Anticipating a 4th Industrial Revolution and the Futures of Learning: A discussion paper for Wolverhampton Learning City Region.

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University of Wolverhampton, 2019

In a world of change, the learners shall inherit the earth, while the learned shall find themselves perfectly suited for a world that no longer exists.

Eric Hoffer

You cannot wait until a house burns down to buy fire insurance on it. We cannot wait until there are massive dislocations in our society to prepare for the Fourth Industrial Revolution.

Robert Schiller

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The tensions that exist within debates over the hopes and fears of new technologies and in this instance, a 4th industrial revolution is exemplified in a 1930's essay by Keynes titled, "Economic Possibilities For Our Grandchildren." On the one hand, John Maynard Keynes recognised that the advancement of new technologies and the lag that characterised society's responses, had led to the rise of technological unemployment: "unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour". And yet, within the same essay, Keynes projected that by the time his grandchildren were adults, it could be possible for people to have increased living standards, whilst reducing paid work to just 15 hours a week.

The Futures of Learning

The report in 60 Seconds

What learning is needed for the 21st Century and what changes can be made for learners today and for tomorrow? What skills, knowledge and experience are needed for jobs that do not exist yet? What institutions and relations and practices will be needed to support the school leavers, apprentices and graduates of 2020 and 2040? In a world that it is projected to change rapidly and unevenly, what role will learning have in helping anticipate and shape the future?

Public sector, market, third sector leaders are faced with some critical challenges and choices. Exponential advances in genetic engineering, nanotechnology, biotechnology, artificial intelligence, robotics, graphene and additive manufacturing (3D printing) are set to constitute a 4th industrial revolution.

A 4th industrial revolution is not just characterised by particular technologies but the fusions between these technologies, the capacity to redraw the lines between physical, digital, and biological domains and the potential scale, speed and spread of these changes.

The breadth of skills and functions afforded by new technologies will not only have an impact on the number and type of jobs available across all sections of the job market, but also have the potential to challenge existing divisions of labour and the nature, value and meaning of work and learning.

Of course, one of the major challenges and contradictions when anticipating futures, is how can one prepare for the unknown? This is a major challenge. There is no consensus as to the number of jobs that will be lost or created as a result of a 4th industrial revolution, but it is anticipated there will be no more routine jobs in the future.

Investment in the development of knowledge and skills in science, technology, engineering and mathematical (STEM) subjects is self-evident, but social, creative and critical thinking skills will be vital as they not only prove resistant to automation, but are essential to efforts to anticipate and engage with the disruption and challenges of a 4th industrial revolution.

By anticipating the changes on the horizon, there is an opportunity to review and redefine the needs of today's and tomorrow's learners. Due to the scale of change that is anticipated it is argued that no one agency will be in a position to meet the grand challenges of a 4th industrial revolution. The level, scale and pace of change require both long-term thinking and cross-sector action. Subsequently a potential role for a nascent learning region will be to help to surface, assess and develop the future readiness of all those who live and work in the region.

Table 1: Projected opportunities and risks of a 4th industrial revolution	
Opportunities	**Risks**
Creation of new knowledge, jobs, products and services. Productivity gains and increasingly bespoke products and responsive services. Improved ergonomics and augmented labour. Abolition of dangerous, repetitive and routine tasks. A connected world, open systems, and increased transparency and accountability. New collaborative and cooperative organisational forms, relations and practices. Possibilities of social emancipation and reductions in social, political and economic inequalities.	Jobless growth with significant levels of job destruction. Emergence of dominant oligopolies and increased concentrations of wealth. Precarious and polarised labour markets. Acute skills shortages in areas of growth and a mismatch between the demand for skills and the supply of education and training. The extension and intensification of monitoring, surveillance and the erosion of privacy. Increased opportunities for cybercrime and disruptive political and economic agents. Digital Taylorism and an 'algorithmic' management of behaviour. Policy and regulatory lag, including the weakening of collective action and social protection systems.

Introduction

The aim of this report is to stimulate thinking, extend conversations and inform actions as to how the futures of learning could and should be shaped. Particular attention is given to the anticipated impacts of a 4th industrial revolution on learning and the potential roles of a learning city region in shaping the futures of learning.

To this end, the aim of the report is not to predict or prescribe a future, but to anticipate the opportunities and challenges of a 4th industrial revolution and to explore the assumptions we hold as to:

- Who learns?
- Why people learn?
- What people do, could and should learn?
- How people do, could and should learn?
- Where people do, could and should learn?

As with previous industrial revolutions, the technologies that constitute a 4th industrial revolution have the potential to disrupt existing social, political and economic relations and raise a number of social, political, economic, and ethical questions. Who bears the risks and who will be able to take the opportunities of a 4th industrial revolution is yet to be determined and will depend in part on the response of policy makers and other stakeholders.

New technologies afford new risks and opportunities and a 4th industrial revolution has the potential to create new knowledge or even fields of knowledge, new products and services, new techniques and new forms of institutional and power relations and practices.

A lesson from history is to note and reflect on the transformative impact of each of the previous industrial revolutions on society. It is argued that many of today's institutions, relations and practices represent responses to previous industrial revolutions. From the recurrent transformation in work practices to the organisation of trades unions, the development of the welfare state and the scale form and function of primary, secondary and tertiary education, previous industrial revolutions have had a huge impact on societies institutions, relations and practices.

Technological change is not new. Previous industrial revolutions have seen job destruction and creation, changes in the organisation of work and wider social and political relations. It is anticipated that a 4th industrial revolution has the potential to have an equal If not greater impact on how we work, live and learn.

Any efforts to anticipate the impact of new technologies need to be treated with a considerable degree of caution and humility. Change is a complex and dynamic process and within this report new technologies are recognised as one of a number of drivers of change. The extent to which such innovations take hold and accompanying risks and opportunities are realised, needs to be understood within the wider context of economic, social and political relations and practices.

A thought experiment.

Imagine we are in 1750, before the big changes of the industrial revolution, and we were trying to describe the future of work in 1800 and 1850. Would you be thinking about all the different ways to preserve that past in the future or would it be better to imagine how work could and should be organised in the next century. This is the challenge, to check our assumptions and to 'use-the-future' to sense and make-sense of emergent novelty and possibilities and open up the present and the future?

Shaped by its industrial past, in the 19th century, the Black Country was one of the most heavily industrialised areas in the world. During the course of the 20th century, the Black Country, together with Birmingham and Coventry, constituted a vital part of the UK's

manufacturing economy and was host to a number of globally known companies.

As shown in Figure 1[1], although manufacturing (groups 8-9) remains vital, other sectors, managers and professions (groups 1-3); and administrative and skilled trades (groups 4-5) and caring, leisure, retail and other service occupations (groups 6-7) also constitute a significant part of the Black Country's economy. Alongside these figures on employment, the upward trend for those who are self-employed also needs to be considered[2].

The Black Country's distinct and significant industrial heritage continues to shape the present, but what about the Black Country's future? What risks and opportunities does a 4th industrial revolution hold for the Black Country and how can a learning city region inform what, where, how and why people learn, both today and in the future.

Although far from a new idea, and with roots in all cultures, the idea of learning throughout life is becoming increasingly relevant in a turbulent, uncertain, novel and ambiguous (TUNA) world. It is argued that lifelong learners, those citizens who are able to acquire new knowledge, skills and attitudes in a wide range of contexts, are better equipped to adapt to changes and enact changes in their environments.

Drawing on UNESCO's model of a learning city, a learning city region is a vital vehicle for promoting lifelong learning for all. UNESCO defines a learning city as a city that:

•effectively mobilizes its resources in every sector to promote inclusive learning from basic to higher education;

•revitalizes learning in families and communities;

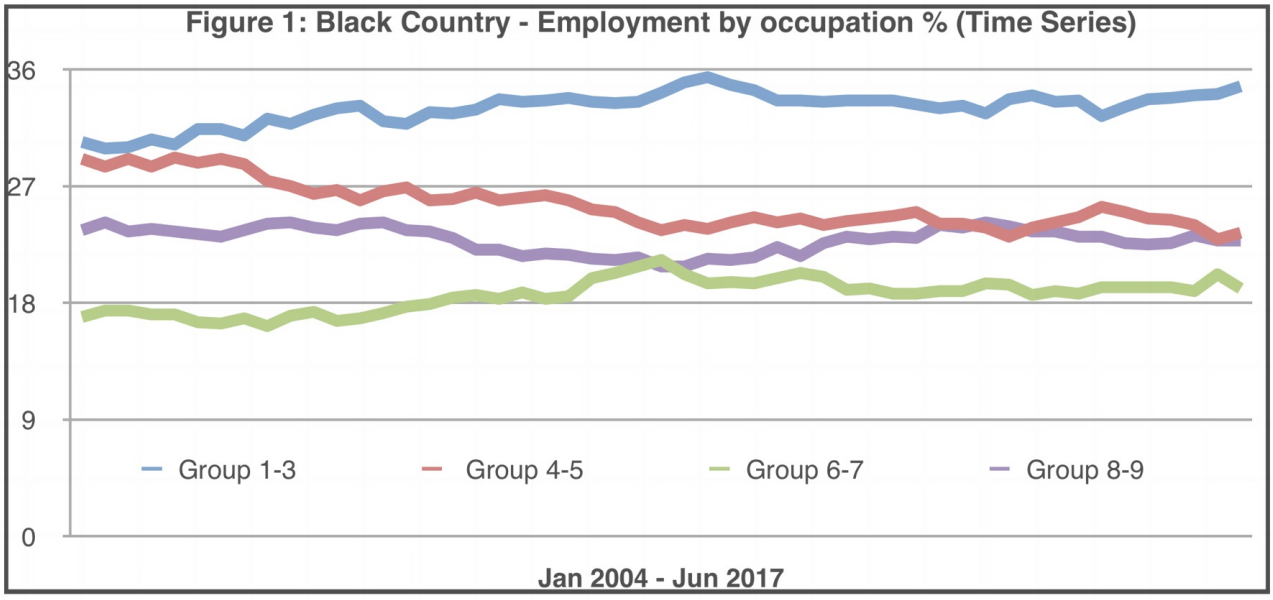
•facilitates learning for and in the workplace;

•extends the use of modern learning technologies;

•enhances quality and excellence in learning; and

•fosters a culture of learning throughout life.

While cognisant of national and regional policies, it is argued that a sustainable and transformative learning city region is driven by commitments made at the local level and the insights, innovation and investments of multiple stakeholders across the region.



[1] ONS (2018) Nomis, official labour market statistics – Local Enterprise partnership profile. https://www.nomisweb.co.uk/reports/lmp/lep/1925185537/report.aspx?town=Black%20Country#tabempocc

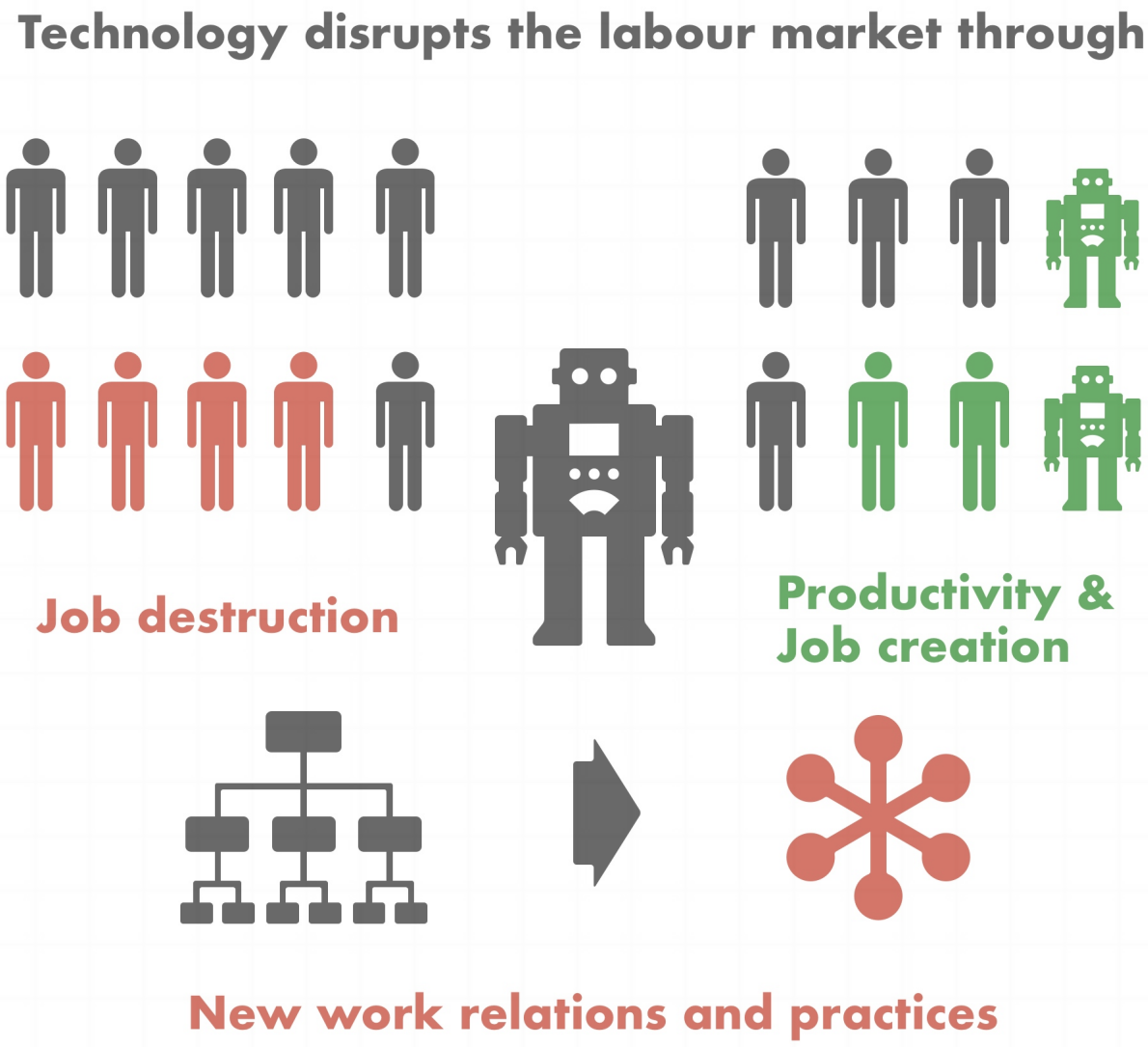
[2] ONS (2016) Trends in self-employment in the UK: 2001 to 2015. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/trendsinselfemploymentintheuk/2001to2015

A 4th Industrial Revolution

It is anticipated that developments in genetic engineering, nanotechnology, biotechnology, artificial intelligence, robotics, graphene and additive manufacturing (3D printing) will constitute a 4th industrial revolution[3]. The technologies associated with a nascent 4th industrial revolution are already beginning to transform the way that goods and services are produced, distributed and consumed in the Black Country.

However, a 4th industrial revolution is not just characterized by particular technologies but the spread, scale and speed at which new technologies are being adopted and the crossover and fusions between these technologies and wider social, political and economic relations and practices.

In this regard, it is anticipated that the distinguishing characteristics of a 4th industrial revolution will be the synthesis of technologies that have the potential to redraw the lines between the physical, digital, social and biological domains[4] and the rapidity and reach of these changes.



[3] Schwab K (2015) The Fourth Industrial Revolution, Foreign Affairs, World Economic Forum, Geneva. https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution, and e-book http://www3.weforum.org/docs/Media/KSC_4IR.pdf.

[4] JRC/IPTS (2007) Consequences, Opportunities and Challenges of Modern Biotechnology for Europe, Joint Research Centre — Institute for Prospective Technological Studies, Seville, Spain; Kurzweil, R. (2005) The Singularity is Near: When humans transcend biology, New York, USA: Viking; Subramanian, V. (2009) Active Nanotechnology: What can we expect? A perspective for policy from bibliographical and bibliometrical analysis, Georgia Institute of Technology, Atlanta, USA; World Economic Forum (2017) Center for the Fourth Industrial Revolution.

It is the projected advances in AI, machine learning, digital learning and an expansion of the internet of things, enabling a new wave of intelligent robotics and automation, which serves as the focus of this report. Efforts to reduce and save labour by automating tasks have a long history[5]. Technology impacts the labour market and wider society through:

Destruction and displacement – the replacement of labour with technology-reducing employment and wages.

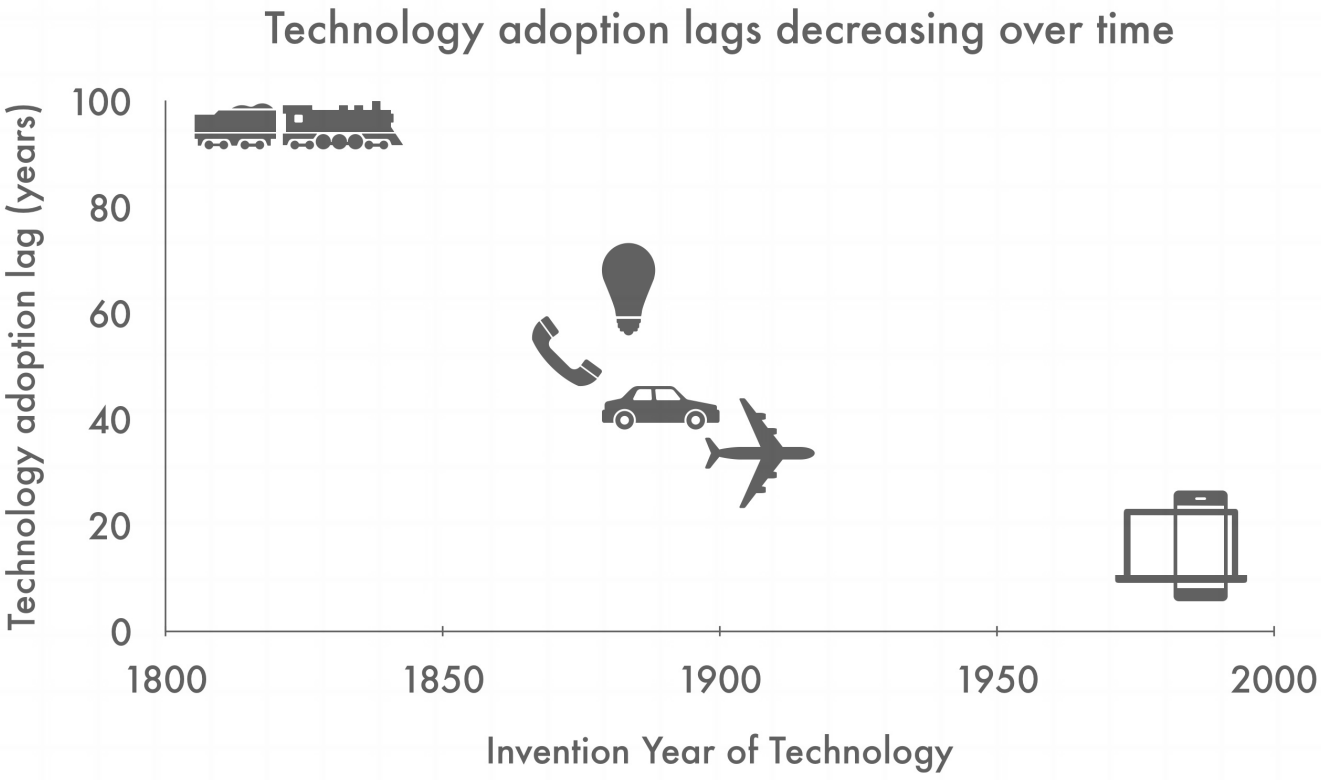
Productivity – technology can enable those in work to be more productive.

Creation – the development of new tasks for labour using the new technologies that have been created.

There are arguments that although a 4th industrial revolution will also share these impacts, the difference will be in the increased speed, scale and form of impact.

Previous industrial revolutions can be characterised by the increased importance of cognitive tasks relative to non-cognitive tasks. Since their inception machines have tended to substitute for human hands not their heads. Those whose manual jobs have been displaced by machines have, over time, tended to be able to upskill and take advantage of the cognitive higher value tasks, beyond the cognitive ability of machines.

A 4th industrial revolution promises a new generation of machines with the capacity to think, sense, move, learn and act autonomously. Developments in machine learning and robotics mean that these new technologies will be able to operate across a



Adapted from Comin, D and Hobijn, B (2010) An exploration of technology diffusion, American Economic Review, 100(5): 2031-59.
Technology adoption lag is a mean estimated lag in cross-country technology diffusion.

[5] Beniger J (1986) The control revolution: Technological and economic origins of the information society. Cambridge, Mass.: Harvard University Press.

Projected change in hours worked and skills used in Western Europe by 2030 (all sectors)

Skills	Hours worked in 2016 Billion	Change in hours worked by 2030 %
Physical and manual	113	-16
Basic cognitive	62	-17
Higher cognitive	78	7
Social and emotional	67	22
Technological	42	52

Source: Adapted from McKinsey Global Institute workforce skills model; McKinsey Global Institute Analysis.

much wider part of the skill spectrum than previous forms of technology. This presents the prospect that new technologies will not just displace manual labour, but cognitive work as well. The result being, no more routine blue or white collar jobs.

That is, a significant difference between a 4th industrial revolution and previous waves of technological innovation is the potential to substitute for human brains as well as hands.

The breadth of skills and functions afforded by these new technologies means that the impact of automation is likely to be felt across all sectors[6].

Therefore, although the ability to automate skilled and non-skilled labour manual has been the predominant feature of the 20th century, the 21st century is beginning to witness job displacement that extends from blue to white collar professions.

This will potentially limit both the number and range of opportunities to upskill to high value jobs.

The speed of changes means a increased lag in the time that new industries can create the jobs that will be able to compensate for the jobs that have been destroyed over the long term.

The cumulative result being a further polarisation of the labour market and a widening of social and economic inequalities.

[6] Deloitte (2015) From brawn to brains. The impact of technology on jobs in the UK. London: Deloitte

Robots and Automation

It is projected that by 2020 1.7 million new industrial robots will be installed in factories worldwide and that this will be accompanied by an increase in robot density (i.e. industrial robots installed per 10,000 employees)[7].

In terms of units, it is estimated that there will be a significant increase in the worldwide supply of industrial robots between 2018 and 2020 (see Figure 2)[8]. A key driver for growth has been the automation of production in order to strengthen the competitiveness of industries and of notable interest to the Black Country, the automotive sector in particular.

There are five major markets for robotics with China, the Republic of Korea, Japan, the United States and Germany representing 74 percent of the total sales volume in 2016 (See Figure 3)[9]. China has significantly expanded its market and is projected to cement its leading position as the largest market with sales coming close to the total sales volume of Europe and the Americas combined.

Further growth is expected to meet the demand for user friendly, connected and cloud robotics, that have the potential to provide smart production processes through more flexible automation and real time monitoring and adjustment.

The 'Internet of Things' (IoT), that is, the number of, devices equipped with electronics, software, sensors, and network connectivity, enabling the collection, monitoring and exchange of data.

Devices such as mobile phones, cars and household appliances, will be capable of

Paid jobs with tasks at risk of automation: estimates

Arntz, Gregory and Zierahn (2016) 9%; PwC (2017) 30%; Frey and Osborne (2013) 50%

[7] International Federation of Robotics IFR (2017) World Robotics 2017 https://ifr.org/free-downloads/

[8] International Federation of Robotics IFR (2017) World Robotics 2017 https://ifr.org/free-downloads/

[9] International Federation of Robotics IFR (2017) World Robotics 2017 https://ifr.org/free-downloads/

collating and sharing vast amounts of data with users, each other and the enterprises that provide such devices. IoT has the potential to change production and consumption relations and practices.

It is projected that IoT will be a significant driver of productivity in the short and medium term. The growth in the volume and speed of access to data enabled by these new technologies generates a number of opportunities, but also presents a range of challenges to existing institutions, relations and practices[10].

As AI and automation increasingly becomes a vital part of daily lives, and the pace of technological innovation accelerates, the potential of a 4th industrial revolution is already, but only just beginning to be realised.

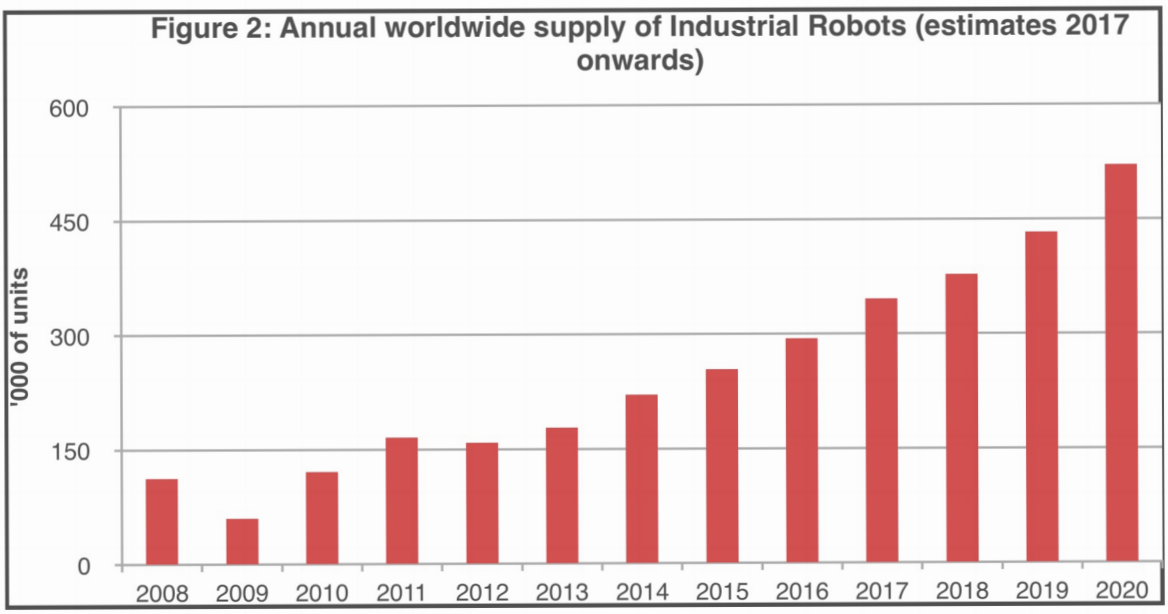


Figure 2: Annual worldwide supply of Industrial Robots (estimates 2017 onwards)

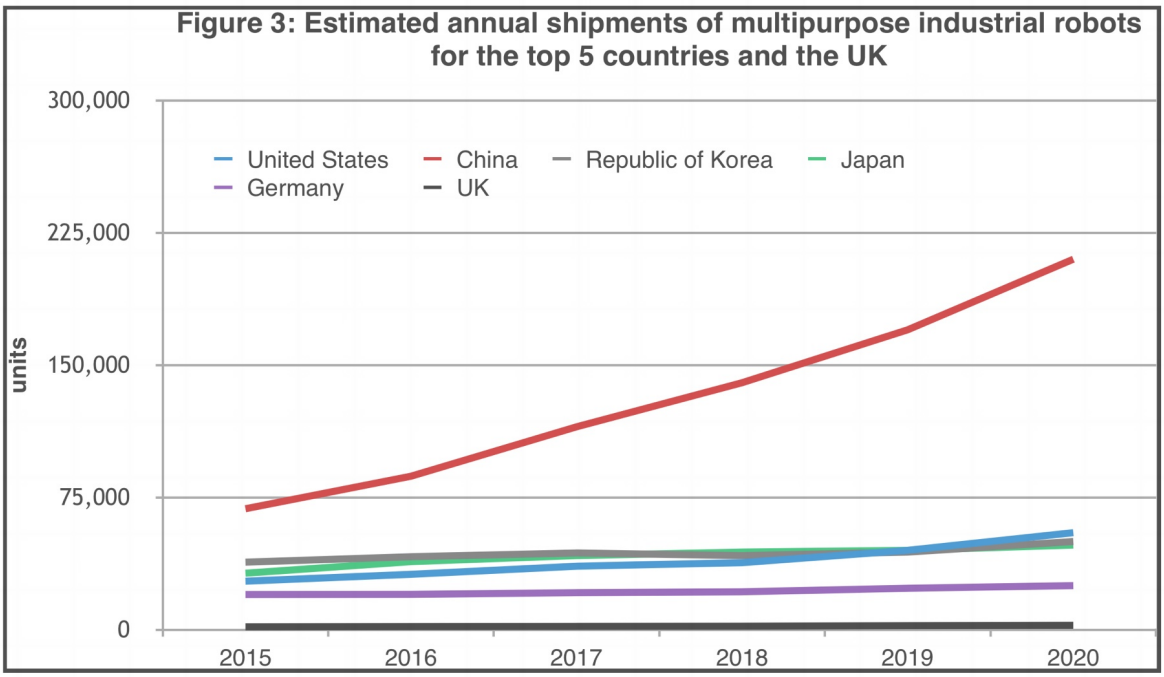


Figure 3: Estimated annual shipments of multipurpose industrial robots for the top 5 countries and the UK

[10] Arntz M Gregory T and Zierahn U (2016) The Risk of Automation in OECD Countries. A comparative Analysis, OECD, Social, Employment and Migration Working Papers No 189, Paris: OECD publishing.

The Futures of (Paid) Work

Debates on a 4th industrial revolution, particularly with regard to intelligent robotics and automation, have tended to focus on disruptions to the paid labour market. The extension and intensification of automation have led to warnings of 'robots at the gate'[11] and raised anxieties and hopes over the prospects and implications of a jobless world and post work society.

Estimates on the impact of new technologies on the labour market differ with regard to the assumptions that are made as to the number of jobs subject to automation and the number of new jobs to be created through developments in robotics, and artificial intelligence[12]. Estimates on the number of jobs with tasks at high risk of automation range from almost 50%[13], through to 30%[14] or 9%[15] (see Table 2).

Table 3 extends and projects a particular scenario[16] as to the estimated proportion of jobs at potential high risk of automation by early 2030s applied to a range of industry sectors in the Black Country.

It should be noted that these projections tend to focus on technological feasibility, not the economic feasibility of automating tasks. Projections of existing jobs being lost due to automation need to be set against the potential of a 4th industrial revolution to boost productivity and generate additional jobs elsewhere in the economy.

It is anticipated that in terms of paid work, there will be growth and an increased demand for highly skilled labour, most notably for people with skills that enables them to operate the technological systems created by advancing technology.

Table 2: Estimated proportion of jobs with tasks in the Black Country at potential high risk of automation based on a range of studies.

Current no. of employee jobs 2017	Frey and Osbourne		PWC		Arntz, Gregory and Zierahn	
	%	No.	%	No.	%	No.
494,200	48	237,216	30	148,260	9	44,478

[11] Rajadhyaksha A and Chatterjee A (2018) Robots at the gate: humans and technology at work. Barclays Impact Series. London Barclays https://www.investmentbank.barclays.com/content/dam/barclaysmicrosites/ibpublic/documents/our-insights/Robots-at-the-gate/Barclays-Impact-Series-3-Robots_at_the_Gate-3MB.pdf

[12] International Labour Organisation (2016) Technological changes and work in the future: Making technology work for all. Issue Note 1 http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_534201.pdf ; UK Commission on Employment and Skills (2014) The Future of Work: Jobs and Skills in 2030, London.

[13] Frey C and Osbourne M (2013) The Future of Employment: How susceptible are jobs to computerisation. Oxford: Oxford Martin School Programme on the Impacts of Future Technology.

[14] PWC (2017) UK Economic Outlook. Section 4. Will robots steal our jobs? London: PriceWaterhouseCoopers.

[15] Arntz M Gregory T and Zierahn U (2016) The Risk of Automation in OECD Countries. A comparative Analysis, OECD, Social, Employment and Migration Working Papers No 189, Paris: OECD publishing. http://dx.doi.org/10.1787/5jlz9h56dvq7-en.

[16] PWC (2017) UK Economic Outlook. Section 4. Will robots steal our jobs? London: PriceWaterhouseCoopers.

Table 3: Illustration of a scenario for the proportion of jobs in the Black Country at potential high risk of automation by early 2030s.

	Employment share of total jobs			Jobs at potential high risk of automation - Black Country	
Industry	Black Country	W. Mids	Great Britain	No.	%
Water, sewage and waste management	0.8	0.6	0.7	2191	62.6
Transportation and support services	6.3	6.1	4.9	**15,792**	56.4
Manufacturing	13.9	11.8	8.1	**28,768**	46.4
Wholesale and retail trade	19.3	17.2	15.3	**37,840**	44.0
Administrative and Support Services	9.0	8.1	9.0	14960	37.4
Financial and insurance	1.8	2.4	3.6	2576	32.2
Public Administration and defence	2.9	3.7	4.3	4173	32.1
Electricity and gas supply	1.1	0.5	0.4	1590	31.8
Real estate	1.3	1.3	1.6	1692	28.2
Information and communication	1.6	2.7	4.2	1911	27.3
Professional, scientific and technical	4.5	6.8	8.6	5120	25.6
Accommodation and food services	4.7	6.6	7.5	5355	25.5
Construction	4.0	3.9	4.6	4266	23.7
Arts and entertainment	2.0	2.4	2.4	2007	22.3
Other services	2.9	3.7	2.4	2418	18.6
Human health and social work	15.0	14.2	13.3	11,390	17.0
Education	8.7	9.1	8.9	3315	8.5

Sources: ONS workforce jobs survey for employment shares (2017); PwC estimates using PIAAC data from OECD. High risk of automation is defined as 70% or over based on technical feasibility considerations only. Employee jobs exclude self-employed, government-supported trainees and HM Forces. Data excludes Agriculture, forestry and fishing; Domestic personnel and self-subsistence and mining and quarrying.

However, it is also anticipated that there will be a demand for skills in those jobs that machines cannot perform. That is those jobs that rely on what will increasingly be recognised as intrinsically, if not exclusively, human traits and interpersonal abilities such as empathy, creativity and system skills[17]. Such skills will also be vital for anticipating and responding to the challenges of a 4th industrial revolution.

Although it is projected that in the long term, job displacement is anticipated in blue and white collar sectors, in the short to medium term, based on current tendencies, **it is manual and routine tasks that are projected to be most susceptible to automation in a 4th industrial revolution**, whereas social, creative and critical thinking skills will be relatively less subject to automation. The likelihood of automation appears lowest in education, health and social work, and highest in sectors such as manufacturing, retail, service, transport and storage.

Given the significance of transportation and support services, manufacturing and wholesale and retail trade jobs in the Black Country, **it is anticipated that the region will be disproportionately impacted by automation.** It should also be noted that those most at risk from automation will tend to be, on average, those who have the lowest wage.

Consequently, the projected uneven impact of technologies across different sectors may further widen income disparities[18] and will have implications for the role of technologies in shaping wider social and political relations. In this context, learning will have a vital role in anticipating and adapting to these projected changes. Not only will changes in learning be required to meet the challenges and opportunities of a 4th industrial revolution, but learning will also be vital to exploring rehearsing and assessing the form of futures we choose to create.

[17] NESTA (2017) The Future of Skills: Employment in 2030. NESTA https://www.nesta.org.uk/publications/future-skills-employment-2030

[18] PWC (2017) UK Economic Outlook. Section 4. Will robots steal our jobs? London: PriceWaterhouseCoopers

The Management and Organisation of Work

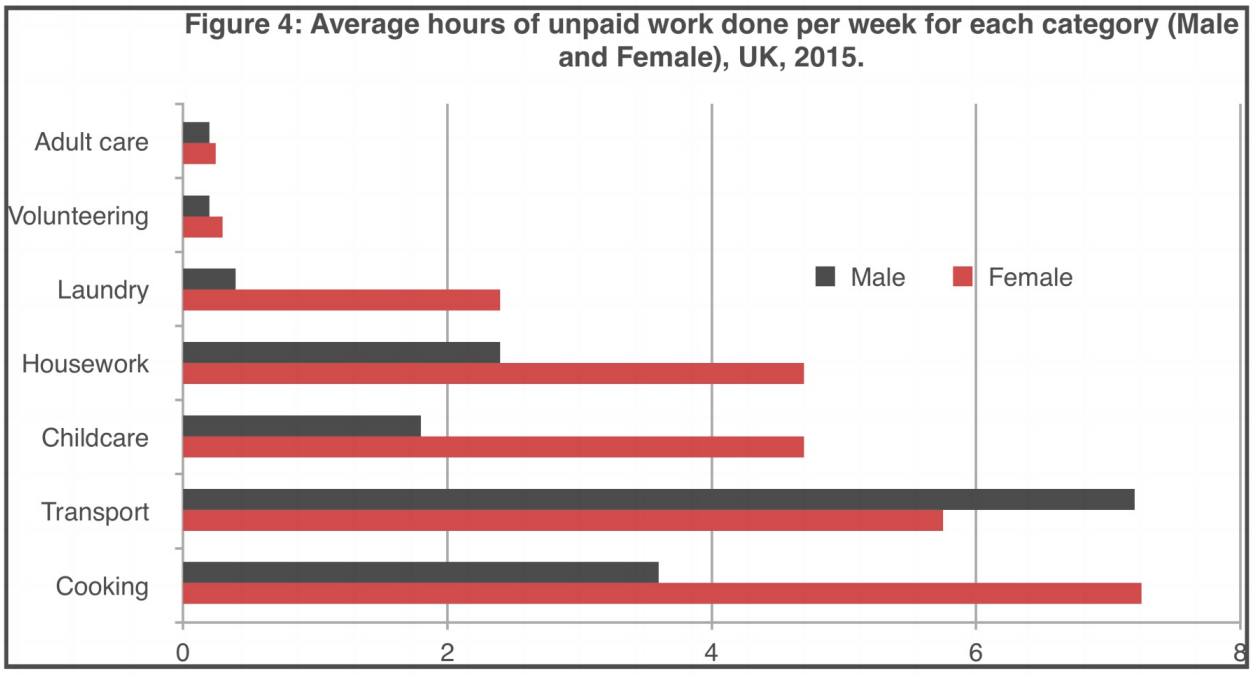
A 4th industrial revolution is anticipated to not only have an impact on the number and type of jobs available in the future, but also on who works, how work is organised and how people work. A 4th industrial revolution has the potential to restore and create new forms of production and work practices. There is the potential to transform the economic landscape by creating opportunities for new entrants, challenging incumbent providers and raising questions regarding the form and function of operations, finance and strategy.

A 'control revolution' that has the potential to transform supply chains, from extraction and production to distribution and consumption is anticipated.

The potential of new technologies to transform the scale and speed of data collection and analysis and increase the capacity to personalise and customise goods and services is envisaged. Innovations in contracting, particularly with regard to the monitoring and verification of transactions and flexible and extended forms of co-ordination and communication are also anticipated[19].

Through the optimisation of production and logistics, the smart consumption of resources and an increased capacity to anticipate risks[20], the technologies of a 4th industrial revolution are projected to dramatically improve decision making[21] and achieve significant productivity gains[22].

With the promise of being able to continually instruct and monitor workers in real time, without the costs of supervision outweighing its benefits, what is described as algorithmic management[23] is changing the organisation of work.



[19] OECD (2017) OECD Digital Economy Outlook 2017 http://dx.doi.org/10.1787/9789264276284-en.

[20] OECD (2017) The Next Production Revolution: Implications for Governments and Business, Paris, OECD Publishing, http://dx.doi.org/10.1787/9789264271036-en.

[21] UK Government Office for Science (2016) Artificial Intelleigence: opportunities and implications for the future of decision-making', Government Office for Science, London, https://www.gov.uk/government/publications/artificial-intelligence-an-overview-for-policy-makers.

[22] Purdy M and Daugherty P (2016) Why artificial intelligence is the future of growth, Accenture, October, www.accenture.com/futureofAI.

[23] Lee MK Kusbit D Metsky E. and Dabbish L (2015). Working with machines: The impact of algorithmic, data-driven management on human workers. In Proceedings of the ACM/SIGCHI Conference on Human Factors in Computing Systems (CHI 2015), 1603-1612

An algorithm is a self-contained step-by-step set of operations to be performed (e.g. calculation, data processing, and/or automated reasoning tasks). Algorithmic management and governance, that is the use of data, software and connectivity, to allocate, optimise and evaluate work flows practices, is already evident and likely to be extended and intensified across different sectors of the labour market and the operation of social institutions. Efforts to manage performance and control production processes are not new.

Each industrial revolution has created changes in the way that work is organised and subsequently had a significant impact on the relations between employers and employees.

Algorithmic management can be seen as an extension of the computing business systems that have helped shape work conditions for years, but the capacity and reduced costs of new technologies enable the seemingly oxymoronic distant but intimate supervision of workers. The 'real-time' monitoring of workers and issuing of personalised 'service level assessments' have already enabled the growth of new platform business models. Digital platforms that make use of algorithmic management are projected to enable and impact on the management of distributed and diverse workers across large distances and at a large scale.

In a range of settings, engineers[24], warehouse workers[25], baristas[26], and delivery workers[27] jobs are assigned, optimised, and evaluated through tracked data and algorithms.

The capacity to extend and intensify the remote and real time tracking of process and outcomes could be transformative.

A 4th industrial revolution also has the potential to enhance the flexibility of when and where work is undertaken, but it is also projected to blur the boundary between private life and work, thereby intensifying an 'anytime, anywhere' attitude to work. It should also be noted that the same technology that tracks workers is also building the data sets that will facilitate the further automation of roles and tasks, thereby enabling the future displacement of human labour.

In this scenario, an increasing number and breadth of workers will potentially be faced with the choice of either working like a machine or being replaced by a machine.

[24] Hodson H (2014). The AI Boss that Deploys Hong Kong's Subway Engineers. New Scientist

[25] McClelland M (2012). I Was a Warehouse Wage Slave. Mothers Jones

[26] Kantor J (2014). Working Anything But 9 to 5. NYT

[27] Davidson A and Kestenbaum D (2014). The Future of Work Looks Like a UPS Truck. NPR

Division of Labour

A less immediate and tangible impact of a 4th industrial revolution is the potential change in the meaning that is attached to work.

Machines substituting human labour can lead to a literal and figurative sense of redundancy or conversely, lead to a reclaiming of meaningful work, where value is no longer defined by a labour market.

In discussions on a 4th industrial revolution and the futures of work, the focus has tended to be on paid work, or more specifically, paid jobs. Given that it is estimated that unpaid work, that is non-market services which households either produce for themselves or for other households, has an estimated value of £1.01tn, equivalent to approximately 56% of the UK's Gross Domestic Product (GDP), or a value of £38,162 per household, a shift in focus is required[28].

As women carry out an overall average of 60% more unpaid work than men, a 4th industrial revolution provides an unprecedented opportunity to rethink work and existing divisions of labour and reduce gender pay gaps (See figure 4)[29].

It is projected that a 4th industrial revolution will have a disruptive impact on the division of labour and unpaid work. Echoing discussions with reference to the paid labour market, the technologies, products and services of a 4th industrial revolution, could provide the opportunity to automate a range of unpaid work, roles and tasks. This in turn could create more leisure time, increase the opportunities to engage in education or enable access to paid labour markets.

However, given the current gender imbalances in what are projected to be growth areas of highly paid sectors of the labour market (STEM subjects) considerable action will need to be taken to ensure that a comprehensive and diverse pool of talent is educated, recruited and promoted in these areas[30].

Conversely, given the scale of technological unemployment that has been projected, as in previous industrial revolutions, it may prove to be desirable and / or necessary to revisit the nature, distinctions and value that is given to paid and unpaid work and labour. Proposals for a post work society that supports citizens through a universal income, provide one such scenario where the conditions for redefining existing divisions of labour and systems of value become a distinct possibility.

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[28] ONS (2016) Household Satellite accounts: 2005 to 2014. https://www.ons.gov.uk/releases/householdsatelliteaccounts2011to2014

[29] Source: UK Harmonised European Time Use Survey (HETUS), 2015

[30] Voss G (2014) The Second Shift in the Second Machine Age: Automation, Gender and the Future of Work, in Our Work Here is Done: Visions of a Robot Economy, NESTA.

Futures of Learning

Technologies do not determine the future, but new technologies do afford new opportunities and risks. The impact of 4th industrial revolution on work and society is a vital political issue of the 21st century[31]. The prospect of a 4th industrial revolution continues to raise a number of social, political, economic, and ethical questions about what sort of learning is probable, possible and preferable for today and tomorrow.

Based on current tendencies, it is projected that a 4th industrial revolution will not only have an impact on the level, type and organisation of work, but also has the potential to disrupt social, political and economic relations.

Current projections suggest that the risks and rewards of a 4th industrial revolution are unlikely to be spread evenly unless anticipatory action is taken.

If technology displaces rather than augments or creates jobs, then labour becomes increasingly polarised and with increased return to capital at the expense of labour. If education is not able to equip more people with the requisite skills, then those with the skills in demand will be able to command higher wages and increase the supply of those competing for lower paid and skilled work.

Subsequently attention will need to be given to the uneven distribution of risks and opportunities of a 4th industrial revolution depending on employment sector, age group, gender, BME groups, educational attainment and socio-economic group.

One of the major challenges and contradictions when anticipating futures, is how to prepare for the unknown? What skills, knowledge and experience are needed for jobs and challenges that do not exist yet and in a world that it is projected will change rapidly?

Prioritising investment in the development of knowledge and skills in science, technology, engineering and mathematical (STEM) subjects that are necessary for a 4th industrial revolution may appear to be self-evident. However, it is also anticipated that social, creative and critical thinking skills will not only prove resistant to automation, but will also continue to represent an area of growth and will be vital to efforts to anticipate and engage with the disruption and challenges of a 4th industrial revolution.

In sum, as technology increasingly takes away routine tasks and disrupts existing relations, people will continue to need to engage in lifelong learning in order to revise and develop the knowledge and skills required to adapt to and transform conditions.

Job security continues to be valued by today's learners. In a context where the requirement for continued innovation and training is already evident and likely to increase, but investment in adult and in work based learning opportunities appear limited, learners are seeking opportunities to access agile and open forms of continued learning that are vital to efforts to keep up to speed with developments and achieve at least a degree of security.

The challenge for policy makers, employers and learning providers is to identify how best they can support all learners to meet the challenges of today and tomorrow.

[31] Gorz A (1985) Paths to paradise: On the liberation from work. Boston: South End Press.

Next Steps?

Given the issues raised in this report, in order to prepare for tomorrow's worlds, what answers would you give to the following questions:

- Who should be learning?
- Why should people be learning?
- What could and should people be learning?
- How could and should people be learning?
- Where could and should people be learning?
- What could and should individual stakeholders be doing to anticipate the futures of learning?
- What role does a learning city region have in creating a learning society and anticipating and shaping the future?
- What does success for a learning city region look like and what evidence could be used to measure this success?

The technologies of a 4th industrial revolution afford a range of challenges and opportunities for why, what, where and how we learn. The tendencies that have been highlighted in this report offer a projection of where we may be heading, but this is not the same as asking and answering the question of where do we want to go. Based on work to date, there are distinct differences in what forms and functions of learning are valued and what values should be learned, both today and for the future. It may not be possible to resolve such differences, but such differences can be recognised and addressed.

Given the uncertainty that remains over the impact of a 4th industrial revolution, at this point, rather than privilege one future or particular response to the risks and opportunities of a 4th industrial revolution, what is vital is that there is an investment in efforts to surface and develop the diverse visions and networks of learning resources, relations and practices that exist across and beyond the Black Country.

Foresight, collaboration and innovation will be required to identify and develop the relevant learning pathways for today and tomorrow. By anticipating the changes on the horizon, there is an opportunity to review and redefine the needs of today's and tomorrow's learners.

Due to the scale of change that is anticipated it is argued that no one agency will be in a position to meet the grand challenges of a 4th industrial revolution. The level, scale and pace of change require both long-term thinking and cross-sector action. Subsequently one of the potential roles for a nascent learning city region will be to help to surface, assess and develop the future readiness of all those who live and work in the region.

Appendix A. UNESCO Global Network of Learning Cities (GNLC)

The UNESCO Global Network of Learning Cities is an international policy-oriented network providing inspiration, know-how and best practice. Learning cities at all stages of development can benefit greatly from sharing ideas with other cities, as solutions for issues that arise as one learning city develops may already exist in other cities. The Network supports the achievement of all seventeen Sustainable Development Goals (SDGs), in particular SDG 4 ('Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all') and SDG 11 ('Make cities and human settlements inclusive, safe, resilient and sustainable'). The UNESCO GNLC supports and improves the practice of lifelong learning in the world's cities by promoting policy dialogue and peer learning among member cities; forging links; fostering partnerships; providing capacity development; and developing instruments to encourage and recognize progress made in building learning cities.

Appendix B. Industrial Strategy

In November 2017 the UK government launched its Industrial Strategy. The strategy set out a long-term vision for how Britain can embrace technological change, address its productivity performance and increase the earning power of people across the UK. In the strategy, the government has identified 4 Grand Challenges. These are global trends that are projected to shape a rapidly changing future and which it is argued the UK must embrace to ensure all the opportunities are realised. The 4 are:

- Artificial intelligence – aiming to put the UK at the forefront of the artificial intelligence and data revolution.
- Clean growth – maximising the advantages for UK industry from the global shift to clean growth.
- Ageing society – harnessing the power of innovation to help meet the needs of an ageing society.
- Future of mobility – becoming a world leader in the way people, goods and services move.

To meet these challenges the Industrial Strategy identifies what it describes as clear and complementary visions for each of its 5 foundations of productivity – ideas, people, infrastructure, business environment and places. Sector Deals, i.e. partnerships between the government and industry on sector-specific issues, are being developed to boost productivity, employment, innovation and skills. Construction, life sciences, automotive and AI sectors are set to be first of these new strategic and long-term partnerships backed by private sector co-investment. With the aim of boosting innovation in the UK by 2030, the government has committed to an Industrial Strategy Challenge Fund (ISCF) (£725 million over the next 3 years) as part of efforts to embrace the opportunities afforded by a 4th industrial revolution and anticipate global trends shaping the future of the UK.

Appendix C. The Black Country Core Strategy

The Black Country Core Strategy32 is a planning and regeneration plan, agreed by the four Black Country Councils, for the whole of the Black Country. The adoption of The Black Country Core Strategy in 2011 was designed to achieve growth and economic transformation. The strategy sets out the scale and form of development intended to create jobs, homes and an improved transport network. Part of the stated rationale for the strategy was to provide immediate planning policy and infrastructure provision 'certainty' for private sector investment and to facilitate the prioritisation of infrastructure investment against the Black Country's economic growth ambitions.

[32] The Black Country Core Strategy http://blackcountrycorestrategy.dudley.gov.uk/

At the time of the writing the core strategy was in the process of being reviewed in order to meet the area's projected development needs up to year 2036.

Appendix D. The Black Country Local Enterprise Partnership

The Black Country Local Enterprise Partnership (LEP)[33] aims to create the conditions for enterprise to flourish resulting in greater economic prosperity across the Black Country area. The Black Country LEP aims to stimulate the drivers of economic development, education & skills development and infrastructure & environmental enhancements. This is done though its role in facilitating and co-ordinating the actions of private, public and voluntary sector organisations. The Black Country LEP states that the transformation of the Black Country's infrastructure and environment is fundamental to the future growth of the region's economy. In tandem with the Black Country core strategy, the Black Country Strategic Economic Plan[34] sets out the vision, objectives, strategy and actions to improve the quality of life for everyone who lives and works in the Black Country. The strategy builds on a 30 year vision and covers programmes to deliver across 3 drivers of change:

• People: Raising employability, education and skills;

• Place: Transforming the Black Country Infrastructure and Environment

• Business: Improving Black Country Business Competitiveness.

The Black Country LEP continues to review and update the Strategic Economic Plan.

Appendix E. Midlands Engine

A series of measures have been put in place to secure the government's ambition of making the Midlands 'a growth engine for the whole UK'. This includes the directly elected Mayor of the West Midlands Combined Authority, a commitment to HS2 and the launch of the Midlands Engine strategy[35]. The government's Industrial Strategy aims to rebalance the economy by committing to ensuring growth across the whole country. In the Midlands five key objectives have been established:

i. Improving connectivity in order to raise productivity.

ii. Strengthening skills in order to make the Midlands a more attractive location for businesses.

iii. Supporting enterprise and innovation in order to foster a more dynamic regional economy.

iv. Promoting the Midlands nationally and internationally in order to maximise trade and investment in the region.

v. Enhancing quality of life in order to attract and retain skilled workers, as well as to foster the local tourist economy.

To support delivery of these objectives, the government has committed to investing, through the Local Growth Fund and Local Enterprise Partnerships, £392 million in the Midlands (£151 million for the West Midlands City Region) over a four year period.

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[33] Black Country Local Enterprise Partnership (no date) https://www.blackcountrylep.co.uk/

[34] https://www.blackcountrylep.co.uk/about-us/plans-for-growth/strategic-economic-plan/

[35] Department for Communities and Local Government (2017) Midlands Engine Strategy. London: HM Government. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/598295/Midlands_Engine_Strategy.pdf

In a world that it is projected to change rapidly and unevenly...

What does the future hold?

What learning is needed for the 21st Century?

What skills, knowledge and experience are needed for jobs that do not exist yet?

What institutions and relations and practices will be needed to support the learners of 2020, 2040 and beyond?

What role will learning and a learning city region have in helping anticipate and shape the future?

It may not be possible to know the future, but it is possible to explore futures in clear, rigorous and creative ways in order to anticipate potential risks and opportunities. This report is part of an ongoing programme of work at the University of Wolverhampton that seeks to work with individuals, groups and institutions to bring future orientated approaches to life on real projects. The aim being to stimulate thinking, extend conversations and inform actions as to how the futures of the Black Country could and should be shaped. For more information please email stuart.connor@wlv.ac.uk

About the Authors

Dr. Stuart Connor is a Reader in the Education Observatory at the University of Wolverhampton. With a background in policy analysis, a recurrent theme in Stuart's research is to not only understand the impact that changing conditions and policies have on people's lives, but to also explore how people can and should have an impact on policies and future relations and practices. This is reflected in Stuart's current research in Futures Studies that examines and enacts the potential of a range of foresight methods to explore, rehearse, assess and realise desired futures.

Dr. Mary Mahoney is Head of Lifelong Learning and Learning Regions Director at the University of Wolverhampton which encompasses flexible, distributed and part-time adult learning in the University's priority areas including communities and places. Mary's research focuses on the structural barriers and enablers to inclusion in society, particularly the role of policy and political contexts and their impacts in population health and wellbeing and access to learning. Mary has an extensive track record in this area and has worked in Higher Education in Australia, Wales and England.

Natalie Lewis is the Co-ordinator for Wolverhampton City Learning Region. The goal of the initiative is to put learning at the heart of the economic and social development of the region. Natalie has a Masters degree in Arts, Health and Wellbeing and has extensive experience in community learning and the challenges of positioning learning in complex environments. Natalie's experience includes setting up and managing Arts in Health programmes within the NHS, Museum and in gallery education and has previously worked as a qualified teacher in the post compulsory education sector.

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