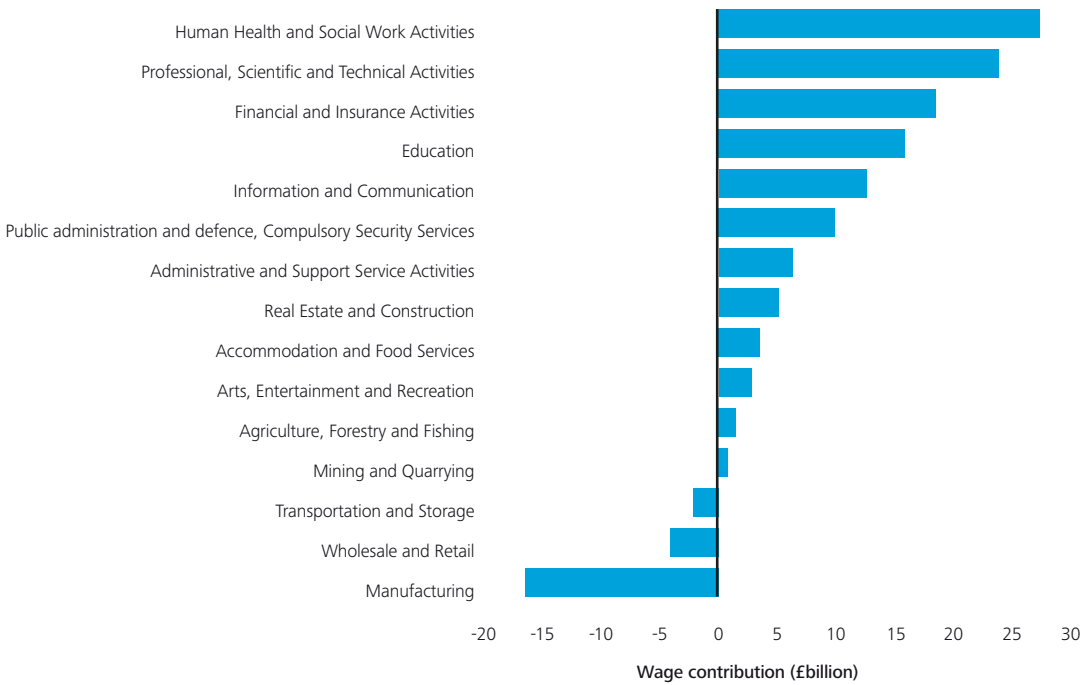


Source: Frey and Osborne, ONS, Deloitte analysis 2016

Figure 5 shows the contribution of wages, by sector, to the UK economy over the last 15 years. The sizeable fall in manufacturing wages is to be expected, given the large fall in the number of jobs in the sector. The two sectors showing the biggest increases in wages are Human Health and Social Work, and Professional, Scientific and Technical Activities. When the increase in wages in these two sectors is related back to the increase in jobs shown in Figure 3 it is clear that the increase in wages is not evenly spread.

Many more jobs have been created in Health and Social work than in Professional, Scientific and Technical, but these jobs are considerably lower paid. Also Education, with the second-largest increase in new jobs in Figure 4, shows a relatively limited increase in wages. This reflects the fact that many of the new roles in the Education sector are also not paid as well as those in Professional, Scientific and Technical activities.

Figure 5. Wages contribution to economy by sector 2001-2015 (In £ billion)



Source: ONS, Deloitte analysis 2016
















Jobs lost versus jobs created

Although workers in some industries may be displaced by technology, this does not necessarily mean that businesses will be at risk of failing. Indeed, for many businesses the increased opportunity to automate their processes and functions will lead to improved productivity, profitability and competitiveness.

The challenge will be to provide the right support for displaced workers to re-skill and take on the newly created jobs. In industries with net job creation, there may be an incentive for employers to retrain their staff so that they can take on new roles in other parts of the business. However, in industries where net job displacement is expected, employers may not have the same incentive to retain their staff; therefore there could be a role for the state in helping those workers to retrain and find employment elsewhere.
















Within every industry sector there will be a certain number of jobs that are especially vulnerable to automation. Equally, there will be those at very low risk. Both differ from industry to industry, but this does not necessarily explain the overall change in employment since 2001. Figures 6 and 7 look at the jobs within sectors that have shown both the highest growth and the highest fall over the last 15 years.

Figure 6. The largest growth occupations for each industry, 2001-2015

	Probability of automation	Change in employment to nearest 1,000	Average earnings to nearest £100
Arts, Entertainment and Recreation Fitness Instructors 	10%	31,000	£10,200
Agriculture, Forestry and Fishing Farmers 	64%	77,000	£24,300
Accommodation and Food Services Chefs 	57%	104,000	£17,400
Administrative and Support Service Activities Beauticians and Related Occupations 	19%	57,000	£12,400
Education Teaching Assistants 	56%	253,000	£11,700
Financial and Insurance Activities Business and Financial Project Management Professionals 	11%	171,000	£49,200
Human Health and Social Work Activities Care Workers and Home Carers 	50%	274,000	£12,800
Information and Communication Programmers and Software Development Professionals 	8%	101,000	£40,300
Mining and Quarrying Production Managers and Directors in Mining and Energy 	25%	13,000	£62,500
Manufacturing Purchasing Managers and Directors 	59%	22,000	£52,100
Public Administration and Defence; Compulsory Security Services Business and Related Associate Professionals 	66%	67,000	£30,000
Professional, Scientific and Technical Activities Managers and Proprietors in other Services 	25%	101,000	£36,000
Real Estate and Construction Property, Housing and Estate Managers 	25%	101,000	£38,900
Transportation and Storage Taxi and Cab Drivers and Chauffeurs 	70%	39,000	£16,500
Wholesale and Retail Sales Supervisors 	28%	100,000	£18,000

Source: Frey and Osborne, ONS, Deloitte analysis 2016

Figure 7. The largest declining occupations for each industry, 2001-2015

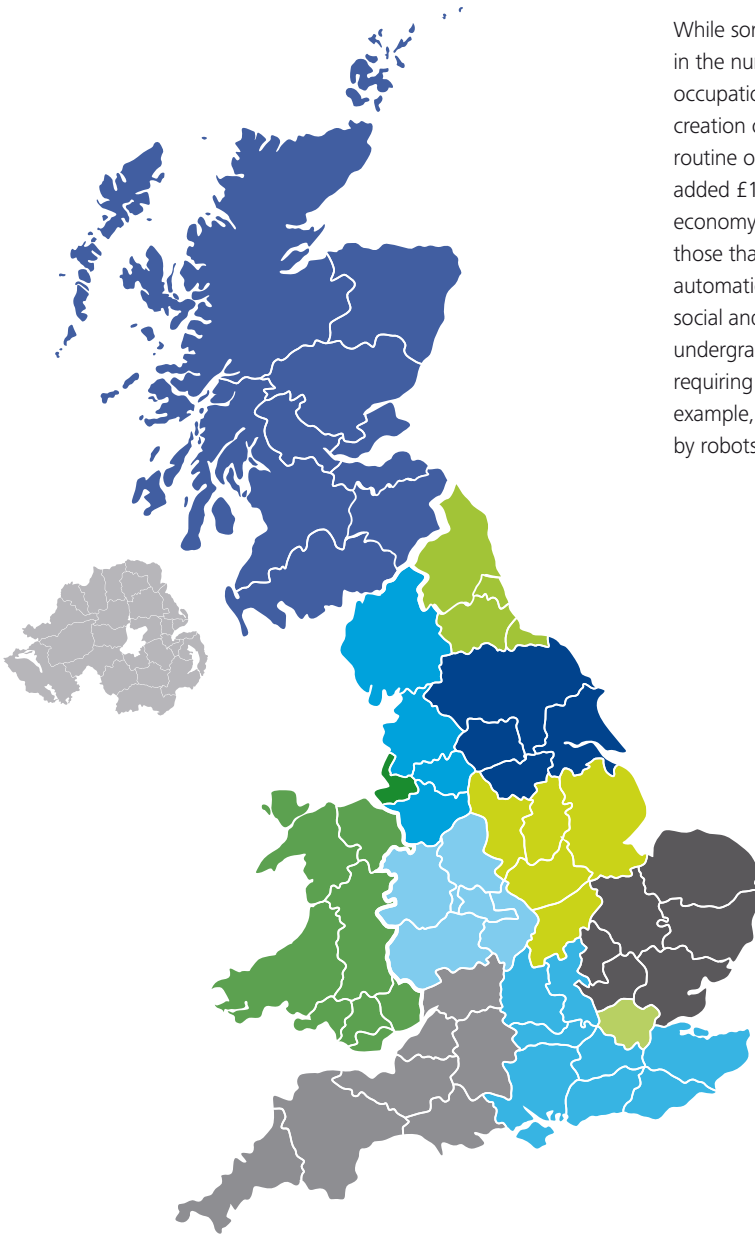
	Probability of automation	Change in employment to nearest 1,000	Average earnings to nearest £100
Arts, Entertainment and Recreation Library Clerks and Assistant 	97%	27,000	£12,200
Agriculture, Forestry and Fishing Fishing and Other Elementary Agriculture Occupations 	95%	11,000	£15,600
Accommodation and Food Services Cooks 	82%	8,000	£11,400
Administrative and Support Service Activities Travel Agents 	18%	27,000	£18,400
Education Educational Support Assistants 	56%	17,000	£11,600
Financial and Insurance Activities Bank and Post Office Clerks 	98%	105,000	£19,500
Human Health and Social Work Activities Typists and Related Keyboard Occupations 	99%	111,000	£16,500
Information and Communication IT User Support Technicians 	22%	11,000	£29,300
Mining and Quarrying Quarry Workers and Related Operatives 	79%	5,000	Unknown
Manufacturing Assemblers (Electrical and Electronic Products) 	94%	63,000	£19,500
Public Administration and Defence; Compulsory Security Services Local Government Administrative Occupations 	96%	22,000	£20,300
Professional, Scientific and Technical Activities Personal Assistants and Other Secretaries 	85%	212,000	£19,600
Real Estate and Construction Bricklayers and Masons 	82%	38,000	£22,800
Transportation and Storage Postal Workers, Mail Sorters, Messengers and Couriers 	80%	70,000	£23,200
Wholesale and Retail Retailers Cashiers and Check Out Operators 	97%	75,000	£9,500

Source: Frey and Osborne, ONS, Deloitte analysis 2016

Although workers in some industries may be displaced by technology, this does not necessarily mean that businesses will be at risk of failing. Indeed, for many businesses the increased opportunity to automate their processes and functions will lead to improved productivity, profitability and competitiveness.

The UK regional picture

Our report *From brawns to brains*, published in September 2015, showed that every nation and region in the UK benefitted from the application of technology to work, both in terms of the numbers of new jobs created and wages.²²



While some regions have seen a decline in the number of jobs in high-risk, routine occupations, this has been outweighed by the creation of new jobs in higher-skilled, non-routine occupations, which have collectively added £140 billion (net) in value to the economy in new wages. Higher-skilled jobs are those that are considered to be at low risk of automation because they require management, social and cognitive skills typically taught at undergraduate level, or are highly vocational, requiring a degree of manual dexterity, for example, and not easily replicated currently by robots.

Figure 8. Summary of regional employment, 2001-15

Region	Increase in high skill jobs	Increase in medium skill jobs	Increase in low skill jobs	Net job creation	Economic value added (£bn)
South East	47%	28%	-3%	845,000	31
London	41%	42%	1%	870,000	30
East of England	29%	22%	-9%	306,000	11
South West	19%	8%	-21%	256,000	11
Scotland	31%	21%	-4%	317,000	11
East Midlands	35%	22%	-11%	221,000	8
Yorkshire and Humber	30%	22%	-11%	214,000	8
North West	24%	16%	-12%	152,000	7
West Midlands	24%	23%	-14%	152,000	6
Wales	31%	29%	0.1%	221,000	6
North East	27%	26%	-6%	131,000	4
Merseyside	48%	32%	6%	127,000	3
Northern Ireland	8%	5%	-9%	135,000	3

Source: Frey and Osborne, ONS, Deloitte analysis 2016

Figure 8 shows that London and the South-East have been particular winners in growth in employment during the last 15 years; this has been driven mainly by growth in high-skilled, non-routine jobs at low risk of automation. However, all regions have seen equivalent proportional increases in employment for these kinds of occupations. The South West, North West and the West Midlands, in particular, have experienced greater-than-average job losses in low-skilled, routine occupations more at risk of automation.

With the exception of London, all regions and nations in the UK show that the biggest growth in jobs since 2001 has been in the Human Health and Social Work, Wholesale and Retail, Education, and Professional, Scientific and Technical sectors, in that order. In London, the largest increase has been in Professional, Scientific and Technical activities, followed by the Human Health and Social Work, and Wholesale and Retail sectors.

Conclusion

The technology-driven shift in recent years has created nearly four times more jobs than it has lost, and it has brought considerable additional value to the UK's economy. However, while repetitive manual and cognitive tasks continue to be automated, further technology adoption is likely but not necessarily guaranteed in every case.

New technology can be expensive and perform inconsistently. For the moment, it may also be considered unsafe or even undesirable. Technology must be smarter, faster and cheaper than the human endeavour it replaces, and above all it has to be socially acceptable if it is to be widely adopted.

As technologies mature, however, and machines become more able to perform tasks consistently in ways that compare favourably with those delivered by human labour, they will be called on to do more. In these circumstances, businesses and public sector organisations are more likely to spend their time and money understanding how automation can augment their current operating models, as well as the implications for their human workforce.

The potential benefits of technology in the workforce, and the rewards that it can bring in terms of innovation and productivity, are high. However employees in some sectors and occupations are likely to need a substantially different skillset to take full advantage of these opportunities. Workers will need to be agile, flexible and willing to retrain, and they will also need access to relevant, high-quality training. Above all, success in the future economy will require employers, educators and policy makers to anticipate future skills requirements correctly, and provide the right education and training for both the existing and future workforce, in schools and universities, and throughout working lives.

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