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BRIEFING

Robot wars
Automation and the labour market

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July 2016

Summary

Should we be concerned that robots will 'take all the jobs'? Certainly there is no shortage of exciting new technologies on the horizon and, although predictions of technological unemployment have never yet come to pass, it is worth assessing what we know about our labour market and automation.

A quick look at the make-up of UK employment shows just how diverse it is, with some sectors having more immediate potential for new technologies than others. Indeed, looking backwards there has been a strong link between the 'routineness' of occupations and their decline. While there are many other factors at play, this provides some backing to those who have tried to assess which jobs (or which tasks within them) have the highest probabilities of future automation.

The decline in routine jobs is also associated with the 'hollowing out' phenomenon, whereby those jobs that were in the middle of the pay distribution have fallen as a share of total employment. However, what is often overlooked is that there has been a counteracting 'filling in' of the middle of the labour market. Jobs such as those in secretarial work, administration and manufacturing have been replaced by (or re-categorised as) new jobs in business, management, science, teaching and care. This is why there has been little change is the distribution of pay (except for those affected by the minimum wage and those at the very top) and why the employment rate has reached record highs.

This is not to dismiss the disruption that can be caused to particular individuals, businesses and localities by gross job losses. However, this paper also provides evidence that large declines in employment – as have been seen in many of the UK's manufacturing industries over the past 20 years – are in part down to reduced inflows of young people, with older workers seemingly continuing in those jobs until retirement. While this presents its own challenges in terms of opportunities for young people, it provides some hope that jobs may be – by design or otherwise – 'grandfathered' in the face of automation or other decline.

In any case, what the UK needs – with its high employment, terrible productivity performance and low investment – is more robots. And public policy may be adding to this need. The welcome National Living Wage is increasing labour costs at the bottom, while the – as yet unclear – nature of Britain's exit from the EU may lead to reductions in low-skilled immigration. Looking at those sectors with the highest proportion of EU migrants, we find that some (such as cleaning and domestic staffing) face relatively low prospects for automation, while others (such as agriculture, food manufacturing and food and drink services) may see new pressures (or opportunities) to automate.

Concerns over technological unemployment are widespread, driven by the rapid pace of technological change

Books such as "The Second Machine Age" [1] and "Rise of the Robots" [2] have helped popularise the notion that many jobs will soon be made obsolete by rapid improvements in technology. At the same time, progress is readily apparent in technologies such as driverless cars, (aerial) drones and supermarket self-checkouts. Most recently, the victory of the 'AlphaGo' program at the game Go was seen as a significant milestone in the development of general-purpose artificial intelligence. And all this is on top of the deeply related IT and internet revolutions that have already changed the world so much.

In their much-cited 2013 paper, academics Frey and Osborne assert that as many as 47 per cent of jobs in the US are susceptible to automation over the next two decades.[3] This claim fits neatly with existing narratives concerned with the rise of inequality, low earnings growth and a 'hollowing out' of the labour market. According to such accounts, robots will make a bleak future bleaker as mass technological unemployment creates an ever-growing group of have-nots, with profound consequences for already over-burdened welfare states.

Yet recent research from the OECD suggests that the scale of the threat from automation may have been overstated.[4] The authors dispute the idea that whole occupations will disappear in the medium term as a result of technological advances. Instead, they argue that only certain *tasks* are in jeopardy, reducing the threat in the US to only 9 per cent of jobs over the next 20 years. Others point out that while the idea that machines will displace workers has a venerable tradition, history has so far not borne the prognostics out. Instead, to date automation has in the round led to the creation of new jobs and improved living standards.

It is tempting nonetheless to argue that "this time is different", due to the transferability of new robot skills and therefore the number of jobs that might be affected and the shortness of the timespan in which this might happen. While the UK's recent economic performance of high employment, low investment and terrible productivity provides little evidence that a new machine age has already arrived, it is certainly worth looking at what the past and present of the UK's labour market might be able to tell us about the risks and opportunities of job automation.

[1] E Brynjolfsson and A McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, 2014

[2] M Ford, *The rise of the robots: Technology and the Threat of a Jobless Future*, 2015

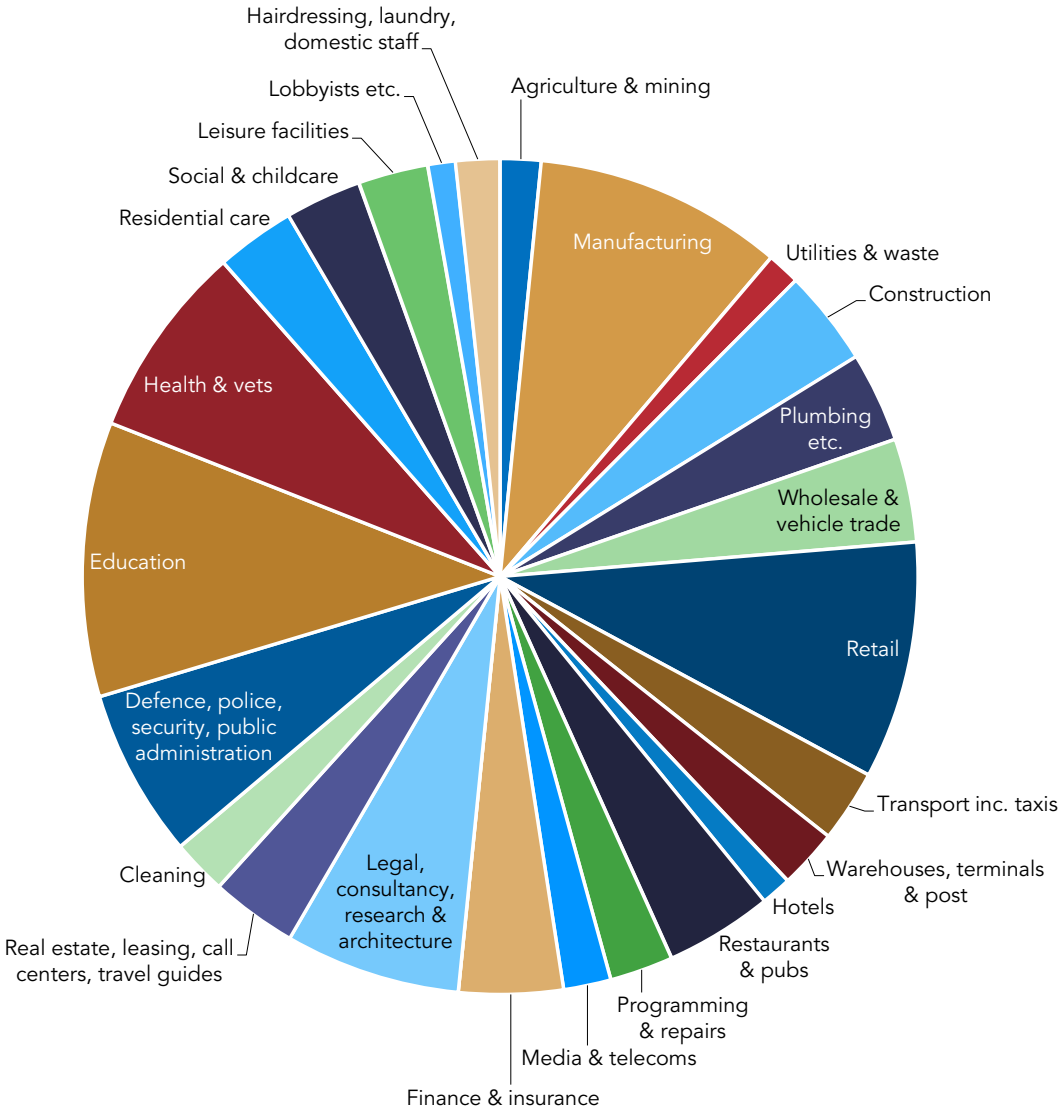
[3] C Frey and M Osborne, *The future of employment: How susceptible are jobs to computerisation?* Oxford Martin School Working Paper, 2013

[4] M Arntz, T Gregory and U Zierhan, *The Risk of Automation for Jobs in OECD Countries A Comparative Analysis*, OECD Social, Employment and Migration Working Papers 189, 2016

The UK economy is diverse and automation will not be felt equally

Any assessment of the risks of (or, more optimistically, the potential for) automation needs to start with an understanding of the industrial make-up of the workforce in the UK. Figure 1 sets out the current composition, showing that the UK economy is highly diverse though clearly now dominated by services. Manufacturing makes up only 10 per cent of the country's 31 million jobs (counting only individuals' primary jobs), while education represents 11 per cent and retail 9 per cent.

Figure 1: Industrial composition of the UK's workforce in 2015-16



Source: RF analysis of LFS. Includes the self-employed. Individuals' main jobs only.

A similarly diverse array of technologies would be needed to deliver large-scale automation across the UK. Given current levels of innovation, it is easier to imagine the replacement of workers with machines in some sectors than others.

Some of the more foreseeable (though still highly speculative) technology-driven changes in the labour market might include taxi and freight drivers, among others, being ultimately replaced by autonomous vehicles, and automation trends in manufacturing and warehouses continuing. And the internet and AI may doubtless continue to change service jobs: think of the reduced need for travel guides, or the use of self-service fast-food.

But it is harder at this point in time to see robots readily replacing plumbers or carers, for example, although new technologies may still be set to play a complementary rather than competitive role in these sectors.

This is not to dispute that automation may significantly change the UK's labour market in coming years. However, given the diversity of the workforce it is fair to assume that the replacement of workers with machines is likely to occur slowly and unevenly. But beyond speculation, it is useful to consider which types of jobs have contracted in the recent past, and what the aggregate and individual impacts of observed declines have been.

Routineness has been a strong predictor of job losses in the past

The composition of the UK's workforce is influenced by many factors other than automation, with innovation, changing skills and education, demographics and policy all playing significant roles. While it is not possible to unpick the various effects of each here, one thing that can be said with some certainty is that there is a link between the 'routineness' of occupations and their decline as a share of the UK's jobs.

It is possible to explore this claim this with some rigour. To begin, we rank different occupational groupings using a 'Routine Task Intensity' score developed by Autor and Dorn.[5] These scores assess the prevalence in each occupation of routine tasks, on the one hand, and abstract and manual tasks on the other: the idea being that routine movements and judgements are more likely to be automatable, while planning and eye-hand-foot coordination are less likely to be. This gives office clerks the highest (most routine) score of 2.24 and managers of small enterprises the lowest (least routine) score of -1.52.[6]

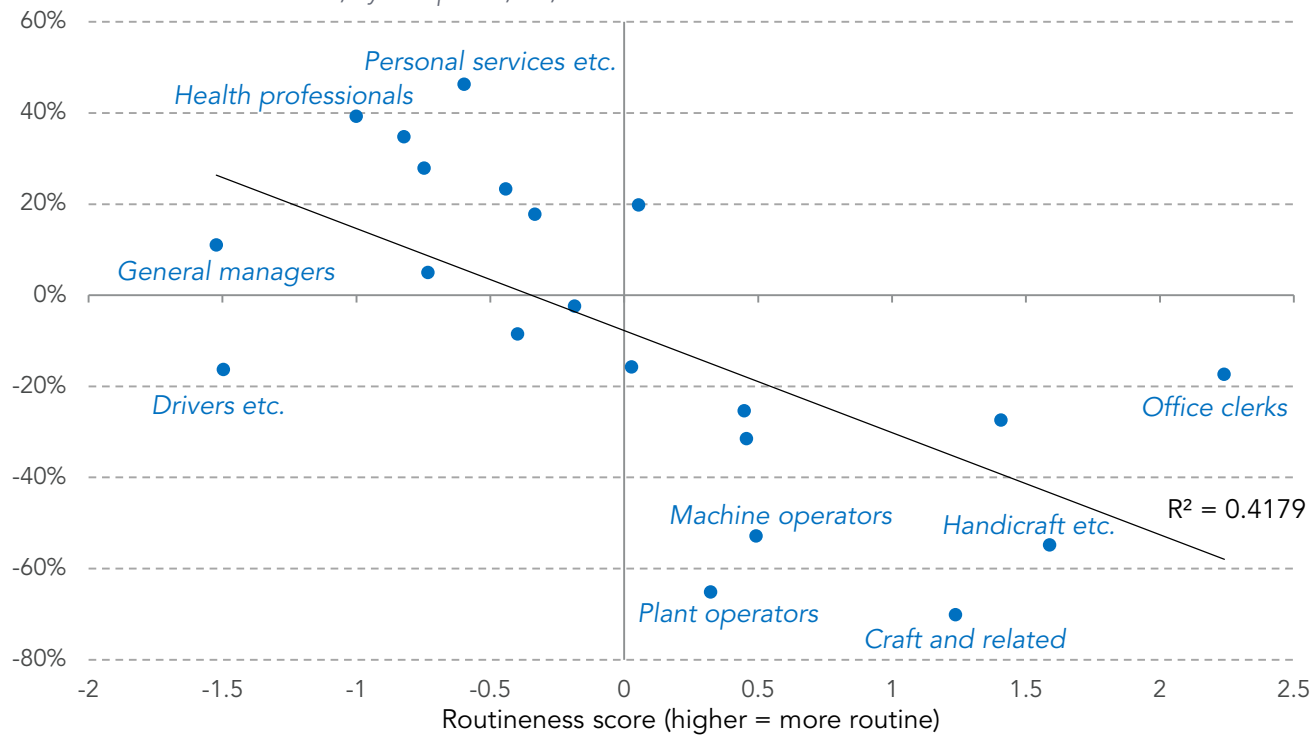
Following work by Goos, Manning and Salomons, we can use these scores to test the relationship between employment share and routineness in the UK from 1993 to 2015-16. As Figure 2 shows, there is a strong correlation between the routine nature of an occupation and the decline in the share of hours worked over time. For example, machine operators and assemblers with their relatively high routineness score of 0.5 represented almost 5 per cent of hours worked in the UK in 1993. By 2015-16, that share had fallen by over 50 per cent.

[5] D Autor and D Dorn, *The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market*, 2013

[6] These scores are normalised. See M Goos, A Manning and A Salomons, *Explaining Job Polarization: Routine-Biased Technological Change and Offshoring*, 2014 for more details

Figure 2: Occupation routineness as a good predictor of (negative) growth in share of hours

Growth in share of hours worked, by occupation, UK, 1993 to 2015-16



Source: RF analysis of LFS, using routineness (Routine Task Intensity) scores from Autor and Dorn, via Goos, Manning and Salomons

Similar studies which use different assessments of routineness and occupational divisions confirm this finding,[7] as does our own preliminary analysis using skills data from the UK Skills and Employment Surveys.[8]

The jobs lost in the last twenty years have mainly been from sectors in the middle of the pay distribution

The disproportionate loss of routine jobs has led to what is often called 'hollowing out' or 'occupational polarisation' in labour markets across richer countries. This is characterised (particularly in some of the early literature focusing on the US) by a decline in the share of employment accounted for by jobs in the middle of the pay distribution and offsetting increases in shares at the top and the bottom. As we have shown previously, the UK pattern over the past 20 years is not quite as 'u-shaped' as this theory suggests: employment shares have risen more strongly at the top than at the bottom in our analysis.[9] Nevertheless, a Nike 'swoosh' polarisation pattern is still apparent.

Figure 3 illustrates the point. As this makes clear the sectors that have recorded the biggest relative (and usually absolute) decline in the UK over the last two decades include skilled trades (agricultural, metal, electrical, construction, textiles and others); process, plant and machine operatives; and administration and secretarial occupations.

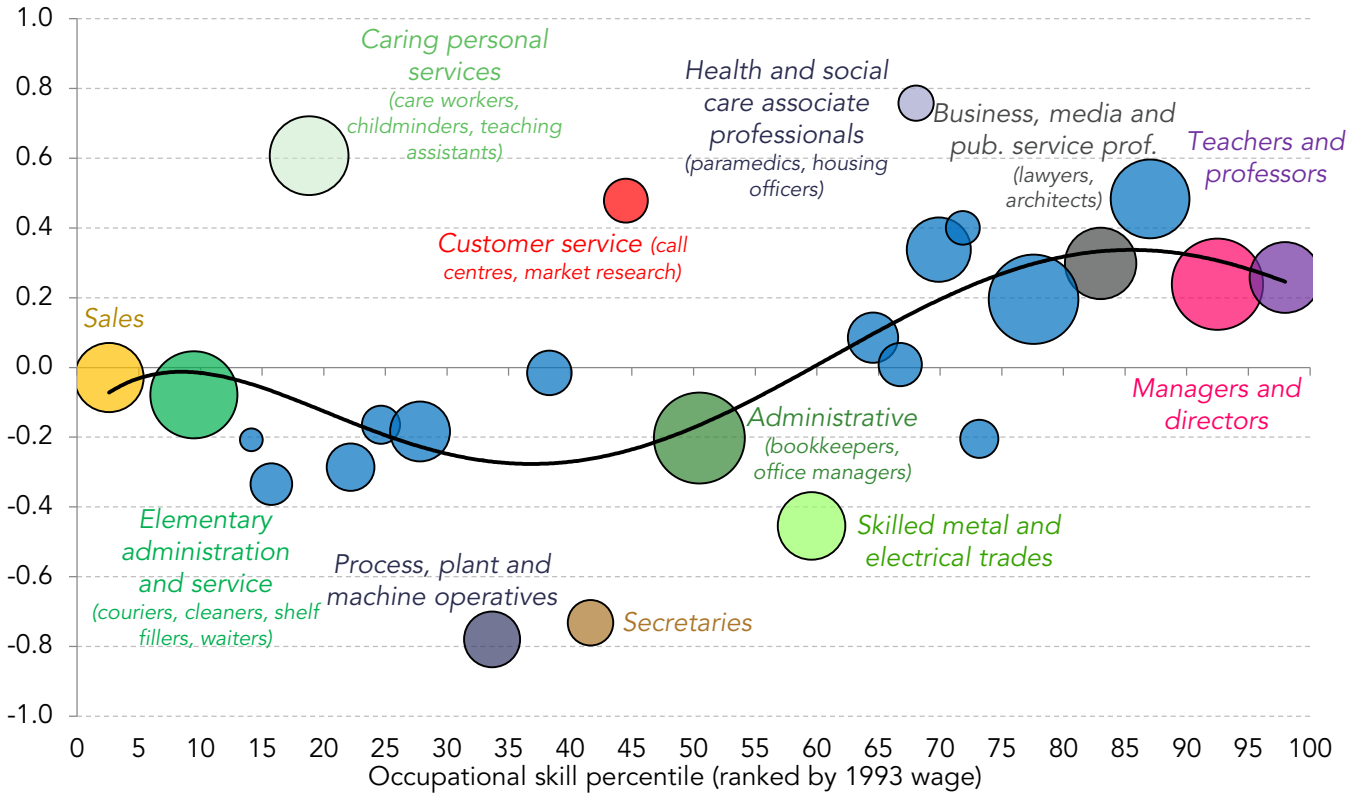
[7] J Plunkett and J Paulo Pessoa, *A polarising crisis?*, Resolution Foundation, 2013

[8] Unpublished Resolution Foundation analysis.

[9] L Gardiner and A Corlett, *Looking through the hourglass: hollowing out of the UK jobs market pre- and post-crisis*, Resolution Foundation, 2015

Figure 3: The 'hollowing out' phenomenon

Change in (log) share of employee hours by occupation: 1993-2015



Source: RF analysis of LFS. Bubble size represents occupation's share of hours in 2015. Best fit line not weighted by shares of hours.

There are competing theories as to why the middle of the pay distribution has been more disrupted than the top or bottom over this period of time. One argument is that routine jobs (which are also more easily offshored) simply happened to be concentrated more in the middle of the pay distribution in this period.[10] An alternative and contested explanation, however, is that these occupations are always first in line for automation *because* they use more highly trained, better paid staff and therefore, according to this theory, have greater financial incentives to invest in automation.[11]

But there has been no hollowing out of the pay distribution and employment is at record highs

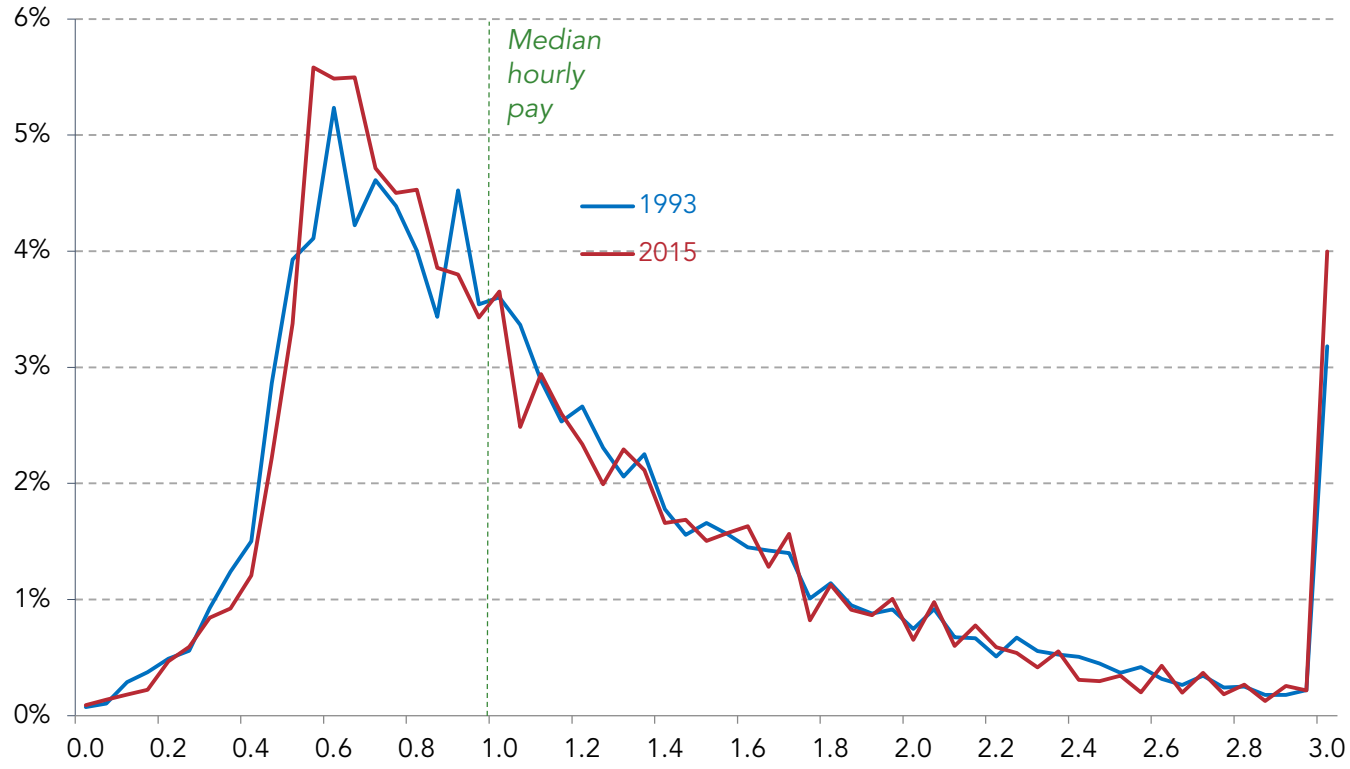
It is natural to expect to see the loss of jobs from the middle of the distribution reflected in the pay picture but this is not the case. Figure 4 shows that, despite the decline in many routine occupations recorded since 1993, there has been very little change in the employee pay distribution. Instead, the only small changes we observe are a small bunching around the 60 per cent of median pay point explained by the introduction of the national minimum wage during this time, and an increased proportion of employees paid more than three times the median hourly rate.

[10] L Gardiner and A Corlett, *Looking through the hourglass: hollowing out of the UK jobs market pre- and post-crisis*, Resolution Foundation, 2015

[11] A Feng and G Graetz, *Rise of the Machines: the Effects of Labor-Saving Innovations on Jobs and Wages*, 2015. The historical US examples of hollowing out that they give are attributed to steam power from 1850-1880 and electrification in the first half of the 20th century.

Figure 4: The shape of the pay distribution – relative to the median – in 1993 and 2015

% of employees in each pay band relative to median pay



Source: RF analysis of LFS. Hourly pay, capped at 3x the median.

In addition, despite the decline of certain occupations (and despite the turmoil associated with the financial crisis of 2008), the UK's employment rate currently stands at a record high.[12] This also holds true for groups who are disadvantaged in the labour market, such as the low-skilled.[13] Underemployment among those in work remains higher than pre-crisis but is declining, suggesting that this remains a cyclical rather than structural change to the labour market.[14]

Given that the pay distribution and employment levels have seemingly been unaffected by declines in middle-skilled occupations, has the 'hollowing out' narrative been overplayed?

New jobs have been created which have filled in the gap

To unpack what has happened within the labour market as particular occupations have declined, Figure 5 looks at changes in their importance within each separate pay decile. Unlike Figure 3, which ranked occupations based on their average wage in 1993, Figure 5 divides the population up by pay in both 1993 and 2015 and looks at changes within these. So, for example, while administrative roles have declined by 2 per cent overall as a share of hours worked, the decline has been larger in the top half of the pay distribution: administration made up a *greater* share of the fourth pay decile in 2015 than it did in 1993.

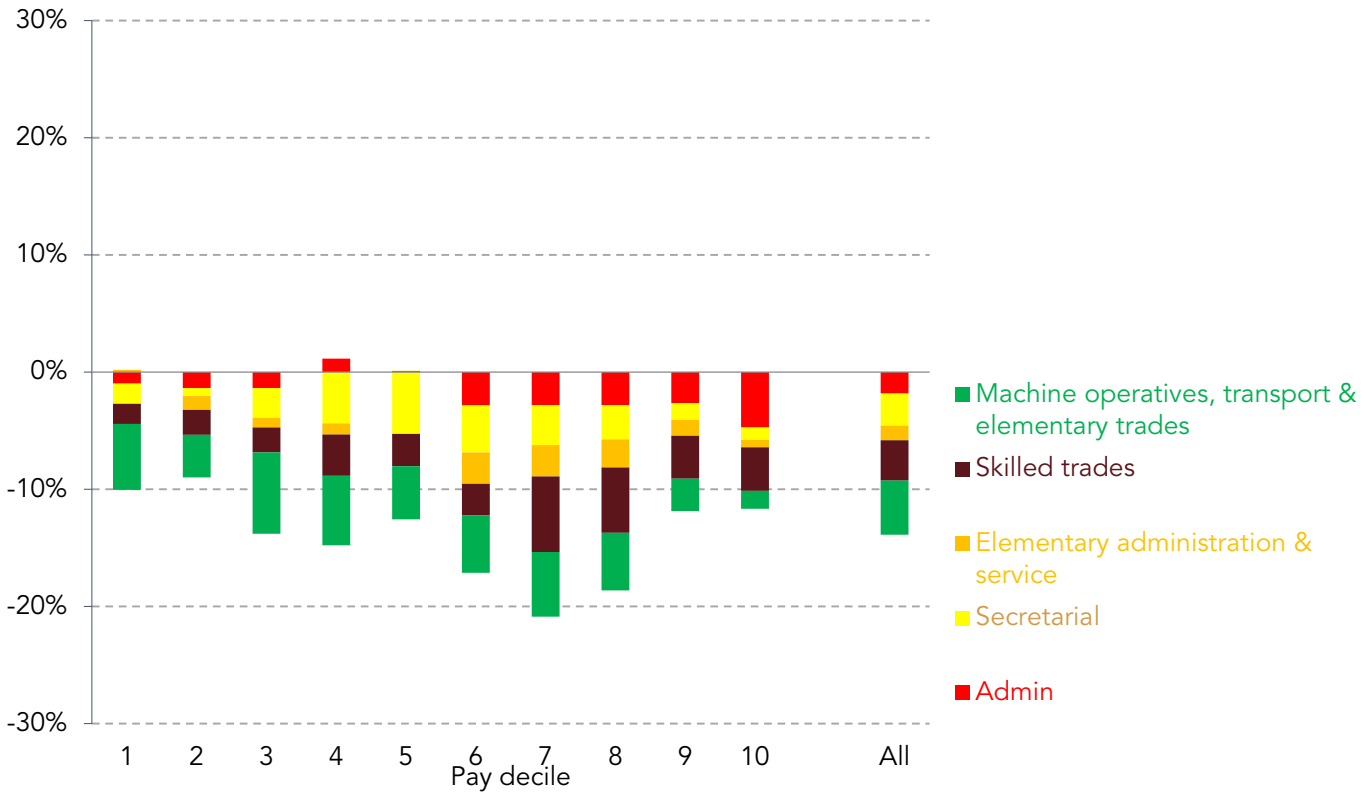
[12] Employment rates have risen in part due to increases in the female state pension age, but even the 16 to State Pension Age measure, which accounts for this effect, has recently matched its record high.

[13] L Gardiner and P Gregg, *The road to full employment: What the journey looks like and how to get there*, Resolution Foundation, 2016

[14] L Gardiner, *RF earnings outlook: Q4 2015*, Resolution Foundation, 2016

Figure 5: The occupations that have declined as a share of hours, in each pay decile

Change in share of hourly pay decile – 1993 to 2015

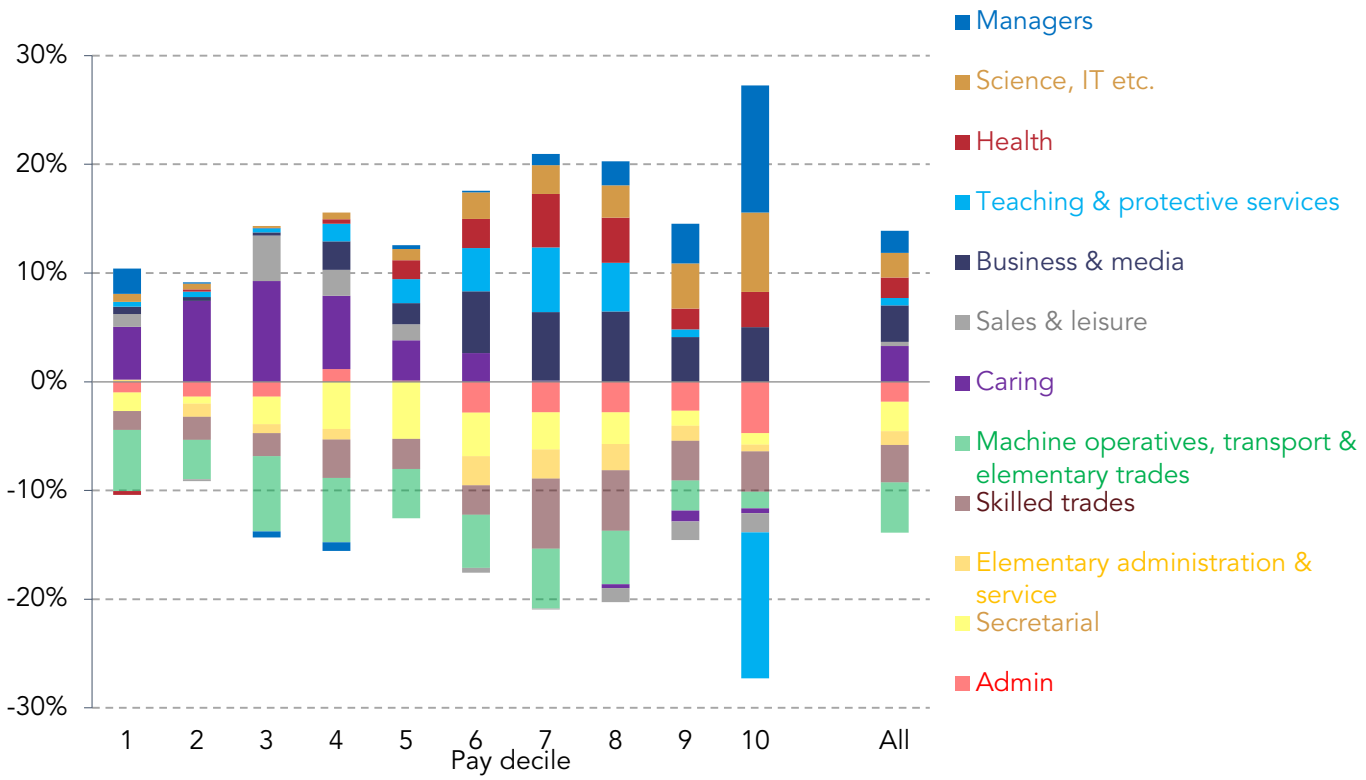


Source: RF analysis of LFS. Hourly pay, employees.

Overall, a 'hollowing out' is again evident: it is the occupations in the middle of the pay distribution that have recorded the biggest reductions in hours over time. However, this analysis allows us to also demonstrate how there has been a counteracting 'filling in' of the middle of the labour market, which helps explain why there has been so little change in the distribution of pay and why the employment rate has nonetheless reached record highs. Figure 6 highlights those occupations that have increased as a share of hours worked from 1993 to 2015. By definition, these exactly counteract the declines of some occupations within each decile.

Figure 6: The occupations that have increased (and declined) as a share of hours, in each pay decile

Change in share of hourly pay decile – 1993 to 2015



Source: RF analysis of LFS. Hourly pay, employees.

When we look to the middle of the distribution we see new roles emerging in science, IT and health that work to plug the gap. But there are other interesting changes occurring in this part of the distribution. One notable shift across the whole picture is what has happened to teachers, lecturers and protective services (largely the police and armed forces). While their importance has increased overall, as a share of the top pay decile they have shrunk dramatically, now swelling the ranks of the middle pay deciles instead.

The growth in business and media roles in the middle (and to a lesser extent top) of the pay distribution also repays some thought. To speculate, it may be that roles previously classed as administrative or secretarial are now deemed professional business roles (perhaps driven by rising numbers of graduates and technological change within jobs). As a result, even if the essential nature of these jobs, and their relative pay, has not changed, they would appear as a 'decline' of middle-skill occupations.

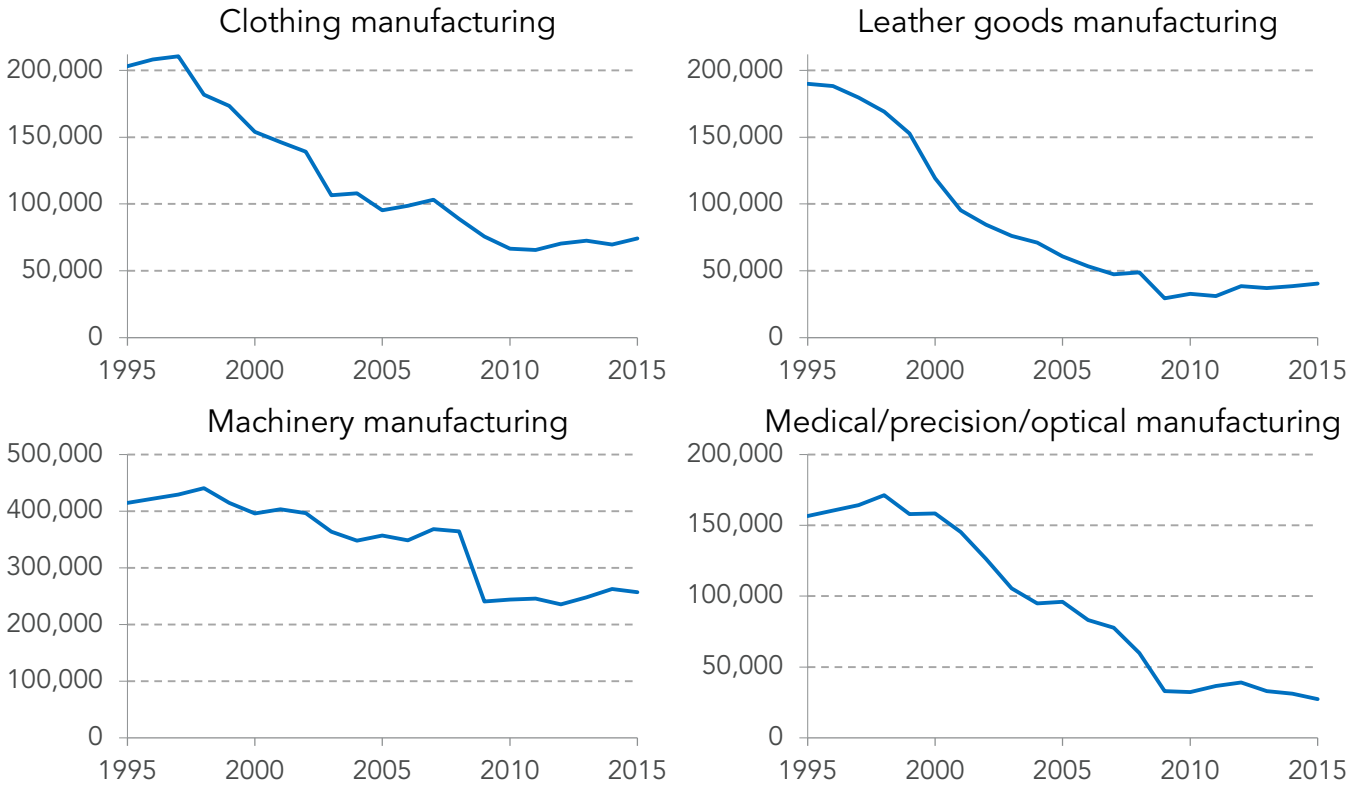
Finally, the fact that caring has emerged as the growth occupation replacing the majority of the hours lost in the bottom half of the pay distribution should also urge us to view automation more cautiously in our accounts of occupational change. In this example at least, changes in demand due to demographic change, as well changes in supply due to the rise in female employment and availability of migrant labour over this period, have had impacts that are more significant than technological change.

Individuals and places can feel the effect of shrinking work-forces, though not always through redundancies

So far we've looked at industries and occupations as shares of the workforce, and commented on overall employment. But this can mask just how stark the decline of some particular sectors has been in terms of employment.

Figure 7 shows four industries that have recorded some of the biggest declines over the 20 year period from 1995 to 2015, together responsible for an employment fall of almost 600,000.

Figure 7: The decline of employment in four classes of UK manufacturing



Source: RF analysis of LFS. Includes the self-employed.

These are remarkable declines. And while these statistics are national, they of course obscure the impact in particular parts of the country and around particular factories. One need only think of the long decline of coal mining (employing 4,000 people in 2014 compared to over a million in 1914)[15] or the current uncertainty around Tata Steel's Port Talbot works.

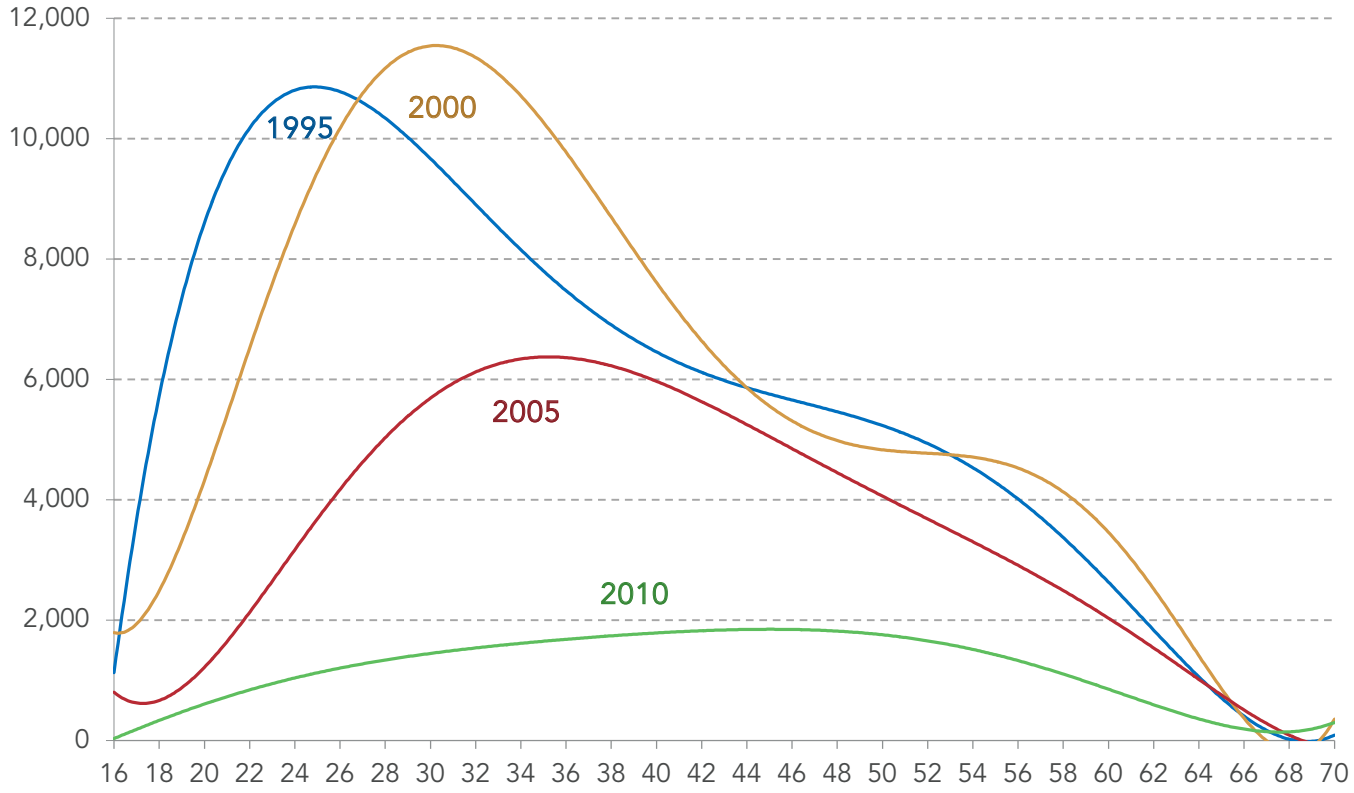
Indeed, one possible advantage of the decline of primary and manufacturing industries, and the rise of the service industry, is that the risk of geographically-concentrated job losses may have been reduced, particularly for the low-skilled.

[15] *Historical coal data: coal production, availability and consumption 1853 to 2014*, DECC, 2015

There is no doubt that sustained unemployment is damaging.[16] However, the decline of industries needn't come about entirely through redundancies. Figure 8 and Figure 9 below present some evidence that employment reductions can come about through reduced inflows – i.e. fewer young people joining the industry – rather than through redundancies. Over the periods in which employment in these industries has declined (see Figure 8 for reference), a rightwards shift in the age distribution is apparent. There is a strong relationship between youth and proportional decline in employment, with employment among those in their 50s and 60s holding up much better – and even rising among the oldest workers in Figure 9.

Figure 8: Medical/precision/optical manufacturing employment by age and year

Numbers in medical/precision/optical manufacturing by age (smoothed)

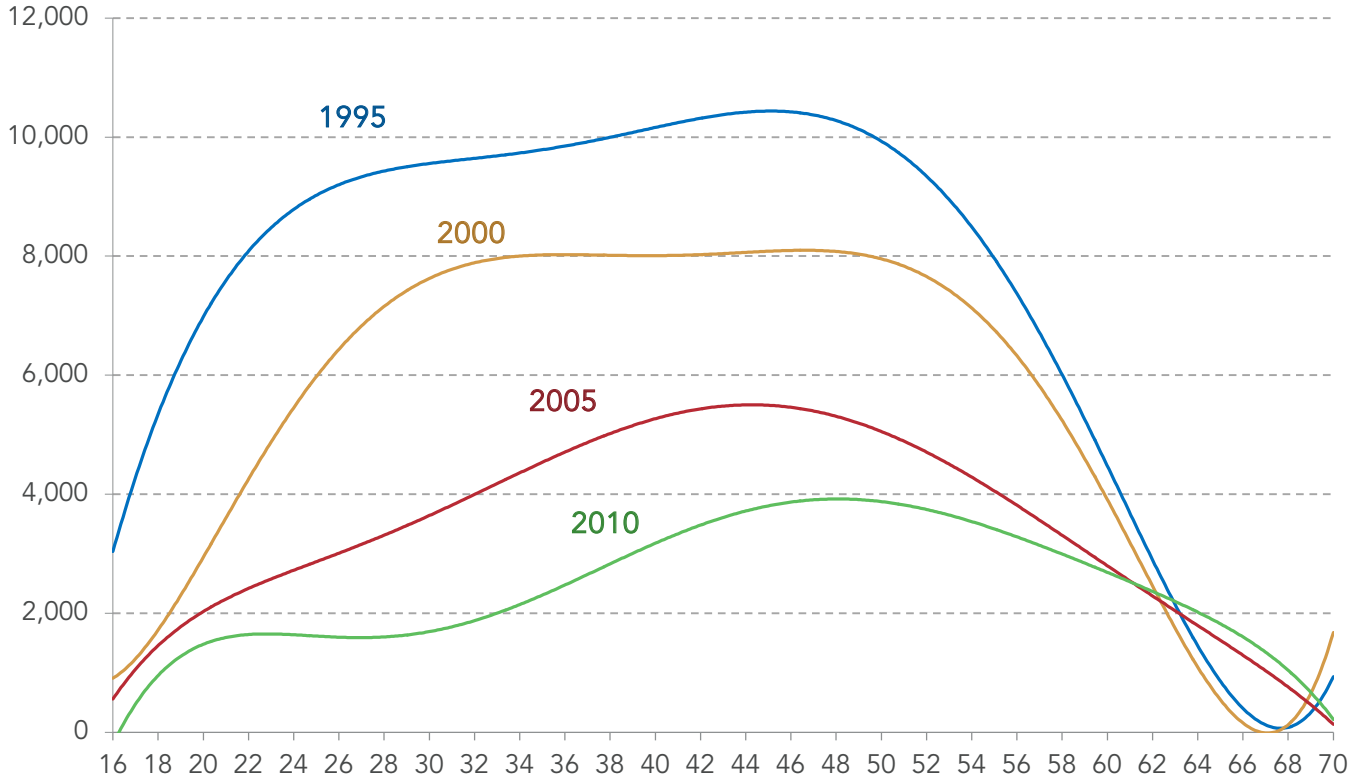


Source: RF analysis of LFS. Includes the self-employed.

[16] G O'Donnell et al., *The Commission on Wellbeing and Policy*, Legatum Institute, 2014

Figure 9: Clothing manufacturing employment by age and year

Numbers in clothing manufacturing by age (smoothed)



Source: RF analysis of LFS. Includes the self-employed.

Additional analysis of survey data on the industries that the unemployed and inactive most recently worked in further indicates that the large declines in employment in these industries have not been accompanied by increases in the numbers out of work; again suggesting that reduced inflow, as well as outflow into other industries, are the main ways in which employment has fallen here.

Fewer young people being brought into industries when they are declining may present its own challenges in terms of opportunities for young people – particularly in specific localities – but this pattern does provide some hope that jobs may be – by design or otherwise – 'grandfathered' in the face of automation or other decline.

The UK needs more automation, given poor productivity in the past and rising labour costs in the future

While automation can clearly have employment effects in the short run it is also a key driver of improved living standards over time. This may be needed more than ever in the UK, where productivity has been in the doldrums for the best part of a decade[17] and is low compared to its competitors,[18] and where average real pay remains below its pre-crisis peak.[19]

[17] Output per hour worked, ONS

[18] International Comparisons of Productivity, ONS

[19] RF analysis of *Labour Market Statistics June 2016*, ONS

Many commentators have argued that the UK's poor economic performance is attributable at least in part to many years of low investment. Gross capital formation in the UK has been consistently below that of comparable countries for many years, and has declined even more markedly after the financial crisis.[20] While there are clearly many factors that determine productivity, including workforce skills and management techniques, and while growth statistics may to a limited extent miss some of the gains brought about by technology, if we are to see a return to high productivity and pay growth then new technologies must play a key role.

There are other compelling reasons for firms to consider automating, however, beyond the need to make up for lost time. Cheap workers have been able to substitute for capital investment in recent years but labour costs are set to rise. Auto-enrolment, defined benefit pension deficits and the apprenticeship levy as well as the welcome introduction of the National Living Wage will all increase employer costs, providing added impetus to firms to raise productivity through automation.

Finally, while the impact of Brexit on migration will take some time to unfold, the ready supply of low-skilled EU migrants ultimately looks likely to be restricted in the future. All else being equal this will raise labour costs in migrant-reliant industries, thereby increasing employers' incentives to invest in labour-replacing or augmenting technologies. This would not be without precedent: evidence shows, for example, that restrictions on migration in the US led to increased mechanisation in the tomato industry.[21]

Table 1 lists the sectors with the highest proportions of EU migrants,[22] alongside their relative assessed probability of computerisation. This relative probability uses scores determined by Frey and Osborne, but adjusted such that 1 is the average probability of computerisation and a score of 2 means that industry is twice as vulnerable.[23] We can also compare these with the proportions of workers expected to receive a pay rise as a result of the National Living Wage by 2020.[24]

Table 1: The industries with the highest proportions of EU migrants

	Industry classes with the largest shares of EU migrants	EU migrants as share of total	Relative probability of computerisation	Share of workers affected by NLW by 2020
1	Manufacture of food products	31%	1.61	37%
2	Domestic personnel	23%	0.67	42%
3	Accommodation	21%	1.45	46%
4	Crop, animal production, hunting	16%	2.40	42%
5	Mining of metal ores	15%	1.51	-
6	Warehousing & support for transport	15%	0.79	16%
7	Services to buildings and landscape	14%	0.39	59%
8	Food and beverage service activities	13%	2.00	48%
9	Manufacture of leather and related	12%	1.03	39%
10	Manufacture of textiles	12%	1.52	39%
	All employees	7%	1	23%

Source: RF analysis of LFS; probabilities from Frey & Osborne for Nesta; RF analysis of ASHE.

[20] Gross capital formation as percentage of GDP, World Development Indicators, World Bank

[21] P Martin, *Guest Workers: Past and Present*, Factors that influence migration

[22] Using country of birth as a proxy.

[23] H Bakhshi, C Frey and M Osborne, *Creativity vs. robots: the creative economy and the future of employment*, Nesta, 2015

[24] See C D'Arcy, A Corlett and L Gardiner, *Higher ground: who gains from the National Living Wage?*, 2015 for more details. These figures include those indirectly affected by the NLW due to being just above it. This work contains statistical data from the ONS which is Crown Copyright. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

This shows something of a divide. There are some industries – such as food manufacturing, agriculture, and food and beverage services – that have both high proportions of EU migrants and high probabilities of computerisation. And these are also sectors where the National Living Wage will have a particularly large impact. But there are others that have high proportions of EU migrants but have relatively low odds of automation, such as cleaning (services to buildings) and domestic staff. Their response to rising wage costs and reduced labour supply may therefore focus less on capital investment and new technologies.

Table 2 flips the picture and shows those industries with the highest probability of computerisation. While there is some overlap with Table 1, there are other sectors such as accounting and postal services that are deemed particularly at risk of automation but have relatively low shares of EU migrants and workers who'll gain from the National Living Wage.

Table 2: The industries with the highest odds of automation

	Industry classes with the highest computerisation probabilities	EU migrants as share of total	Relative probability of computerisation	Share of workers affected by NLW by 2020
1	Legal and accounting activities	5%	2.51	12%
2	Forestry and logging	6%	2.42	-
3	Crop, animal production, hunting	16%	2.40	42%
4	Fishing and aquaculture	0%	2.16	-
5	Manufacture wood and wood products	9%	2.04	30%
6	Food and beverage service activities	13%	2.00	48%
7	Postal and courier activities	8%	1.97	11%
8	Retail trade, except vehicles	6%	1.91	46%
9	Manufacture of wearing apparel	11%	1.86	44%
10	Manufacture rubber plastic products	10%	1.77	25%
	All employees	7%	1	23%

Source: RF analysis of LFS; probabilities from Frey & Osborne for Nesta; RF analysis of ASHE.

Conclusion

Given the UK's poor productivity growth in recent years, and the potential for further economic disruption related to Brexit, it seems fair to say we need more robots, not fewer. And the experience of the past 20 years (if not the past 250 years) provides some reassurance that the overall negative consequences of automation are easy to overstate. Part of the logical policy response would be encouraging more investment, research, education and responsive regulation; while continuing to pursue goals of high pay and full employment, which in turn promote capital investment.

But there are always losers in a changing labour market, and policy must reflect that too. It may not be time for a basic income for all – an oft suggested solution to a potential future problem – but inequality and a weak safety net clearly exacerbate the risks when jobs are automated. Ultimately, constantly improving skills and education is the key challenge, as ever. But while many already have the transferable skills to respond to changing demands, policy should be aware of those industries, places and people that are least able to respond and ensure that no-one is left behind if new technologies really do deliver substantial growth.

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