Warwickshire Economics

The Risk of Automation in Warwickshire

Full Report

March 2018

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1. Executive Summary

Advances in production techniques have historically benefitted the economy, however, smart technology capable of deep learning and free movement, has the potential to replace complex jobs. Warwickshire Economics, part of Warwickshire County Council, has undertaken research based on the seminal work of Frey and Osborne (2013) that sheds light on the jobs most at risk of automation in the county.

We estimate that approximately 116,000 jobs in Warwickshire are at very high risk of automation. Each of these contains daily tasks that have at least a 70% chance of being carried out by robots/computers. The figure represents 41.3% of Warwickshire's total workforce, higher than the West Midlands Combined Authority (WMCA) region (39.6%) and England (37.7%).

The impact of digitalisation and computerisation is, however, not uniformly felt across occupations. Level 1 occupations, typically requiring GCSE grades D-G, are most at risk with almost 3 in 4 jobs being impacted by technological advancements. Warwickshire employs a larger proportion of workers in these types of occupations (15.2%) relative to Coventry (14.5%), the WMCA (13.3%) and England (13.7%).

Jobs requiring a degree level qualification (level 4) are least likely to be automated. Just 3% of professional occupations are expected to be automated and 3 in 5 will certainly not be affected. Despite this, the county employs relatively few in level 4 occupations. Also, those in Warwickshire who do have a degree are in occupations more likely to be significantly impacted by automation. For example, 1,400 of the 1,500 chartered and certified accountants in the county have a high chance of being replaced.

The majority of jobs in Warwickshire require level 2 and level 3 qualifications, and are categorised as *middle-skilled* in the report. Approximately one in two middle-skilled workers are at very high risk of automation, which amounts to 82,500 of the 116,000 jobs likely to be replaced. This reaffirms expectations that computers will be better positioned to take on the routine tasks of the middle-skilled workers. The automation of sales & retail assistants, large goods vehicle drivers and other administrative occupations will displace the highest number of workers, 23,500.

Across these three most-affected occupations, Warwickshire employs 6% more than the national average. This result extends across all the occupations the county specialises in; more than two in five jobs (42%) that are in occupations Warwickshire employs more than the national average in are at very high risk of automation - higher than Coventry (36.5%) and WMCA (36.5%).

Warwickshire also employs 24% more than the national average across all of the top 5 sectors most likely to be affected by automation. An estimated 81,500 jobs may be lost in the wholesale & retail trade, manufacturing, transportation & logistics, tourism and construction industries. The abundance of *process, plant and machine operatives* in the county makes the transportation & logistics and manufacturing sectors the biggest sectoral drivers of Warwickshire's high automation risk score.

Our analysis also finds a clear correlation between the number of job losses in an area and the proportion of high-skilled and knowledge intensive jobs - a result shared by the Cities Outlook 2018 report. Warwickshire employs 13% fewer in knowledge intensive occupations than the national average and just 59.6% in high-skilled jobs compared to 64.4% nationwide. This, alongside the

sectoral differences highlighted on page 20 of the report, explain why 8.5% more workers are at risk of automation in Warwickshire compared to the national average.

Our work is one of the first to look at the impact of automation on the types of jobs currently being advertised online. These adverts help researchers build a picture of how the labour market is adjusting to current economic conditions and gives an insight into what the future job market might look like. We find that just 28.5% of job vacancies posted in 2017 are at very high risk of automation, although again higher than Coventry (24.4%), the WMCA (27.3%) and England (23.8%).

Using labour demand and supply factors, we also identify those occupations closest to the tipping point. At this point businesses begin to actively invest in automation to replace the roles of workers. Of the 138 occupations at very high risk of automation, there are 15 occupations in Warwickshire we believe are likely to be automated sooner rather than later. These have been identified by assessing the relative job & wage growth, job demand and automation risk attributable to each profession.

Elementary storage occupations, large goods vehicle drivers and vehicle & metal goods assemblers are the three most demanded occupations that are closest to the tipping point. Based on the cost of a local automotive sector worker and the significant rise in job demand in this industry, we expect that automation may start to become more of a reality for those involved in the local car industry.

The proportion of job vacancies at very high risk (28.5%) is lower than the proportion of existing jobs likely to be automated (41.3%). The rationale given is that employers are already seeing the value in jobs that either have a lower chance of being replaced or could complement the technological transformation within their business. For example, the number of IT analysts & systems designers has increased 28% since 2012, double the national average and three times faster than the average job growth in Warwickshire.

The occupations with the lowest chance of being automated are those that require a high degree of creative thinking. Nesta's 2015 report 'Creativity vs. Robots' identified a number of sectors and occupations that were less likely to be automated because they had an element of creativity attached to the jobs. Our research identifies 11 occupations that are likely to remain, and expand, despite the impacts of automation. The most important for Warwickshire are; design & development engineers, electronics engineers, quality control and planning engineers, mechanical engineers and IT business analysts & systems designers.

Design and development engineers are the largest occupational group that Warwickshire has an above average number of workers employed in. This group has grown 26.4% in employment over the last 5 years, almost double the national average. Across all five of the occupations, job growth has increased 23.7% over the last 5 years, 10 percentage points higher than the national average.

Advancements in robotics and computerisation can also provide opportunities when labour is scarce. In a situation where workers are hard to find, automation could be a viable alternative for businesses. We looked at a Brexit scenario in which EU workers would face the same visa requirements for current non-EEA workers. Our findings estimate that 124,850 jobs in Warwickshire would be hard-to-fill if we left the EU and a smaller proportion, relative to the national average, are able to be automated. This suggests that Warwickshire could be impacted more from leaving the EU than the average area in England.

Warwickshire's labour market is set for significant changes over the next decade, perhaps more so than other areas across the country. The opportunities are endless; a better equipped health care

system, more consistent evidence-based decisions, wage and productivity increases, greater firm-level efficiency and workers specialising on more complex parts of their role that use talents such as empathy, creativity and problem solving. The risks, however, are also not too inconceivable; inequality, job losses and an under-equipped future generation of workers.

To ensure that the benefits of automation are realised, whilst minimising the losses, policy makers require a cohesive and proactive approach that can deal with rapid improvements in technology. For this reason, we set out five policy recommendations that can ensure a socially optimal outcome; *retraining and continuous learning*, *support co-investment by businesses in technology and skills*, *attracting highly skilled, knowledge intensive occupations*, *embedding skills for the future within education and training programmes*, and *recognising and promoting multiple careers*.

The Risk of Automation

Report

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2. Introduction

The film industry has benefitted from societies' curiosity about artificial intelligence since Fritz Lang directed 'Metropolis' in 1927. The fascination of opportunity juxtaposed by the fear of the unknown has resulted in the success of films such as The Terminator, A.I. and iRobot. Despite the sci-fi genre being distinctly apart from reality, filmgoers' interests are borne out of the potential impacts of technological advancement on today's society.

In the workplace, the fear of job losses resulting from technological progress is a familiar phenomenon. In the late 18th Century, Luddites opposed new manufacturing processes in the textile industry. More than a century later, Henry Ford's moving assembly line required less manpower and ushered in the age of mass production. Both prompted significant labour market changes and arguably initiated the first and second industrial revolutions, respectively.

Despite the restructuring, the industrial revolutions are widely considered to be an instigator of economic growth and prosperity in developed countries. The short-term adjustments were far outweighed by the creation of new jobs in the long run. As a result, the UK profited from productivity improvements and huge new wealth. Recently, however, advances in technology-driven automation[1] has re-kindled fears of potential job losses.

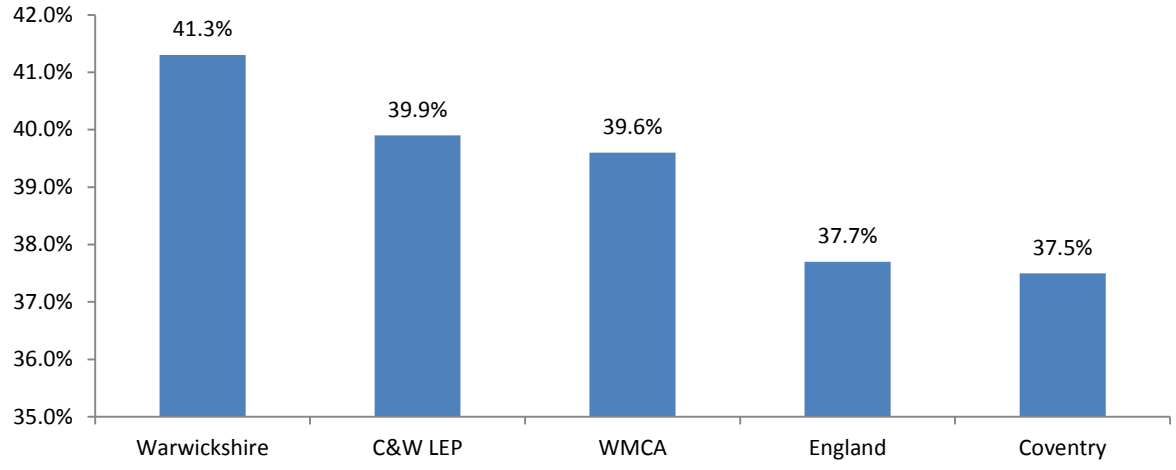
Whereas advances in production techniques have historically benefitted the economy, smart technology, capable of deep learning and free movement, has the potential to replace complex jobs. This means computer-based industrial automation has the ability impact many occupations and industries. The challenge is thus to optimise the benefits of automation whilst minimising the impact on society. If not, the replacement of skilled workers by AI could lead to workers moving toward lower-skilled jobs. If their skills become under-utilised, automation could have negative impacts on productivity, unemployment and inequality.

In using the seminal work of Frey and Osbourne (2013)[2], FO henceforth, we can make direct comparisons with other research around the subject to evaluate the relative risk of automation locally. The aim of this report is, therefore, to supplement existing UK-wide automation literature by identifying which occupations and sectors are at 'very high risk'[3] of computerisation in Coventry & Warwickshire.

[1] The use of methods for controlling industrial processes automatically, esp by electronically controlled systems, often reducing manpower (Collins English Dictionary).
[2] Frey and Osbourne (2013) – The future of employment: how susceptible are jobs to computerisation?
[3] Very high risk refers to at least a 70% probability of being computerised by the early 2030.

FO (2013) use a machine learning algorithm to generate a 'probability of computerisation' for each 4-digit occupation. This probability score does not tell us that a proportion of jobs will be automated within an occupation, rather which occupations are more at risk of being computerised. Figure 1 shows the proportion of employees at very high risk of automation for each of the different geographical areas.

Figure 1: Proportion of workers at Very High Risk of Automation

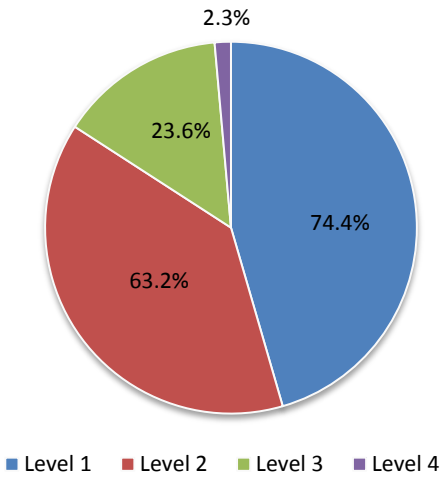


Source: FO (2013), EMSI

An estimated 116,000 jobs in Warwickshire are considered to be at very high risk of computerisation by the early 2030s. This represents 41.3% of all jobs, much higher than the West Midlands Combined Authority Area (WMCA) and national figures[4].

3. Which workers are at greatest risk in Warwickshire?

The impact of digitalisation and computerisation is not uniformly felt across occupations. On average, we find that jobs requiring fewer qualifications are at higher risk of automation. Level 1 occupations, typically requiring GCSE grades D-G, are most at risk with almost 3 in 4 jobs being impacted by technological advancements. On the other hand, jobs requiring at least a degree level qualification (level 4) are least likely to be automated.



The easiest way to illustrate the impact of automation on Warwickshire's workforce is to break them down by the nine conventional occupational groups. The following table shows how jobs within each occupational group are expected to be impacted by automation.

[4] On page 17 we discuss the reasons behind the differences between Warwickshire and the other areas.

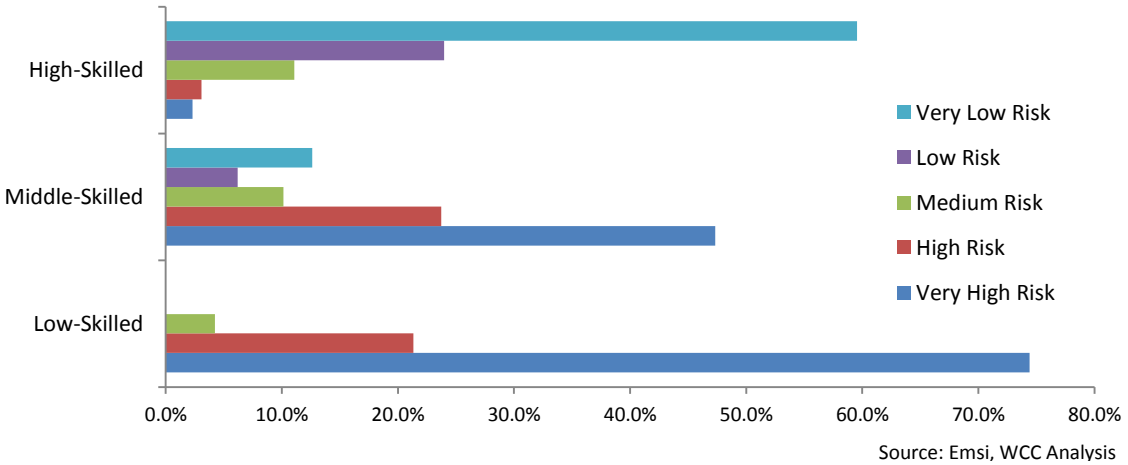
Table 1: Automation in the workplace			
	# of local workers	% at very high risk of automation	% at very low risk of automation
Managers, Directors & Senior Officials	26,700	5%	48%
Professional Occupations	44,200	3%	64%
Associate Professionals & Technical Occupations	34,000	11%	31%
Administrative & Secretarial Occupations	33,600	88%	4%
Skilled Trade Occupations	26,600	36%	7%
Caring, Leisure & Other Service Occupations	23,600	10%	12%
Sales & Customer Service Occupations	24,700	65%	0%
Process, Plant & Machine Operatives	25,700	77%	0%
Elementary Occupations	42,800	74%	0%
Source: Emsi, WCC analysis			

Administrative & Secretarial Occupations are expected to be affected most by the integration of automation into the workplace, with almost 9 in 10 jobs being categorised as 'very high risk'. Within this occupation, Warwickshire has a particular abundance of metal machining setters & setter-operators, employing more than 1,000 people in this occupation, twice its proportional average. It is estimated that as many as 850 of these jobs could be at risk of automation by 2030. Other occupations at risk in this group are; cooks, welding trades, carpenters and joiners[5].

On the other hand, professional occupations are at least risk of automation, with 64% of jobs having less than a 10% change of being automated. There are approximately 4,750 sales accounts and business development managers in Warwickshire and, in theory, just 61 of these jobs are expected to be impacted by computers.

The occupational categories in table 1 can be grouped by their qualification requirements[6]. Figure 2 shows the automation risk for each of the different qualification levels.

Figure 2: Automation Risk by Qualification Level



Source: Emsi, WCC Analysis

[5] These occupations have at least 500 workers, an above-average number of workers locally and are at very high risk of automation.

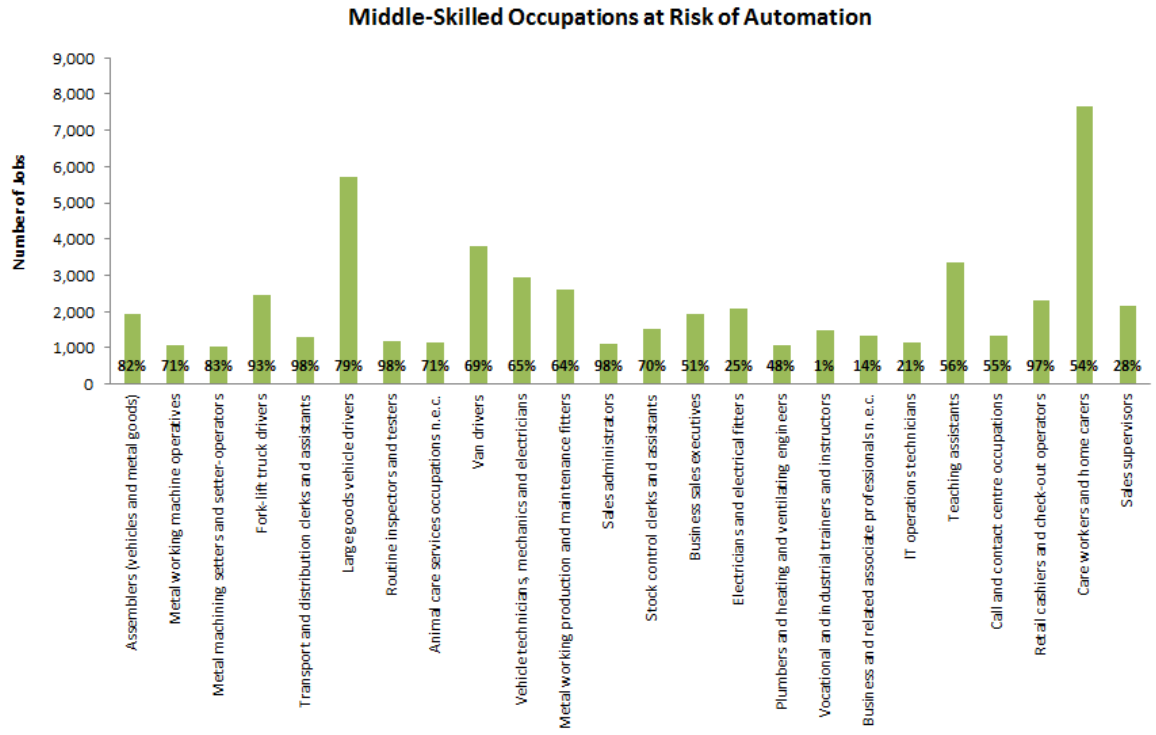
[6] High-skilled jobs require the equivalent of a degree, middle-skill jobs require at least a GCSE A*-C and at most A-levels and low-skilled jobs need GCSE's D-G grades.

Around 1 in 4 jobs in Warwickshire require at least a degree. Those workers that do are expected to be significantly less impacted by automation than those who do not. These occupations include nurses, teaching professionals, chief executives and senior professionals.

On average, 13 in 100 high-skilled jobs will be affected by automation. The only occupation that is anticipated to be significantly impacted by robotics within this category is *chartered and certified accountants*. Warwickshire's labour market contains 1,500 of these professionals of which 1,400 are expected to be affected by computerisation.

The majority of workers are employed in jobs requiring at least a GCSE grade A*-C and at most an A-levels or equivalent. In total, 3 in 5 jobs in Warwickshire are in this category and half of them are at very high risk of automation. Transport and distribution clerks, sales administrators, routine inspectors and book-keepers all have a 95% chance of being impacted by automation. On the other hand, nursery nurses, sales accounts & business development managers and vocational & industrial trainers are all unlikely to be affected.

The following graph lists the number of workers in each middle-skill occupation that Warwickshire specialises in. It also gives the probability that these occupations will be impacted by automation.



The way to interpret the graph would be: Warwickshire has a larger than average share of large goods vehicle drivers, employing around 6,000 workers across the county. This occupation is, however, expected to be significantly affected by automation over the next 12 years – there is a 79% probability that the day-to-day functions of these workers will be computerised by 2030.

More generally, 1 in 3 middle-skilled workers, who are employed in occupations that Warwickshire has an above average share of employment in, are very likely to be significantly impacted by automation. If we extend this to include all occupations in which there are an above average share of workers in, this increases to 41.8%. It is worth noting that this is higher than Coventry (36.5%) and

the WMCA (36.7%) areas. This suggests that automation is likely to not only have a larger impact on Warwickshire as a whole, but also more likely to impact key occupations that contribute significantly to the success of the local economy.

Finally, figure 2 highlights that scale of the automation risk for low-skilled occupations. Although just 15% of workers are in jobs requiring just GCSE grades D-G, 3 in 4 are at very high risk of automation. This equates to just under 32,000 workers and is the major contributor the 116,000 most at risk jobs in Warwickshire.

There are not many occupations within this group that are unlikely to be automated, however the majority of vehicle cleaners, school midday & crossing patrols and elementary security occupations are not expected to be impacted as much. With a 90% chance of computerisation, waiters & waitresses and refuse & salvage occupations are the most likely low-skilled occupations to be affected.

The following table summarises the top 10 largest occupations that are expected to be affected by automation in Warwickshire by 2030. These ten occupations employ around 55,250 in Warwickshire, of which the majority have middle-skilled qualifications. The county has a larger than average share of employment in half of the top 10 occupations and across all of them, Warwickshire employs 13% more than the national average.

Table 2: Top 10 occupations anticipated to be impacted by automation the most

Occupational Title	Workers	Skill Level	Employment vs national average
Sales and retail assistants	10,954	Middle-Skilled	9% below
Elementary storage occupations	10,402	Low-Skilled	86% above
Other administrative occupations n.e.c.	6,853	Middle-Skilled	3% above
Large goods vehicle drivers	5,711	Middle-Skilled	82% above
Book-keepers, payroll managers and wages clerks	4,655	Middle-Skilled	2% below
Kitchen and catering assistants	4,383	Low-Skilled	19% below
Bar staff	3,584	Low-Skilled	8% above
Waiters and waitresses	3,411	Low-Skilled	4% below
Receptionists	2,831	Middle-Skilled	4% below
Fork-lift truck drivers	2,457	Middle-Skilled	103% above

Source: Emsi, WCC analysis

Table 2 reaffirms expectations that computers will be better positioned to take on the routine tasks of the middle-skilled workers. The challenge for policy makers will be to minimise the polarisation that this phenomenon could create (and there are suggestions it already is creating, Piketty 2014) to avoid growth in income inequality.

The Tipping Point

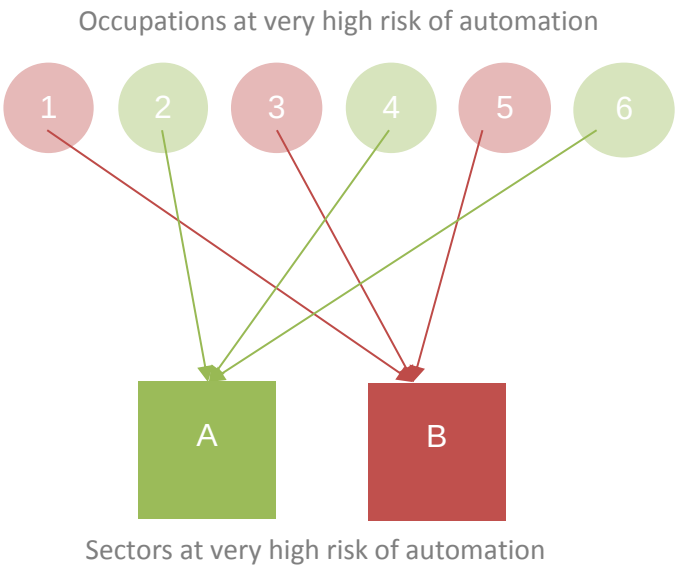
Although a significant proportion of jobs (41.3%) are at very high risk of automation, the point at which they become automated will differ. The tipping point refers to the moment in time where businesses begin to actively replace labour with computers. This point is determined by many

factors, including location, occupation, sector, business size and economic uncertainty. This makes it difficult to estimate when the tipping point will arise.

Ultimately, however, it would seem reasonable to assume that businesses will look towards robots more quickly in sectors and occupations that have a shortage of skills. Intuitively, in sectors where there are fewer job applicants per advertised position, it becomes more difficult for businesses to find an applicant with the right skills, qualifications or work experience. A job vacancy that is hard to fill for these reasons is called a "skills shortage vacancy" by the UK Employer Skills Survey (UKCES).

Vacancies in occupations that are difficult to employ workers in will have a higher advertised starting salary. This is because a higher wage is required to entice a worker with the right skills. For this reason, we can assume that the cost of labour in these occupations will be higher for businesses than others.

Take the following graphical representation as a demonstration of how these signals can help us explain the tipping point. Occupations 1-6 are all at very high risk of automation, however, any vacancies requiring workers in even occupations are easy to fill. These occupations may be waiters and waitresses, bar staff and receptionists and they feed into the hospitality sector, A. On the other hand, vacancies in odd occupations are hard to fill. Businesses in sector B need to post several job adverts and increase the starting salary to attract the right workers. These may be van, truck and large good vehicle drivers in the transportation sector.



Despite all six occupations being categorised as 'very high risk', sector B businesses will most likely look to invest in automation first. For these businesses, the real cost of a worker is higher than in sector A, because it is harder to find one with the right skills. In other words, the 'tipping point' will come sooner for sector B and occupations 1, 3 and 5, than it will for sector A and occupations 2, 4 and 6.

This example also explains how we might be able to identify which occupations are most at risk of being automated sooner rather than later. By looking at occupations where online adverts have increased faster than the average and have experienced higher than average wage growth, we can attempt to give a 'best guess' of which occupations are closer to the tipping point than others.

The following table lists the occupations that we believe are most likely to be automated first. According to FO (2013), there are 138 occupations at very high risk of automation. Our analysis finds that, other things being equal, the following 15 occupations are at most risk of being automated in Warwickshire.

Table 3: Occupations in Warwickshire that are closest to the 'Tipping Point"			
Occupation Title	**Sector**	**Jobs**	**LQ***
Book-keepers, payroll managers and wages clerks	Legal & Accounting	4,650	1.0
Stock control clerks and assistants	Warehousing & Storage	1,500	1.3
Human resources administrative occupations	Admin & Support Services	850	1.3
Other administrative occupations	Temporary Employment Agency	6,850	1.0
Office managers	Business & Management Consultancy	1,750	1.0
Receptionists	Tourism	2,850	1.0
Typists and related keyboard occupations	Admin & Support Services	500	1.0
Welding trades	Automotive	950	1.8
Animal care services occupations	Other Service Activities	1,150	1.7
Beauticians and related occupations	Other Service Activities	500	1.2
Assemblers (vehicles and metal goods)	Automotive	1,900	4.9
Large goods vehicle drivers	Transportation & Logistics	5,700	1.8
Elementary construction occupations	Construction	1,150	1.1
Elementary administration occupations	Wholesale & Retail Trade	550	1.2
Elementary storage occupations	Warehousing & Storage	10,400	1.9
*LQ refers to Location Quotient[7]		Source: Emsi, WCC analysis	

On average, online job posting in these occupations have increased 172% over the last four years, higher than the increase across all occupations (129%). Advertised salary has also increased at an above-average pace, growing 16% compared to 8% for all occupations. Crucially, these occupations all have a location quotient greater than one. This implies that there is stronger demand for these occupations locally than there is for the average local authority in England.

There are two key conclusions from this analysis. On the one hand, automation within these occupations will help alleviate local inefficiencies that have been created from above-average wage growth. This will also improve productivity and help local business competitiveness. On the other hand, a total of 41,250 workers are employed in these occupations, 14% of the total workforce. Therefore, not only does automation have the ability to improve labour market/skills shortages, it can significantly impact/displace a large proportion of the labour market sooner rather than later. The 'Sector' column in table **3** is the sector in which each occupation has the majority of workers in. The impact of automation by sector will be discussed in greater depth in section **3**.

Although we expect automation to impact these occupations first, the average advertised salary[8] between Jan 1st-Dec 31st 2017 for very high risk occupations locally was £25,900, compared to £26,600 across England. This implies that there is still scope for local businesses to increase wages further before being tempted into significantly investing in robotics.

The exception, however, is in the automotive industry. Local workers in this sector earn more, on average, than their national counterparts. Relatively high wage growth and online adverts suggests that the risk of automation may start to become more of a reality for those involved in the car industry.

[7] The **Location Quotient** is a measure of the concentration of employment in a sector in an area. A value of **one** suggests that the amount of employment in a sector is proportional to its size compared to the national average.

[8] Labour Insight – Advertised salary for very high risk occupations. Note around 1 in 3 adverts do not advertise a wage and are, therefore, excluded.

The future labour market

In the previous section, we used job vacancies to identify potential skills shortages. We can also use them to gauge the impact of automation on the future labour market. Online advertisements are good indicators of the types of jobs that are currently in demand. This can help us identify how the labour market is changing and, if the risk of automation is relatively high for these new jobs, we could infer the impact of technology on the future labour market. For example, if a larger proportion of jobs that have a good chance of being replaced are being advertised, then relatively more needs to be done to avoid job losses in the future.

Table 4 divides the online job vacancies posted in 2017 into automation risk categories for Warwickshire, Coventry, the LEP area and England. The first observation is that the most in-demand occupations in 2017 are in occupations at less risk of automation than the existing occupation structure of each economy.

Table 4: The number of job postings by automation risk level

Vacancies in occupations…	Warwickshire	Coventry	CWLEP	England
…at **very high risk** of automation	43,038	14,828	57,866	1,584,252
Proportion of total vacancies in 2017	28.5%	24.4%	27.3%	23.8%
…at **high risk** of automation	29,344	12,102	41,446	1,211,383
Proportion of total vacancies in 2017	19.4%	19.9%	19.5%	18.2%
…at **moderate** risk of automation	15,175	6,740	21,915	802,047
Proportion of total vacancies in 2017	10.0%	11.1%	10.3%	12.1%
…at **low risk** of automation	30,181	12,280	42,461	1,368,632
Proportion of total vacancies in 2017	20.0%	20.2%	20.0%	20.6%
…at **very low risk** of automation	33,423	14,899	48,322	1,677,111
Proportion of total vacancies in 2017	22.1%	24.5%	22.8%	25.2%

Source: WCC analysis, Labour Insight

For Warwickshire, an estimated 28.5% of current job vacancies are advertised for occupations at very high risk of computerisation, 4.7 percentage points more than the national average. Locally and in each of the different geographical areas, the proportion of advertised jobs at very high risk of automation is lower than the proportion of existing jobs at very high risk. This evidence would suggest that the future job market will be impacted less by automation than the current labour market.

There could be a number of explanations; Firstly, some jobs are more likely to be advertised online than others. Job adverts for workers in occupations in the highest risk category may be less likely to be advertised online, for example tourism related jobs.

Alternatively, the opportunities that an increase in computerisation presents may already be creating additional jobs. Job adverts for electronics engineers, IT professionals and web designers

have increased faster than the average occupation has over the last four years. In this case the results are relatively intuitive - as some jobs are lost to computerisation, others will be created. This phenomenon is most likely to be captured by the change in the jobs being advertised online.

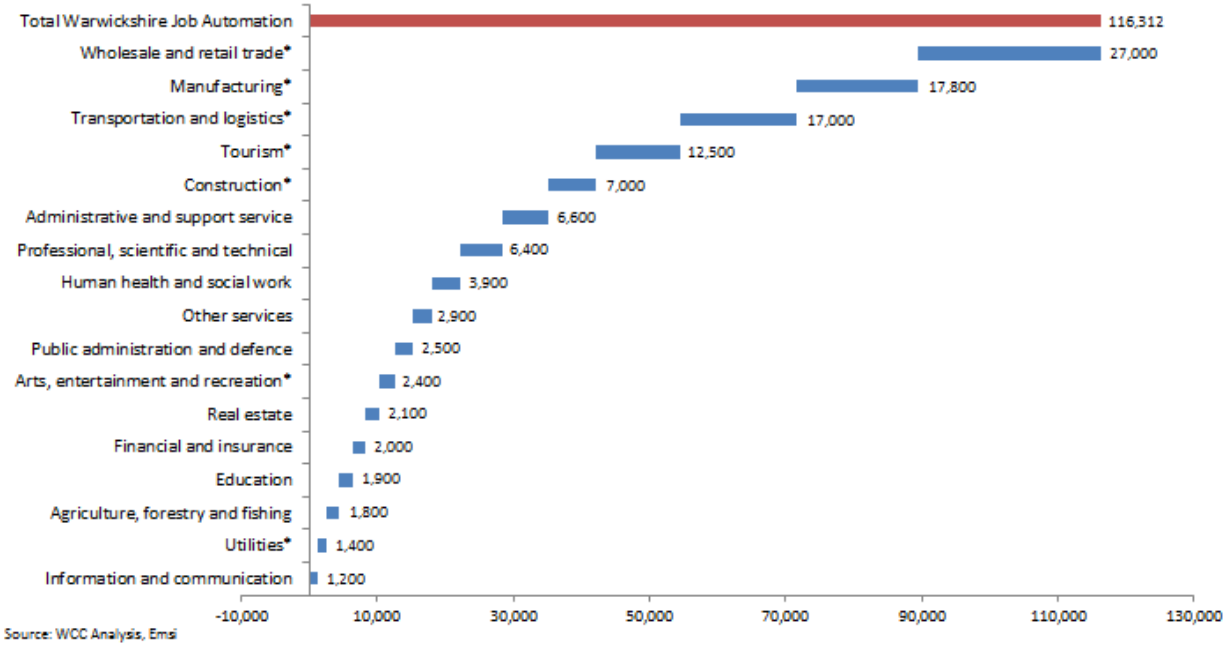
The results continue to show that Warwickshire's labour market is more at risk of automation than the average local authority in England. The 28.5% is 4.7 percentage points more than the national average. The reason behind this is the number of job advertisements for elementary storage occupations, large good vehicle drivers, plant and machine operatives, metal machine setters, credit controllers and draughtspersons. There are also fewer online vacancies in occupations at very low risk of automation.

We can expect that there will, therefore, be larger displacement issues for Warwickshire as automation starts to filter into the workplace. With more vacancies being at very high risk of automation, more vacancies in the future will need to be different from today. This implies that Warwickshire's workers have relatively more to do to in order to obtain the relevant skills and qualifications for the jobs of tomorrow.

4. Which sectors are most susceptible to automation?

We have mapped our occupational results to Warwickshire's industries, allowing us to examine their relative susceptibility to automation. The following figure gives the number of jobs expected to be automated over the next ten to fifteen years by sectors.

Figure 3: Potential jobs in Warwickshire at very high risk of automation by sector



Source: WCC Analysis, Emsi

From our analysis, the top four sectors that are expected to be most affected by automation are; wholesale and retail trade, manufacturing, transportation & logistics and tourism. These are similar to the top four most affected UK industries published by PwC in their UK Economic Outlook Report (2017). The difference is the inclusion of the tourism sector and transportation & logistics sector taking a higher position on the list.

Each of the industries that contain a '*', Warwickshire has an above average share of employment in. This means that, for the top five industries on the list, Warwickshire's economy is relatively more dependent on these for its success than the average UK area is. Our strength in these sectors implies that an additional 17,000 workers are at very high risk of automation, compared to if our economic structure was the same as the UK average.

Wholesale and Retail Trade

An estimated 1 in 6 of Warwickshire's workforce are employed in the wholesale and retail trade sector. More than half of these are at very high risk of being automated, amounting to around 27,000 jobs.

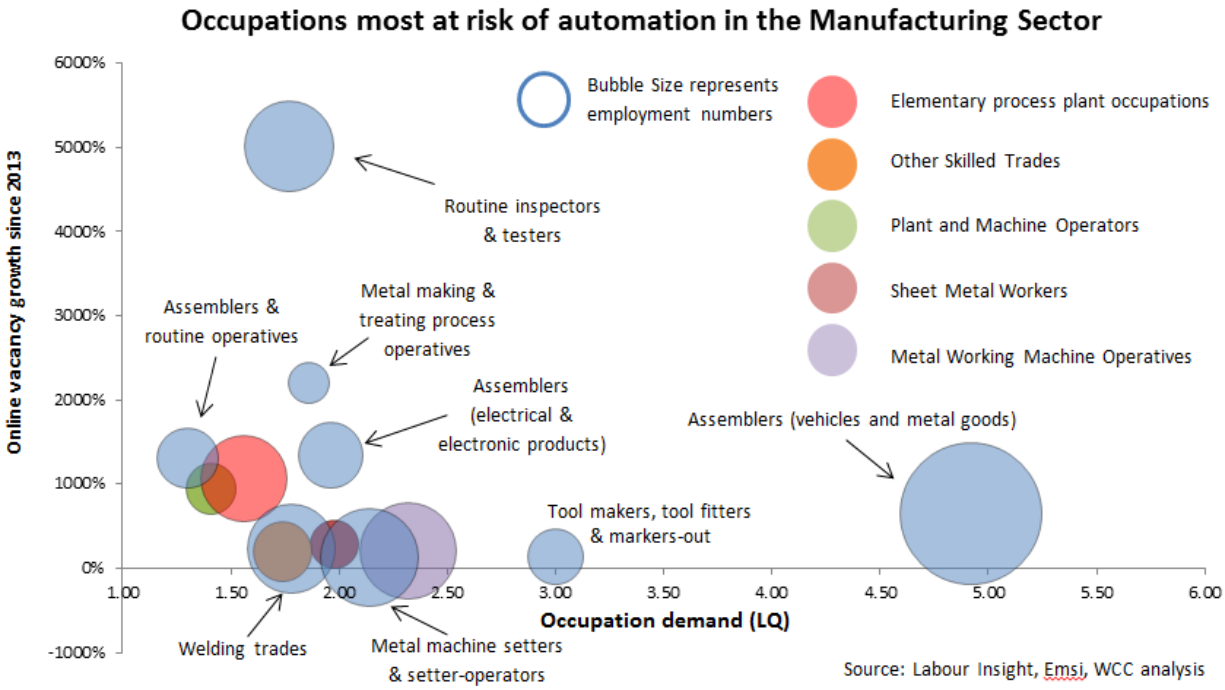
The graphic on the right shows the top 10 occupations that are anticipated to be most affected. Sales & retail assistants are by far the most at risk, followed by elementary storage occupations and cashier and check-out operators. However, on the basis of significant job demand and vacancy growth, *vehicle salespeople* are most likely to be automated sooner.

Manufacturing

The manufacturing sector has been a significant contributor to Warwickshire strong productivity and economic growth over the last seven to eight years. Employment has grown 30% since 2009, compared to a 1% fall nationwide. As a result, 1 in 8 people work in the sector and 1 in 2 are in jobs at very high risk of computerisation.

Assemblers, storage occupations and metal machine setters are likely to be affected most, although unlike the wholesale and retail sector, automation is more widely felt across occupations.

The following graph highlights the jobs that we believe are most likely to be at risk of automation first in the manufacturing sector. The horizontal axis measures the local demand for each occupation and the vertical axis is the growth in online vacancies since 2013. The size of the bubble is the number of people employed.



Online job adverts for routine inspectors & testers have grown significantly over the last four years, increasing by more than 5,000%. Demand for these occupations, as measure by employment share, is also above the national average. Assemblers, on the other hand, are in much more abundance in the current labour market, employing 5 times the national average for the size of Warwickshire's workforce. Online adverts have also increased by more than the average occupation, but much lower than routine inspectors & testers.

Out of the 122 occupations that are involved in the manufacturing sector, the 13 described in the graph are the ones that could be reasonably expected to be impacted by automation in the coming years.

Transportation & Logistics

Workers in this sector are likely to be impacted by computerisation most. Of the 25,000 people who are employed in this sector in Warwickshire, 17,000 are in jobs that have a very high probability of being automated.

With improvements in Deep Learning machines, it is no surprise vehicle drivers are in the top 10 occupations to be impacted in this sector. Again, we estimate that the following are at higher risk of being automated sooner: Transport & distribution clerks, large goods vehicle drivers, postal workers and elementary storage occupations.

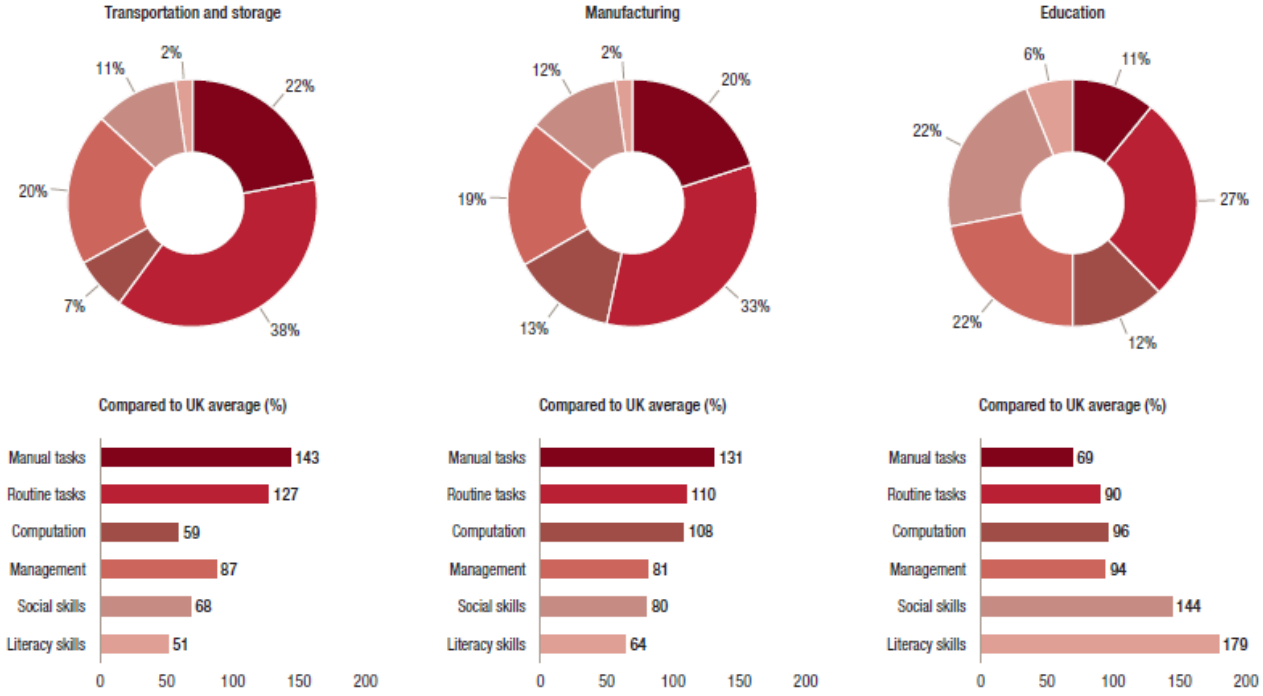
Tourism

The tourism sector employs the 8th largest number in Warwickshire. An estimated 3 in 5 or the 21,000 jobs in this sector are very susceptible to automation. After agriculture and transportation & logistics, this is the third highest proportion of workers at very high risk.

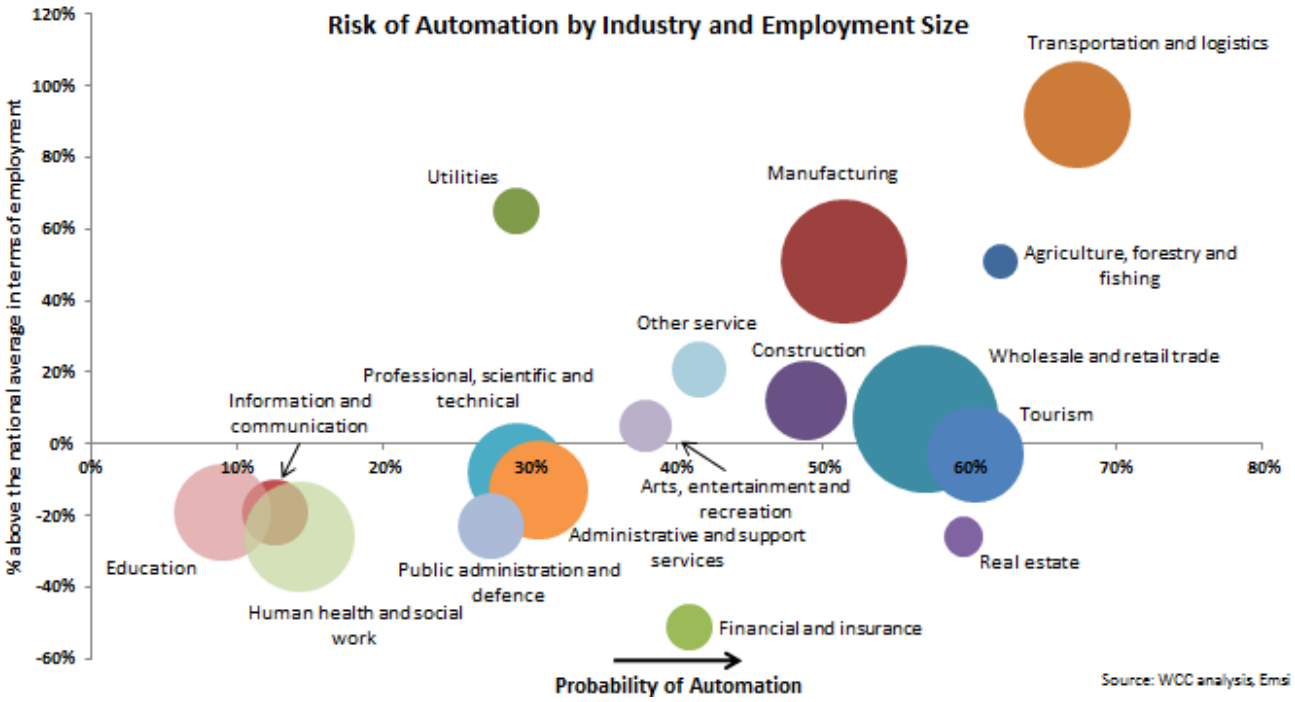
Supplementary to the list beside, waiters & waitresses bar staff and other elementary service occupations are, by our estimations, most likely to be automated before any others in this sector.

Although the impact of automation is likely to affect many jobs in these four sectors, figure 3 illustrates nicely how computerisation has the ability to impact many jobs across every sector.

Why does the risk differ by sector? One of the main drivers of a job being at potential risk of automation is the composition of tasks that are conducted. Workers in high automation risk industries, such as transport and manufacturing, spend a much greater proportion of their time engaged in manual tasks. Take the following diagram from PwC for example.



The following figure highlights the impact of automation on each sector in Warwickshire. The size of the bubble reflects the employment numbers in each sector locally. The higher the bubble is located, the greater the employment share is relative to the national average, and the further right it is positioned, the more it is impacted by computerisation.

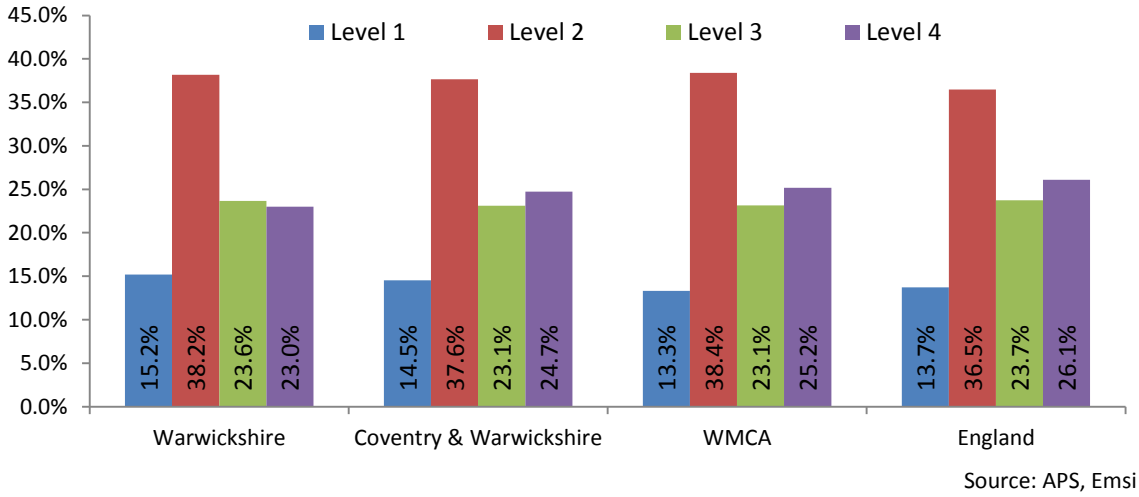


Even though real estate is significantly impacted by automation, Warwickshire does not specialise in this sector. However, manufacturing has an above average automation score (41%) and it is a particularly strong sector locally. This may help explain why Warwickshire has a larger than average proportion of workers at very high risk of automation.

5. Why is Warwickshire more susceptible to automation?

The occupational structure of Warwickshire's economy lends itself to higher automation risk probabilities. The following graph shows the proportion of workers by qualification level in each of the different regions.

Figure 4: Proportion of Jobs by Qualification Requirement



Source: APS, Emsi

Warwickshire has a higher proportion of workers in low-skilled occupations (15.2%) and a lower proportion of workers in high-skilled occupations (23.0%). This also means that the county has a higher proportion of workers in middle-skilled occupations (61.8%).

Even though Warwickshire has more workers in lower-skilled occupations, this is not a sufficient condition to have a larger proportion of workers at very high risk of automation. While level 1 occupations are, *on average,* at higher risk of automation, each individual occupation may have a higher or lower risk probability. For example, train and tram drivers have a 92% probability of being impacted by computerisation compared to just a 13% chance of driving instructors. The following table breaks the risk of automation down by area for each occupational level.

Table 5: Proportion of jobs by risk of automation score for each occupational level

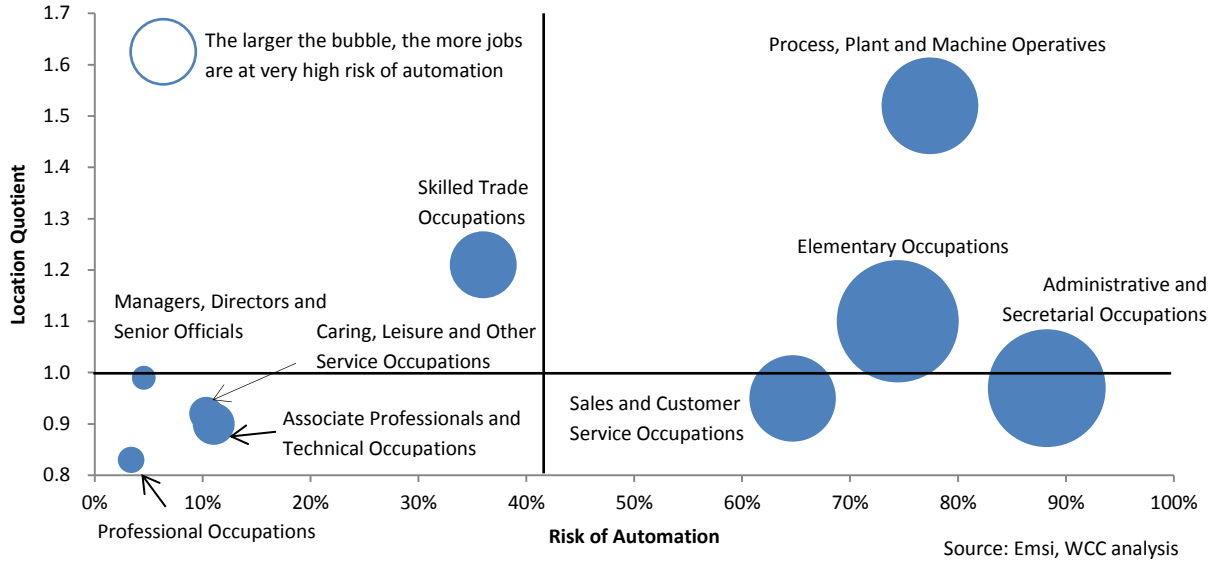
Level	Score	Warwickshire	CWLEP	WMCA	England
Level 1	Very high risk	74.4%	73.5%	72.2%	70.8%
	Very low risk	0%	0%	0%	0%
Level 2	Very high risk	63.2%	63.0%	62.0%	61.0%
	Very low risk	3.9%	3.9%	4.0%	4.8%
Level 3	Very high risk	21.8%	21.2%	23.9%	21.4%
	Very low risk	26.6%	25.9%	24.4%	27.0%
Level 4	Very high risk	2.3%	2.1%	2.6%	2.7%
	Very low risk	59.6%	63.0%	66.3%	64.4%

Very low risk refers to at most a 10% probability of being computerised — Source: Emsi, WCC analysis

We find that Warwickshire does not only have a greater proportion of lower-skilled workers, but more of these workers are at very high risk of automation. Elementary occupations are those that require level 1 qualifications. Warwickshire employs approximately 40,000 workers in these occupations, 10% more than the national average, and an estimated 74% of these workers are at very high risk of being computerised.

Warwickshire also has an above average share in employment of process, plant and machine operatives and skilled trade occupations. Figure 3 highlights the occupations that are most at risk of automation and play a larger than average role in the local labour market.

Figure 5: Warwickshire's strength in occupations at very high risk of automation



Source: Emsi, WCC analysis

The graph is effective in summarising the relative impact of automation on Warwickshire's occupations. In two of the three most at risk occupations (Process, Plant and Machine Operatives and Elementary occupations), Warwickshire has a larger than average proportion of workers[9]. This is one of the biggest drivers behind the relatively high proportion of workers at very high risk of automation in Warwickshire.

Those at very low risk of automation also impact the average risk levels in the economy. With a probability score of below 10%, these occupations require skills that are unlikely to be computerised. Across all occupations in Warwickshire, 20.5% of workers are in jobs at very low risk of being impacted by technological change. This is below Coventry (25%), the WMCA (23.0%) and the rest of England (23.9%).

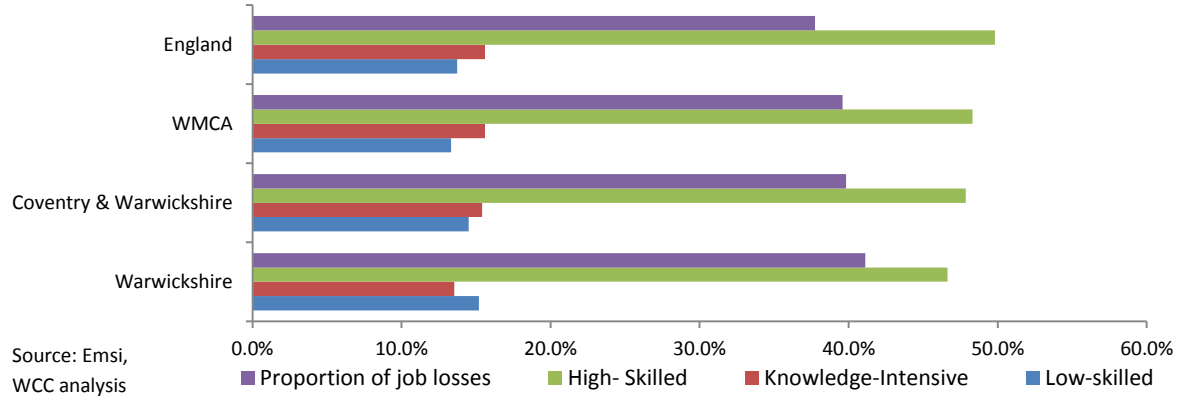
Table 1 breaks the proportion of workers at very low risk of automation down by qualification level. We can see that Warwickshire not only has fewer workers in high-skilled occupations, but fewer of these are in occupations at very low risk of automation. Just 59.6% of high-skilled workers are in jobs unlikely to be impacted by computerisation, compared to 63.0% across the LEP area, 66.3% in the WMCA and 64.4% across England.

Part of this can be explained by the relatively small number of knowledge intensive jobs in Warwickshire. These jobs tend to be at the forefront of innovation and research & development and just 1.4% of jobs in these occupations are at risk of computerisation. In Warwickshire, however, just 13.5% of jobs are in knowledge intensive occupations, 13% lower than the national average. Of these, fewer are at very low risk of automation.

The majority of workers in knowledge intensive occupations are in the 'professional' and 'associate professionals and technical occupations' categories. These are positioned to the bottom left of figure 3, suggesting they are in less demand here than the average local authority area.

These results support the Cities Outlook 2018 statement that "Cities with a higher risk of job losses tend to have a lower share of jobs in knowledge intensive business services and a lower share of high-skilled workers". The following diagram shows how this statement applies to wider geographical regions. Areas with more high-skilled and knowledge intensive workers are less exposed to the risks of automation.

Figure 6: Job Losses and Employment by Skill Level



Source: Emsi, WCC analysis

[9] This is measured by the location quotient. The **Location Quotient** is a measure of the concentration of employment in an occupation in an area. A value of **one** suggests that the amount of employment in an occupation is proportional to its size compared to the national average.

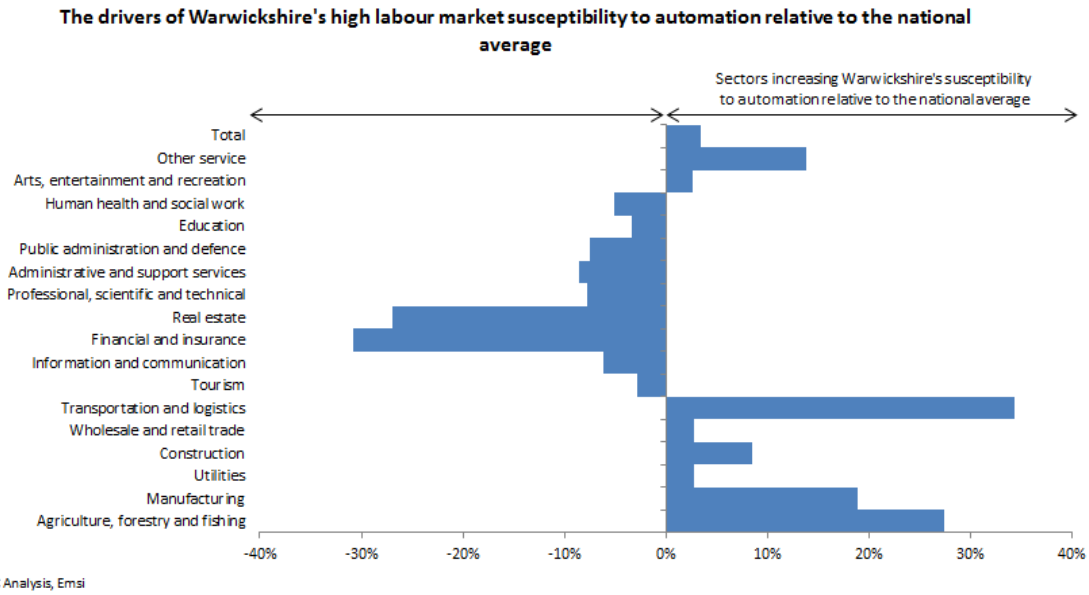
Our analysis goes one step further by examining the automation risk within each category. Figure 5 summarises the automation risk for each of these groups. It shows that, not only does Warwickshire have fewer high-skilled and knowledge-intensive workers, but that workers in these skill categories are at higher risk of automation than the LEP, WMCA and England averages. For example, England has a larger proportion of knowledge intensive and high-skilled workers at very low risk of automation. It also has a lower proportion of low-skilled workers at very high risk of automation.

Figure 7: Automation Risk by Skill Levels

Source: Emsi, WCC analysis

The types of occupations in demand in Warwickshire are determined by the structure of the local economy. There are an abundance of low-skilled jobs because Warwickshire has a relatively large low-wage economy. The agricultural sector plays a significant role in the labour market and many of these workers at very high risk of automation.

The following graph shows which sectors are contributing to the relatively high proportion of workers at very high risk of automation in Warwickshire compared to the national average.



Source: WCC Analysis, Emsi

Blue bars situated to the right of the '0% line' are sectors contributing to the above-average number of workers at very high risk of computerisation in Warwickshire. The transportation and logistics sector employs 25,250 people locally, almost double the national average for Warwickshire's labour

market size. Also, 67% of workers in this sector are at very high risk of automation, compared to 62% across the rest of the country. The employment strength and the relatively high automation risk score means this sector is one of the main reasons for Warwickshire having a higher relative susceptibility to automation.

The local agricultural, manufacturing and construction sectors also have a higher average risk of being impacted by computerisation. For each of these sectors Warwickshire has a location quotient of greater than 1, demonstrating its relative employment strength in industries that are at a higher risk of automation. Indeed, in every sector that Warwickshire has relative employment strength in, other than the Utilities sector, the average risk of automation is higher than the national average.

The same process can be repeated for Coventry and the WMCA (and the results can be shared with whoever is interested but will not be included here). Tourism, agriculture and transportation & logistics are the three major sectoral differences between them and Warwickshire.

6. The opportunities arising from automation

In section 2, we discussed how a smaller proportion of jobs posted online are at very high risk of automation compared to the existing workforce. One of the justifications is that employers are already realising the value of workers in occupations that can support the development of robotics and deep learning machines. The first of the opportunities that we discuss are the jobs considered to be at very low risk of automation and where future growth may come from.

Creative occupations

Nesta's 2015 report 'Creativity vs. Robots' identified a number of sectors and occupations that were less likely to be automated because they had an element of creativity attached to the jobs. This was to supplement existing literature on the risk of automation that took less account of the learning capabilities of robots. Since FO (2013), developments in machine learning and mobile robotics have increased the probability that computers may be able to undertake non-routine tasks. The Nesta report confirms that creative occupations are more future-proof to computerisation.

Table 6: Growth in jobs least at risk of automation in Warwickshire

	Online Adverts Growth	Wages	Jobs
Architects	366%	£43,000	305
Biological scientists and biochemists	260%	£32,000	445
Higher education teaching professionals	237%	£39,000	175
Electronics engineers*	232%	£46,000	315
IT specialist managers	206%	£52,000	1,920
Quality control and planning engineers*	191%	£42,000	520
Mechanical engineers*	179%	£43,000	980
Graphic designers	173%	£32,000	410
IT business analysts and systems designers*	165%	£46,000	1,045
Civil engineers	164%	£43,000	520
Design and development engineers*	141%	£44,000	1,120

*Above average employment numbers, LQ>1 Source: WCC analysis, Nesta (2015), Emsi, Labour Insight

Taking the automation risk scores of FO (2013) to identify occupations at very low or no risk, using data on job demand from Labour Insight and combining it with Nesta's creative industries, we can identify which occupations are least likely to be impacted by automation. The eleven occupations in table 6 are classed as 'creative'[10], have experienced higher than average job vacancy growth over the last 5 years and have less than 10% probability of being automated. These are the fastest growing occupations in Warwickshire that will not be negatively impacted by computerisation.

There are approximately 7,250 workers employed across these eleven most in-demand occupations. On average, vacancies have expanded 210% since 2013 and the corresponding advertised salaries average £42,100. These salaries are higher than the average advertised salary in Warwickshire in 2017, which suggests these jobs are in roles that are, on average, more productive.

Significant job growth in more productive jobs that are at very low risk of automation will be the ambitions for many policy makers going forward. A larger than average employment share in these occupations will result in lower overall susceptibility to computerisation. Indeed, more jobs in IT related roles have the potential to not only lower susceptibility, but also benefit from greater demand for robotics and computerisation in the workplace.

However, growth and employment in the occupations listed in table 6 is behind the national average. For example, the number of biological scientists and biochemists is 34% below the national average and has fallen 7% over the last 5 years, compared to a 9% rise nationwide. Also, IT specialist managers, who are the largest group on the list, have seen employment numbers have fall 1.5% over the last year, compared to a 1.8% rise UK-wide.

More generally, there are 8,250 people employed in all nine IT and telecommunications occupations, 5% more than the national average. Annual growth across these, however, is -1.1%, far below the national average of 2.1%. Furthermore, over the last 5 years, employment growth across the country has been twice the rate of the county average. Given the high automation resilience of these occupations, it will be important to capitalise on the high demand in these sectors.

On the other hand, there is good news for the occupations in which Warwickshire specialises. Design and development engineers are the largest occupational group that has an above average number of workers employed in. This group has grown 26.4% in employment over the last 5 years, almost double the national average.

The other four occupations that Warwickshire has a higher concentration of are electronics engineers, quality control and planning engineers, mechanical engineers and IT business analysts & systems designers. Across all five of the occupations, job growth has increased 23.7% over the last 5 years, 10 percentage points higher than the national average.

Employees from the occupations in table 6 are most likely to be working in the following three sectors: Engineering & technical consultancy, automotive and computer consultancy, programming & other service activities. Excluding the automotive sector, employment in these sectors is 35% above the national average, but they are growing at just one fifth of the pace. As computerisation begins to become more entrenched into the workplace, growth in these low-risk, high productive sectors will be important for the success of Warwickshire's economy.

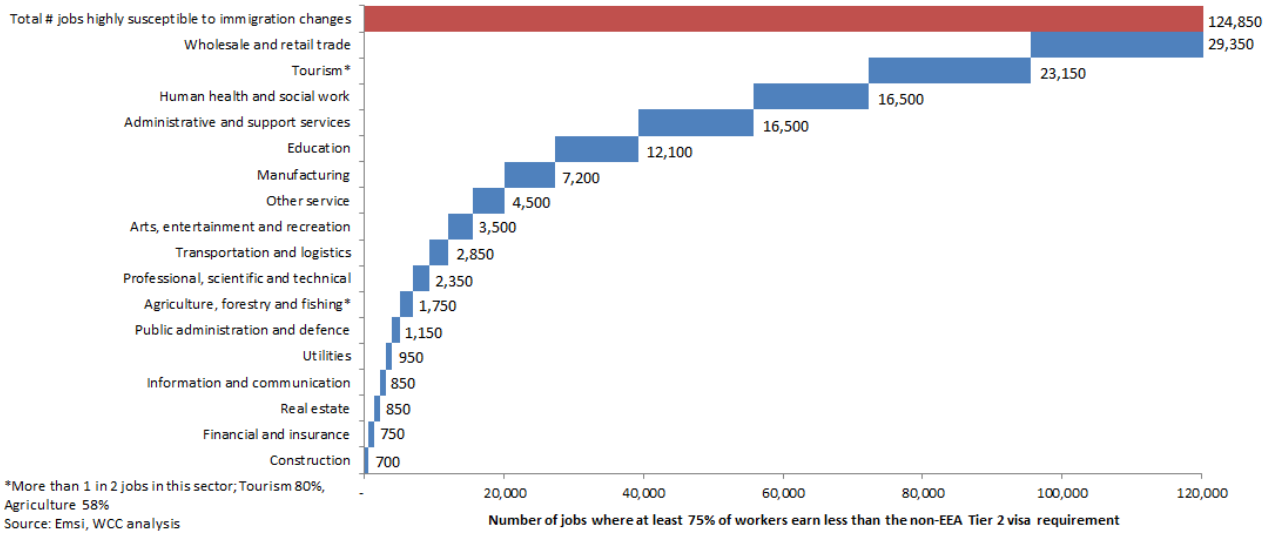
[10] Creative: probability of 70% or more of being creative

Brexit

Earlier we discussed the option of using robots to fill labour shortages. As the price of a unit of labour gets more expensive, the benefits of investing in automation increases. A scenario that could impact the rate of automation is the UK's exit from the EU. The following section looks at the potential susceptibility of different occupations to changes in immigration policies. Those that have the potential to be significantly impacted by policy changes could experience future labour shortages. These occupations will be mapped against the occupations at risk of automation.

A tier 2 visa is the main immigration route for non-EEA nationals to apply to work in the UK. The minimum 'appropriate' salary to obtain a work permit is £20,800, although most tier 2 (general) visa's will only be considered if workers earn more than £30,000. We use salary data for each occupation to establish how susceptible the occupation is to EU nationals facing the current non-EEA immigration requirements. The following graph shows the number of jobs in Coventry & Warwickshire that would be difficult to fill with an EU national if the immigration rules changed.

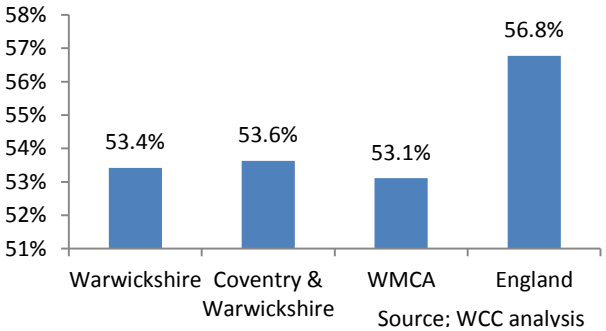
Number of jobs that are very susceptible to immigration policy changes in Coventry & Warwickshire



We estimate that around 124,850 jobs are very susceptible[11] to changes in immigration policies. Sectors that typically contain a large proportion of low-paid workers will be most affected. If we match those who are very susceptible with the occupations at very high risk of automation, we find that more than 1 in 2 jobs that are at very high risk of immigration policy changes are also at very high risk of automation.

This result confirms that those in lower paid occupations are more likely to be at risk of automation. It also shows how important investment into automation will be if we come out of the EU customs union. Inevitably, restrictions on migration will lead to a shortage of labour and here we can see that automation will be a feasible option for 1 in 2 jobs that could be hard to fill.

Brexit and Automation Risk



[11] Very susceptible – at least 75% of workers earn less than the non-EEA tier 2 visa requirement.

7. Summary & Policy Recommendations

Moore's Law refers to the doubling of computer processing speed every 18 months[12] and is part of a greater trend that has seen technology change at an exponential rate. As it manifests itself within the workplace more, a wider range of occupations – and skill levels – could potentially be affected. Our analysis helps discern those occupations and sectors that are most likely to be impacted by automation from those that may benefit.

The report is also unique in that it offers an opinion on the roles in Warwickshire that are closest to the statistical automation tipping point. Elementary storage occupations, large goods vehicle drivers and vehicle & metal goods assemblers have been identified as the three most in-demand occupations at risk of being automated sooner rather than later. These make up a significant proportion of both the transportation & logistics and automotive industries, which are also set to displace the greatest number of workers, behind the wholesale & retail trade sector.

Undoubtedly, smart technology, capable of deep learning and free movement, has the potential to displace many people. Our results in this sense are not unusual. However, the tools that our research gives policy makers, who wish to understand the reasons behind Warwickshire's relatively high susceptibility to automation, is wherein our difference lies. The report is aimed at enabling a proactive approach to minimising the displacement of and maximising the returns to the event that, over the next decade, will have the largest impact on the Warwickshire's workers.

The effect of technological advancements on the workforce is not a new challenge for businesses and employees, and neither is it for policy makers. We could go back as far as the Factory Acts, passed in the 1800s, that were the by-product of manufacturing process improvements throughout the industrial revolution. The scale of the challenge, however, is what makes it different. For this reason there has been an explosion of interest in what future technological trends will imply for policy.

In an economic context, minimising the losses of automation will help maximise many of the opportunities. Productivity improvements and economic growth would lead to higher wages and disposable income. Technological improvements in health and social care can aide an ageing population. Big data processors can generate consistent evidence-based decisions and scenario testing can help us achieve more efficient outcomes. This will, however, require a cohesive and proactive approach on how we deal with rapid improvements in technology.

Some of the key policy recommendations that present themselves from this detailed analysis:

1) **Retraining and continuous learning:** The exponential growth in technology will coincide with job roles changing at a faster pace. It will be increasingly important that all individuals have the opportunities to retrain, giving them the ability to obtain the new skills that are required to meet the changing demands of their job. Automation will impact middle-skilled workers most and if the option to up-skill is not provided, we shall see a hollowing-out of those located in the middle of the qualification spectrum. Career changes, apprenticeships and a National Retraining Scheme could all help avoid the potential for greater inequality.

[12] http://bigthink.com/think-tank/big-idea-technology-grows-exponentially

2) **Supporting co-investment by businesses in technology and skills:** Kate Sweeney, Partner and UK Lead for Future of Work at Deloitte, emphasised the need for businesses to move from experimenting around the edges with innovation to full-scale transformation. For policy makers, the focus should be to help businesses think about strategic investment in automation. By supporting the implementation of new technology, businesses should ensure that robots and computers sit alongside workers. This will require firms to train existing workers to allows them to work in parallel with technology and specialise on more complex parts of their role that use talents such as empathy, creativity and problem solving.

3) **Increasing highly skilled, knowledge intensive occupations:** A key reason behind the county's high number of workers at risk of automation is the low proportion of high skilled and knowledge intensive workers. These jobs tend to be at the forefront of innovation and research & development, adding significant value to the local economy. By increasing the number of workers in these occupations, we will not only improve Warwickshire's economy and increase its resilience to automation, we can also maximise the potential upsides of automation. Warwickshire is making huge strides in CAV, AV/VR technologies and robotics, thus, by creating a cluster of firms and workers specialising in their development, the county can be a driver of technological advancements.

4) **Embedding skills for the future within education and training programmes:** In future, jobs will be very different and the skills required will become obsolete ever faster as the pace of innovation continues to increase. We will not be able to rely on predefined career paths to create people who are 'ready-made' for roles in our organisations. According to the U.S Department of Labour, 65% of today's school children will eventually be employed in jobs that have yet to be created. Instead, we must focus on transferable skills that the literature has identified[13], such as communication – *listen, respond and express ideas effectively in different contexts*, strategic – *exercise judgement, leadership and creativity*, analytical – *acquire knowledge, process information and draw accurate conclusions* and innovative – *generate and express new ideas, challenge & question existing thinking and solve problems*.

5) **Recognising and promoting multiple careers:** Going forward, work is likely to be much more flexible, and people will undertake a number of roles during their working life. We must raise awareness of this in careers education, and within HR professionals, and ensure we have provisions in terms of retraining, continuous learning, and focus on the transferable skills. In effect this last recommendation is about supporting the culture change, without which the recommendations above will not work.

With these broad recommendations it should be feasible to reduce the number of jobs we have shown to be at risk of automation. It should also, however, be emphasized that the estimates of the jobs at risk of automation are based on probabilities. Although some occupations are more susceptible to automation than others, in reality expected advancements in technology may not be realised in the future. Also, if automation does impact the workplace by the early 2030s, the job estimates are not indicative of the expected job losses. In many instances, computerisation will be used to improve the productivity of a worker rather than replace his/her job.

[13] Deloitte (2018) Power Up: UK skills, Pearson (2017): The future of skills, employment in 2030

Ultimately, the decision to invest in automation lies with a business and it must understand the benefits before undergoing transformation. There is a difference between a task that can be automated and ones that should be. If the organisation can identify the level of disruption and ascertain the value-added of changing the focus of existing workers roles, it can make informed decisions on whether to automate. In the case where it is beneficial, it is crucial that they undergo a transformation that supports the wider economy. This can only be guaranteed if policy makers think proactively about the impacts of automation and develop clear, structured frameworks.

8. Acknowledgements

We would like to thank Emsi and Hannah Green, WCC Economy & Skills Administrator, for their part in the development of this report. The data that underpins the work is the foundation for any good research and without the input of our Economy & Skills colleagues, Emsi, Labour Insight and other contributors to the automation field, this report would not be as insightful for policy makers as it is.

Also, the data used in this report is up to date as of the 31st December 2017. We are happy to share any of the publically available data we have used and can provide any additional analysis that is supplementary to this piece. Please contact Warwickshire Economics for more information.

9. Warwickshire Economics

Warwickshire Economics is our newly established branch that is dedicated to economic analysis and research. Sam van de Schootbrugge, a postgraduate economist, is the lead on projects for the team. Our main aim is to help local governments, institutions, businesses and other interested parties to support local economic growth. By supplying our expertise we can ensure that there is a local research hub for all of those who need it.

Please visit our website (http://www.warwickshire.gov.uk/economicassessment) for more information or give Sam a call on (01926) 412949.