



Masters of the Revolution:

Why the Fourth Industrial Revolution
should be at the heart of
Britain's new Industrial Strategy

By Alan Mak MP

Table of contents

Introduction: Alan Mak MP	04
Foreword: George Freeman MP	06
Chapter 1: Winning the Global Race	08
Chapter 2: Implications of the 4IR for Britain	12
Chapter 3: Adapting Britain's economy to the 4IR	20
Chapter 4: Mastering the Revolution	35

Introduction from Alan Mak MP

Around 250 years ago, the world's first industrial revolution began here in Britain, powered by coal and steam, and accelerated by new railways, roads, bridges and viaducts, heralding a new era of British industrial strength.

Today, after two further industrial ages, driven first by electricity and then by electronics and the internet, we find ourselves at the start of a new, Fourth Industrial Revolution (4IR). The world is witnessing an unprecedented fusion of new technologies that blur the traditional boundaries between the physical, digital and biological spheres. Breakthroughs – and new products – in fields such as artificial intelligence, robotics, the Internet of Things, driverless cars, drones, 3D printing and nanotechnology have already captured the imagination of the public. Now the policymakers must respond.

As the 4IR gathers pace, we in Britain can – and should – lead it. We must act now to ensure that our political and economic structures are fit for purpose, because mastering the 4IR is the greatest economic and political challenge – and opportunity – of our generation.

Turning away from the EU's over-reliance on the "precautionary principle" when it comes to new technologies, and adopting a British, pro-innovation approach to the 4IR is key. Brexit gives Britain the opportunity to strategically pivot away from a risk-averse culture that stifled science and innovation to a new, more entrepreneurial approach.

We must build new 4IR research centres to nurture sectors where Britain can lead the world, such as vaccines and robotics, and launch new investment funds to back our 4IR entrepreneurs in every region so wealth and innovation aren't just concentrated in London. Continued investment in digital infrastructure and further reform of our welfare and education policies will also be key. This report contains 20 practical and actionable recommendations to Government so that we place the 4IR at the heart of our new Industrial Strategy.

As Britain forges ahead, we must also address the 4IR's shortcomings, making sure that no one is left behind as we reshape our economy and society. This new industrial revolution must consist not of changes that happen to us, but changes that work for us all.

Thank you to Mark Littlewood, Stephanie Lis and the Institute of Economic Affairs team for their support. I'm grateful to Greg Clark MP, Secretary of State for Business, Energy & Industrial Strategy for launching this report with me in Parliament, and to his Parliamentary Private Secretary Conor Burns MP for his help. Professor Klaus Schwab, Executive Chairman of the World Economic Forum, has championed the 4IR at a global level, and inspired me to lead the first ever House Commons debate on the 4IR which then led to this report. My Westminster office staff, especially my senior researcher Chris Hazell, have worked hard to make this report a reality, alongside their day-to-day work, which I very much appreciate.

Interest in this strategically important policy area is growing in Parliament, so I have founded a new All-Party Parliamentary Group to promote 4IR-related issues in Westminster, and amongst the wider policy-making community, so Parliamentarians can play their part in helping Britain lead the world when it comes to the 4IR.

As Britain develops its new Industrial Strategy, and prepares for dramatic changes to our society and economy, we must seize this once-in-a-generation opportunity to lead the 4IR. I hope this report provides a useful set of ideas to stimulate debate, and more importantly, acts as a blueprint for action to turn that vision into reality

Alan Mak MP

Member of Parliament for Havant

Chair, All-Party Parliamentary Group on the Fourth Industrial Revolution

Foreword from George Freeman MP

The Fourth Industrial Revolution (4IR) is already changing the world as we know it. That much is certain. But the key public policy question of our time is whether governments will be ready, both to seize the opportunity represented by the change, and to adapt to the impact it will have on society.

As Alan Mak sets out with welcome clarity in this report, the 4IR presents the UK with a once-in-a-generation opportunity. With our global strengths in both science and finance we have the chance to drive a new cycle of growth in our economy, positioning the UK post-Brexit as a scientific “tiger economy” for high impact scientific research and innovation and the formation, funding and global launch pad for the technologies, companies, products and jobs of tomorrow. As we lay the foundations for our post-Brexit model of economic prosperity, trading with the EU and the fastest growing emerging economies around the world, we have a huge opportunity through advances in artificial intelligence (AI), Big Data analytics, the Internet of Things, biotechnology and nanotechnology, to ensure the UK leads the world in the appliance of the science and innovation that will transform our 21st century economy and society.

However impressive the macro picture though, the key for policymakers will be getting the micro detail right. Building on the work of David Willetts, Greg Clark and our landmark “Eight Great Technologies” industrial strategies, this report presents a forensic list of twenty clear priorities for Government. Whether it is continued investment in digital infrastructure, national research institutes for 4IR technologies or a move away from the EU’s “precautionary principle” that has too often stifled innovation, the direction of travel is clear. The UK can lead the 4IR by continuing as a beacon of enterprise, committed to being the best place on earth to innovate and start a business.

Indeed, as we negotiate our exit from the EU, we have an incredible opportunity to put in place a regulatory framework that is the most pro-science and pro-innovation anywhere in the world. As the nation of Newton, Darwin, Turing

and Berners-Lee, we must further our comparative advantage as the world's leading scientific superpower. Having spent fifteen years before coming to Parliament founding and financing some of the highest-growth companies of tomorrow, I know first-hand that pro-active, modern government support for innovation is what 21st century industry and business leaders want to see.

But, as this report makes clear, we also need to prepare for the seismic impact the 4IR will have on society. The 4IR will reshape our employment landscape as radically as the revolutions that preceded it, changing the nature of the workplace and the skills required to thrive in a 21st century economy. The key, as Alan notes, will be continuing to invest in our education system, focusing on both STEM and creative subjects, as well as lifelong skills training. But considering such changes also provide an answer to those who claim there is no place for an industrial strategy in a modern, free-market economy. The truth is, we simply cannot ignore an economic and social revolution on this scale.

For some the term "industrial strategy" can conjure up images of the failures of the long discredited Labour "industrial policy" of the 1970s which saw government subsidies prop up failing companies and regions. Nobody wants to see a return to that. And no-one has been more instrumental in shaping the Conservative enterprise revolution of the 1980s than the IEA.

As this report makes clear, 21st century industrial strategy is about harnessing a UK enterprise and innovation economy for post Brexit prosperity.

George Freeman MP
Chair, Prime Minister's Policy Board & Chair, Conservative Policy Forum
Minister for Life Sciences at BIS and DoH 2014-16

Chapter 1:

Winning the Global Race

Britain is in a global race for economic success and must actively seize the opportunities presented by the Fourth Industrial Revolution (4IR) to drive future economic growth, pro-actively shaping and harnessing the technological and societal changes it heralds for the nation's benefit.

Since the turn of the century there has been an unprecedented fusion of technologies that “blur the lines between the physical, digital, and biological spheres,”¹ and an exponential increase in automation and connectivity, all offering significant growth and productivity advantages to economies that seize the corresponding opportunities. Research from NGOs like the World Economic Forum (WEF),² investment banks including Merrill Lynch and UBS,³ professional services firms such as Deloitte and BDO,⁴ and manufacturing organisations like EEF,⁵ supports the view that the 4IR's impact on the global economy – and therefore Britain's – will be dramatic. Mastering the 4IR was the theme for the 2016 WEF Annual Meeting in Davos, Switzerland, underlining the topic's strategic, global importance.

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- 1 Schwab, Klaus 'The Fourth Industrial Revolution: what it means, how to respond' *Foreign Affairs* (12 December 2015) available online here: <https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution>
 - 2 Davis, Nicholas 'What is the fourth industrial revolution?' *World Economic Forum* available online here: <https://www.weforum.org/agenda/2016/01/what-is-the-fourth-industrial-revolution/> (19 January 2016)
 - 3 Baweja, Bhanu et al "Extreme automation and connectivity: The global, regional, and investment implications of the Fourth Industrial Revolution" UBS White Paper for the WEF Annual Meeting 2016 available online here: https://www.ubs.com/global/en/about_ubs/follow_ubs/highlights/davos-2016.html
See also: Ma, Beijia et al "Robot Revolution – Global Robot & AI Primer" *Thematic Investing* (Bank of America Merrill Lynch, 16 December 2015)
 - 4 Deloitte "Industry 4.0 – Challenges and solutions for the digital transformation and use of exponential technologies" (2015). See Also: BDO & Institution of Mechanical Engineers "Industry 4.0 Report" (June 2016) available online here: <https://www.bdo.co.uk/en-gb/insights/industries/manufacturing/industry-4-0-report>
 - 5 EEF, The Manufacturers' Organisation "UK Manufacturing and the 4th Industrial Revolution" available online here: <http://www.eef.org.uk/campaigning/campaigns-and-issues/current-campaigns/industry-four>

The 4IR is characterised by recent and anticipated breakthroughs in fields such as artificial intelligence (AI); automated robotics and advanced manufacturing; pervasive digital networking (the “Internet of Things”); autonomous vehicles (such as “driverless cars”); 3D printing and additive manufacturing; “Big Data” analytics; nanotechnology; biotechnology; materials science; energy storage; and quantum computing. These advances will disrupt almost every industry in every country, and pose profound economic, political, and societal challenges to countries that are unprepared or unresponsive to a rapidly changing world.

Some of these technologies were recognised by the 2010-2015 Coalition Government’s industrial policies, which highlighted “Eight Great Technologies” where the UK could lead the world, and included significant investment to support their development. These were: big data and energy-efficient computing; satellites and commercial applications of space; robotics and autonomous systems; synthetic biology; regenerative medicine; agri-science; advanced materials and nanotechnology; and energy storage.

The Chancellor of the Exchequer, Philip Hammond, further recognised the importance of these disruptive technologies during his 2016 Conservative Party Conference speech, placing the 4IR at the heart of Government policy and acknowledging that “there is a once-in-a-generation opportunity for Britain to cement its role as a leader in tech innovation [...] the fruit of British genius being harvested here in Britain as we move into a Fourth Industrial Revolution, creating jobs, wealth and success. Future-proofing the economy of post-Brexit Britain.”⁶ This followed the first ever House of Commons debate on the 4IR which took place in September 2016,⁷ attracting a high level of cross-party interest.

With this technological fusion permeating and disrupting all sectors of the economy, and attention turning to the 4IR in Parliament and now in Government, we should take this opportunity to make sure that the 4IR in Britain is comprised not simply of changes that happen to us, but changes that work for us all.

6 Hammond, Philip “An economy that works for everyone” Speech at Conservative Party Conference 2016 – available online here: <http://press.conservatives.com/post/151284663940/hammond-an-economy-that-works-for-everyone>

7 HC Deb 8 September 2016, Vol 614, Cols 532-566; available online here: <https://hansard.parliament.uk/commons/2016-09-08/debates/1609083500001/FourthIndustrialRevolution>

The free-market case for the 4IR, advanced in this Free Enterprise Group report backed by the Institute of Economic Affairs, sees Britain embracing the 4IR – not resisting it – by exploiting new technologies for the nation’s benefit. This will result in substantial supply-side benefits, including increased productivity, lower prices for goods and services, and greater consumer choice. Mastering the 4IR must also be at the heart of the Government’s new Industrial Strategy.

4IR Timeline

Drawing on the work of Klaus Schwab, Executive Chairman of the World Economic Forum, the 4IR can be seen in the following historical context:

- First Industrial Revolution [Late 1700s] – The mechanisation of production through water and steam power, and more efficient communication and trade links due to railways and more reliable merchant shipping, acted as a catalyst for automation and connectivity.
- Second Industrial Revolution [Late 1800s] – Electricity enabled greater industrial and manufacturing automation through the development of mass production. Wireless and wired communication further improved national and international information networks.
- Third Industrial Revolution [1970s] – Electronics and the rise of computing allowed more sophisticated automation of production, and the birth of digital communication technology created global information networks \ such as the Internet.
- Fourth Industrial Revolution [2000s onwards] – The emergence of “cyber-physical systems”; the fusion of advanced digital technology and artificial intelligence with both people and machines.⁸ Additive manufacturing, robotics, and breakthroughs in materials science, will revolutionise both heavy industry and the fabrication of consumer products. Advances in machine learning and data processing will vastly improve connectivity at all levels of society. Synthetic biology and genetic engineering have the potential to fundamentally transform the relationship between technology and the human body.

8 Schwab, Klaus op. cit.

Chapter 2:

Implications of the 4IR for Britain

Britain is well placed to seize the opportunities presented by the 4IR. Around 250 years ago Britain led the First Industrial Revolution, as engines and factories powered by coal and steam changed the world's economic landscape. Britain's manufactured goods were exported around the world, fuelling the nation's economic growth at home and establishing our reputation as innovators and exporters abroad.

Today, Britain has strong foundations on which to build a 4IR-enabled future economy, catalysing a manufacturing renaissance and bolstering our status as a great trading nation. The UK has a trusted legal system; a vibrant base of science and technology research; world-leading universities; a strong record of innovation; excellent access to capital; and the financial & professional services expertise that empowers 4IR entrepreneurs to commercialise their ideas and establish new businesses.

The UK's internet economy as a percentage of GDP continues to lead the G20,⁹ and is expected to grow to more than £200bn during this Parliament. The turnover of the UK's digital technology industry is growing 32% faster than the rest of the economy, and provides employment opportunities for more than 1.5million people.¹⁰

London's Tech City is one of the largest tech clusters in the world, and the digital capital of Europe. Home to thousands of start-ups and numerous multi-national technology giants, many of whom have academic partnerships with British universities, London-based technology companies have raised billions of pounds of venture capital funding since 2010. Regional high-tech clusters

9 BCG, "The Internet Economy in the G-20: The \$4.2 Trillion Growth Opportunity" available online here: <https://www.bcg.com/documents/file100409.pdf> See Also: Tech UK "UK's digital economy is world leading in terms of proportion of GDP" available online here: <https://www.techuk.org/insights/news/item/4075-uk-s-digital-economy-is-world-leading-in-terms-of-proportion-of-gdp>

10 Tech City UK and Nesta "Tech Nation 2016: Transforming UK Industries" available online here: <https://www.swipe.to/9057ct>

like Silicon Fen in Cambridgeshire demonstrate that this growth is not confined to London and the South East.

The UK is also at the forefront of establishing new companies working on artificial intelligence, the most notable of which is probably DeepMind – acquired by Google for around £400m in 2014. Vocal IQ was acquired by Apple for an undisclosed amount in 2015, and SwiftKey was bought by Microsoft for \$250m.¹¹ Most recently, Magic Pony, an AI-powered image processing company, has been acquired by Twitter for \$150m,¹² demonstrating that the UK continues to be a great place to start, grow, and invest in AI ventures, and technology businesses generally.

Given our strong foundations for technological growth, Britain can - and should - develop an early comparative advantage in this nascent industrial revolution, to become a world leader in the new 4IR global economy. In order to achieve this, the UK must take a proactive and free-market approach to policy development, preparing for the impact of disruptive technologies instead of reacting to events as they occur, and adapting to new business models rather than resisting them. The Government should focus on pro-business reforms and targeted investment policies that unlock and support the latent entrepreneurial spirit and innovative talent of the British workforce.

If we are to seize an early global advantage in the 4IR, then we must adopt an unreservedly pro-business approach to the regulation and taxation of 4IR businesses. We must not allow the innovative spirit of British entrepreneurs to be restrained by burdensome and costly over-regulation, and we must take immediate steps to tackle some of the social, ethical, and legal questions that could undermine public trust in new technologies. Concerns about privacy (for example in relation to the use of “Big Data”) or safety (in the context, for example, of driverless cars on the road) should be addressed, not ignored,

11 *The Guardian* “Microsoft buys British keyboard apps firm SwiftKey” (3 February 2016) available online here: <https://www.theguardian.com/technology/2016/feb/03/microsoft-buys-british-keyboard-apps-firm-swiftkey>

12 *The Telegraph* “Twitter pays £150m for London AI startup Magic Pony” (20 June 2016) available online here: <http://www.telegraph.co.uk/technology/2016/06/20/twitter-buys-london-startup-magic-pony-for-close-to-150m/>

so that they do not dominate the debate and hold back the development of innovative and socially useful products.

British leadership in the emerging AI sector, for example, has positive implications for economic growth and presents significant opportunities to increase the efficiency of British businesses and British workers – finally solving the productivity gap that remains one of the only structural weaknesses of the British economy. However, AI also has the potential to expose millions of new jobs to automation and cause short-term upheaval in the labour market as the economy adapts to incorporate 4IR innovations.

The Government therefore has a role to play in dampening the effects of the most likely economic downsides of the 4IR, by bridging the gap between short-term unemployment, resulting from structural changes in the labour market prompted by the 4IR, and long-term prosperity produced by sustained economic growth. The 4IR is likely to increase automation in a wide variety of sectors, including ‘white collar’ jobs that have thus far been sheltered from the effects of mass production and early generation robotics. This structural re-alignment of the labour market could result in rising unemployment and growing inequality.

The Government must therefore take a pro-active and strategic approach to education policy, skills training, welfare benefits, and taxation, to make sure that nobody is left behind as Britain builds its 4IR-focused economy of the future.

Embracing disruptive technology

The key technological drivers of the 4IR will be pervasive digital connectivity, widespread automation, and sophisticated computer software using machine learning and other artificial intelligence techniques. These will give rise to a range of economically disruptive products and services like autonomous “driverless” vehicles; AI data analysis & supply chain management; ubiquitous robotic manufacturing and industrial processes; additive manufacturing (such as 3D printing) and decentralised product fabrication (including the ability to “print” goods at home); and AI-led logistics and customer service platforms.

Proponents of the 4IR argue that the shift from simple digitisation of information (typical of the Third Industrial Revolution, or 3IR), to comprehensive digital networking (including the “Internet of Things”), big data, and artificial intelligence (all key elements of the 4IR), will allow computing systems to manage both physical production, and the supply chain, with increasing sophistication. It is conceivable that in the near future entire production facilities could become automated, requiring only an uninterrupted supply of raw materials and energy in order to operate twenty-four hours a day. There is already a clear shift towards robotic manufacturing, with an average 17% annual growth in the industrial robot market since 2010.¹³

While the UK still has some way to go towards realising the full potential of these technologies, a recent report by Barclays concluded that, in spite of barely rising above the global average in terms of robot density in the manufacturing sector, “even a moderate increase of £1.24bn in automation investment could raise the overall value added by the manufacturing sector to the UK economy by £60.5bn over the next decade.”¹⁴

Advances in data analysis, and increasing digital connectivity, will offer

13 International Federation of Robotics ‘World Robotics 2015 Industrial Robots’ available online here: <http://www.ifr.org/industrial-robots/statistics/>

14 Barclays Bank “Future-proofing UK manufacturing” (2015) available online here: <https://www.barclayscorporate.com/content/dam/corppublic/corporate/Documents/resereport.pdf>

businesses long-term gains in efficiency, allowing them to optimise supply chains and lower employment costs. The 4IR will also blur the lines between the manufacturing and service sectors, as networked products empower manufacturers and customers with greater functionality and detailed usage data. For example, smart boilers that monitor themselves to detect a fault, contact the gas company to request an engineer, and even pre-order spare parts, are already entering the consumer market. Fridges that keep track of the food inside, and remind users to buy a fresh pint of milk, are far from science fiction. As the Internet of Things matures, this integration between physical consumer products and web-based services will allow 4IR businesses to add value for the consumer, while giving them the data they need to efficiently manage supply chains and inspire product development teams.

Transportation and logistics costs will also fall, as autonomous vehicles and near real-time analysis of the distribution network improves efficiency across all sectors of the economy. Over the long-term, advances in AI could also expose many new jobs to automation in retail, administration, and service roles. This will offer businesses the chance to increase efficiency and lower costs across a whole range of data processing, customer service, and middle management positions.

Increasingly sophisticated 3D printing technology could also decentralise the manufacture of many consumer products, making it possible for individuals to buy a digital design over the internet and print it at home using desktop 3D printers. As this technology matures, domestic manufacturing could also increase the lifespan of some complex consumer goods, allowing simple spare parts to be downloaded and printed at home.

An excellent example of how British entrepreneurs are already exploiting these emerging technologies, to create new jobs and generate new growth from new industries for their local economies, can be found in the Havant constituency. Local start-up and specialist retailer Dream 3D is getting a head-start in the 4IR economy by offering a range of 3D printing products and services, including ongoing consumables, software training, and comprehensive customer support.

Embracing these 4IR disruptive technologies will lower costs for British businesses and increase national productivity, resulting in economic growth, new industries and new jobs, lower prices, and greater product choice for consumers. As production costs are cut by automation and data-led supply chain management, British businesses will have more resources for the research and development they need to stay competitive in a global market. This environment of change will promote innovation, and the creation of jobs in new, emerging industries.

Potential challenges of the 4IR

We should be clear that the 4IR will also result in societal challenges, not just economic benefits. As automation increasingly substitutes for human labour across multiple sectors of the economy, the displacement of workers by machines could result in rising short-term unemployment and exacerbate the gap between the richest and poorest in our society. As the returns for those with capital to invest in 4IR-empowered businesses increase exponentially, and those at the low-skill/low-wage end of the labour market are replaced by robotics and AI, inequality, probably limited to the short term, will emerge as one of the greatest economic, social, and political challenges of this new industrial revolution.¹⁵

If advances in artificial intelligence expose mid-skill/mid-wage white collar jobs to automation, as proponents of the 4IR believe will occur within the next five to ten years, then Britain could experience a dramatic re-alignment of the labour market, as automation segregates the available jobs into high-skill and creative tasks unsuitable for AI or robotics, and extremely low-skill jobs in roles where automation is not cost effective. This potential polarisation of the labour market will have a greater impact on older and lower-income demographic groups, who will find it harder to re-train with new skills or move to a new industry. The 4IR will also increase automation in roles like retail, customer service, and administration.

Dr Carl Frey and Dr Michael Osborne from Oxford University estimate that 47% of jobs in the United States are at “high risk” from automation in the next twenty years,¹⁶ that similar implications are likely to extend to the UK and other developed economies, and that this will disproportionately impact low-skill and low-wage occupations, while also threatening middle-income administrative and service roles.

15 Schwab, Klaus op. cit.

16 Frey, Carl and Osborne, Michael “The Future of Employment: How Susceptible Are Jobs to Computerisation?” Oxford Martin Programme on the Impacts of Future Technology. Full paper available online here: http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

In the long-term our labour market should be able to adapt to the 4IR, as workers retrain for the new jobs available in Britain's future economy, and education policy adjusts to take account of this transformation. However, short-term unemployment and rising inequality may present significant challenges. Moreover, if inequality rises there could be an initial affordability gap for new products like driverless cars and 3D printers, adding social tensions to an already divisive inequality challenge.

This is where a One Nation government can help to bridge the gap between short-term disruption to the labour market and long-term economic growth, by making sure the 4IR works for everyone. Mastering the 4IR means mastering the challenges as well as the opportunities.

Chapter 3:

Adapting Britain's economy to the 4IR

The countries best able to adapt to the 4IR will be those with nimble free-market economies, supportive governments, low taxes, and a competitive regulatory environment that encourages flexibility, innovation, and entrepreneurial spirit. The Government must continue to focus on pro-enterprise policies that encourage businesses to invest in 4IR technologies, and it must place these at the heart of its new Industrial Strategy. The Government will also need to adopt policies that help bridge the gap between long-term economic growth and short-term inequality.

In order to secure our lead in this global race for economic success, the Government will also need to continue making strategic investments in 4IR research, infrastructure, and innovation. This should be done in a way that maximises long-term returns on public investment, stimulates growth in the 4IR economy, and encourages British entrepreneurs to found new businesses and create new jobs.

Government shouldn't be involved in "picking winners", but instead, focus on creating positive conditions for innovation to flourish, science and technology to develop, and for commercialisation to take place. From adopting a pro-business mindset after exiting the EU, to targeted public investment in new funds for technology, to promoting Britain as an innovation centre abroad, Government has a key role to play strategically and financially.

Twenty key recommendations for Government action are set out below:

1. **Use Brexit as a catalyst to accelerate Britain's 4IR leadership role: identifying opportunities to support the 4IR should be at the centre of the Government's post-Brexit horizon-scanning exercise.** The British people's historic decision to leave the European Union (EU), and the no less dramatic emergence of the 4IR at the heart of our economy, are two recent but strong and clear signals that need to be reflected in Government policy on science and technology in the years ahead.

The Prime Minister has provided a clear steer on Brexit, and as our Brexit preparations accelerate, we are in a position to home in on key areas of importance. In particular, as the new Department for Exiting the European Union (DEXEU) conducts its post-Brexit horizon-scanning exercise to identify new economic and strategic opportunities for Britain, opportunities to strengthen our leadership in the 4IR should be centre stage.

There are undoubtedly opportunities – not just challenges – flowing from Britain leaving the EU and its component structures, processes, regulations and sub-organisations. Brexit should energise and catalyse our Government's commitment to the 4IR by ensuring that no stone is left unturned. As we review the direction of our science and technology policy in the age of Brexit, we should be especially vigilant for new sources of funding for research and development, and opportunities to exploit commercial applications arising from research that has been supported by public investment.

DEXEU, working with Number 10, the Business, Energy and Industrial Strategy (BEIS) Department and the Treasury, should also consider the UK's post-Brexit regulatory framework and funding streams for science and technology. A key example of the need to examine 4IR funding in light of Brexit is Robotics and Autonomous Systems (RAS), a field in which the Government estimates that 80% of research investment presently comes from the EU.¹⁷ The Chancellor's decision in August

17 Prime Minister's Council for Science and Technology "Science landscape seminar: robotics and autonomous systems" (15 June 2016) available online here: <https://www.gov.uk/government/publications/science-landscape-seminar-robotics-and-autonomous-systems>

2016 to guarantee EU funding beyond the date the UK leaves the EU,¹⁸ for projects agreed before the 2016 Autumn Statement, has provided much needed certainty about transitional arrangements. Now our attention should turn towards how we provide long-term funding for science and technology after Brexit, and what opportunities exist for us to strengthen our pre-eminence in the 4IR.

Put simply, the Government should review how British science and innovation can benefit from Brexit, and how can we use Brexit as a launchpad to accelerate Britain's role in leading the 4IR-centred global economy.

- 2. Britain should turn away from the EU's over-reliance on the precautionary principle when it comes to new technologies, and adopt a British, pro-innovation approach to the 4IR.** Brexit gives Britain the opportunity to strategically pivot away from the EU's reliance on the "precautionary principle" when regulating, funding and approaching new technologies and scientific breakthroughs.

Enshrined in EU law, the precautionary principle is a risk management strategy, used widely by EU regulators, under which the burden is on inventors of new medicines, products or technologies to prove that their new invention is *not* harmful where some risk exists, even if there is no scientific consensus to suggest that it may actually be harmful. Under the precautionary principle the message is: if in doubt, don't innovate. This led to what George Freeman, former UK Life Sciences Minister and now Chairman of the Prime Minister's Policy Board, described as an "increasingly science hostile"¹⁹ approach from the EU to innovation. For example, the EU's hostility to genetically modified (GM) crops caused German-based chemical company BASF and US-based agribusiness Monsanto to withdraw from conducting agricultural research and development in Europe at a time when Europe could have been a world leader in crop technology.

18 HM Treasury "Chancellor Philip Hammond guarantees EU funding beyond date UK leaves the EU" (13 August 2016) available online here: <https://www.gov.uk/government/news/chancellor-philip-hammond-guarantees-eu-funding-beyond-date-uk-leaves-the-eu>

19 Devlin, Hannah "Medical Research, Threatened by EU hostility to science" *The Times* (10 January 2014) available online here: <http://www.thetimes.co.uk/tto/science/article3970967.ece>

Similarly, David Willetts, then UK Science Minister, criticised the EU's ban on the use of Bisphenol A in making babies' bottles. He said "too often, activities that are potentially hazardous are treated as genuinely risky, when the size of the exposure is so low that there is no real risk,"²⁰ citing the fact that the chemical had long been used to harden plastics. In the same vein, the 2004 EU Clinical Trials Directive is often cited as a key factor in making Britain a less attractive place to conduct clinical trials of new medicines.

Now that Britain is leaving the EU, we should leave behind the precautionary principle as a guide to how we approach innovation and new technologies. The EU's culture of regulatory conservatism failed to understand that invention and innovation involves risk, and sought to exert excessive control over many aspects of science and technology that are not deemed to be a significant danger in Britain. The EU left little room for new technologies that emerged which didn't fit in to their static regulatory frameworks. That approach should change in the age of Brexit.

The UK should now adopt a more open, risk-based regulatory approach that allows innovators and inventors to move quickly, erring on the side of progress not excessive precaution. We must liberate our researchers and entrepreneurs if we are to make the most of our post-Brexit opportunities. We can remain at the cutting edge of the world's science and technology but to do so we must avoid an approach to regulation that was so far removed from any rational appraisal of risk that it threatened to exclude Europe – and previously the UK – from leading the 4IR.

20 Willetts, David "EU red tape is now getting in the way of scientific progress" *The Telegraph* (18 October 2012) available online here: <http://www.telegraph.co.uk/news/worldnews/europe/eu/9617756/EU-red-tape-is-now-getting-in-the-way-of-scientific-progress.html>

- 3. Dedicated regional investment funds for 4IR businesses, infrastructure and technologies**, backed by Local Enterprise Partnerships (LEPs) and central Government, to promote regional 4IR hubs that stimulate growth outside of London and the South East.

These funds would operate on a regional basis, for example covering one or more LEP areas, and would support a range of initiatives depending on local priorities, from establishing new tech start-up clusters and science parks, to grant programmes for 4IR small and medium-sized enterprises (SMEs). The objective would be to encourage the adoption of 4IR technologies across the country and spread growth outwards to all nations and regions in the UK, giving 4IR entrepreneurs and innovators a focal point for funding in their own region. The funds could take the form of loans, equity funds, or a mixture of the two.

- 4. New national Catalyst Fund for 4IR innovation based on convergent technologies.** Catalyst Funds are UK government-backed national funding streams for research and development in key scientific sectors, such as agri-tech, energy and bio-medicine.

Uniquely, the 4IR is characterised not by innovation in discrete and specific sectors, but by the *convergence* of numerous technologies, whether digital, biological, chemical, physical, or some combination of these. For example, Lotus Cars, based in Norfolk, produce state-of-the-art vehicles powered by low-carbon Formula-1 grade fuel, made from agricultural waste broken down and converted into fuel by genetically-modified bacteria.

New technologies and products that are based on a number of innovations are becoming more commonplace, and they form a key part of Britain's leadership of the 4IR economy, bolstering consumer choice, whilst driving forward technological innovation.

A new, national 4IR-specific Catalyst Fund, backed by BEIS and the Treasury, should be launched to give entrepreneurs and innovators who use convergent and hybrid technologies the funding they need to develop, launch and commercialise their inventions.

5. **Strategic focus on scale-up support for 4IR SMEs.** Government and private sector investment in start-ups has improved significantly in recent years, particularly in the UK tech sector, but support for entrepreneurs wishing to scale-up a proven concept into a fully-fledged medium-sized business is less visible.²¹ This “scale-up gap” could be costing the UK economy £38bn in short-term gains and £225bn in long term economic growth.²² We need a concerted effort to make Britain’s scale-up culture as strong as our start-up culture.

Innovate UK and the BEIS Department should continue to work closely with entrepreneurs, investors, and other stakeholders, to improve the scale-up ecosystem for 4IR entrepreneurs, so that more British 4IR innovations remain British businesses. While foreign investment into the UK technology and manufacturing sectors has been welcome, too many British entrepreneurs and start-ups find it easier to sell-up rather than scale-up. That must change.

While industry should play the largest role in addressing this challenge, the Government can help by encouraging scale-ups through pro-business tax and regulatory policies. Innovate UK should also be given more resources to facilitate access to finance for SMEs, as well as connecting small-scale entrepreneurs to the managerial and organisational support needed to scale a business. The Department for International Trade should also focus on assisting British 4IR SMEs who want to export to foreign markets and grow their business internationally.

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- 21 Bounds, Andrew “Need for policy rethink to favour scale-ups rather than start-ups” *Financial Times* (7 June 2016) available online here: <https://www.ft.com/content/ac7fe8b2-1202-11e6-91da-096d89bd2173> See also: Douglas, Lucy “Never mind startups, it’s scale-ups that urgently need funding” *The Guardian* (30 June 2016) available here: <https://www.theguardian.com/small-business-network/2016/jun/30/never-mind-startups-scale-ups-urgently-need-funding> and Barclays, University of Cambridge and University of Oxford “Scale-up UK: Growing Businesses, Growing our Economy” (April 2016) available online here: https://www.home.barclays/content/dam/barclayspublic/docs/BarclaysNews/2016/April/Scale%20up%20UK_Growing%20Businesses_Growing%20our%20Economy.pdf
- 22 Coutu, Sherry “The scale-up report on UK economic growth” Information Economy Council (November 2014) available online here: <http://www.scaleupreport.org/scaleup-report.pdf>

The Treasury should also examine the opportunities available from Brexit to provide tax relief for 4IR SMEs stuck between the dynamism of a start-up and the financial stability of a larger corporation. This once-in-a-generation opportunity to take a global lead in the 4IR, and stimulate the UK economy, calls for a greater focus on concepts like research and development and patent tax relief. This would be of particular assistance to 4IR businesses attempting to establish an early lead in emerging technologies or the commercialisation of new discoveries and innovations.

6. New 4IR-focused Catapult Centre for vaccines and bio-security.

The 17 Catapult centres are a network of world-leading physical centres where the very best of the UK's businesses, scientists and engineers work side by side on research and development – transforming high potential ideas into new products and services to generate economic growth. They are designed to transform the UK's capability for innovation in specific areas, and the current Catapult centres cover a broad range of specialisms from gene therapy and precision medicine to energy, digital and high-value manufacturing.

A 4IR sector where Britain leads the world is the development of vaccines, and bio-security generally (preventing the transmission of infectious diseases to people, animals and plants). Research and development on vaccines is currently carried out by a range of privately-owned pharmaceutical businesses, university-based research facilities and laboratories operated by charitable trusts and other organisations.

A new Catapult Centre for Vaccines and Bio-Security should be established to bring together business, academia, and government to develop and commercialise the next generation of vaccines. Funds from the current DFID budget should be channelled into this new Catapult centre, to enable the best of British science to be directed at producing vaccines that will be used to combat diseases that affect the wider world.

Potential sites for the new Catapult centre include: Porton Down in Wiltshire, already home to the Ministry of Defence's Science & Technology Laboratory, and a national centre for bio-security excellence; or the South

Coast of England, which is one of only a handful of major economic regions without a Catapult centre.

7. **A fast-tracked visa system for high-skilled 4IR workers.** Regardless of the particular approach the Government takes to immigration after Britain leaves the EU, we should continue to prioritise science and technology skills for both academia and 4IR start-ups. The Entrepreneur Visa and Tier 1 Exceptional Talent Visa (which can be endorsed by organisations like Tech City UK) demonstrate that the need to welcome skilled workers and ambitious businesspeople is well understood in Government. If the 4IR is to be a success for Britain, then we must retain this outward-looking, pro-business approach.
8. **A Robotics and Autonomous Systems (RAS) Leadership Council,** as recommended by the House of Commons Science and Technology Select Committee in October 2016, to act as a focal point for the Government to work with academia and industry to create a Government-backed national strategy for RAS. The Committee concluded that the UK currently trails other 4IR economies in terms of funding, skills, and leadership for RAS research and commercialisation.

The forthcoming Industrial Strategy should challenge this position and set out policies that will empower the UK's RAS industry, and secure a strategic advantage for Britain. Developing a clear comparative advantage in RAS will increase national productivity and drive economic growth.

9. **National research institutes for 4IR technologies.** The National Graphene Institute and Alan Turing Institute are shining examples of how Government can encourage future economy innovation by investing in collaboration between academia and the private sector.²³ Innovate UK's Catapult Centres are also a strong catalyst for 4IR innovation and are helping to drive future economic growth in fields as diverse as High Value Manufacturing, Cell & Gene Therapy and Energy Systems.

23 For more info: <http://www.graphene.manchester.ac.uk/> and <https://www.turing.ac.uk/>

The Government should continue to work in partnership with academia and British business to ensure that Britain gains a strategic lead in research and development of key 4IR technologies. To achieve this, a series of national research institutes should be established in areas like artificial intelligence, robotics, autonomous vehicles, additive manufacturing, materials science, and others.

These strategically important centres would coordinate the work of Government, research councils, universities, and the private sector – not just facilitating research and development but also encouraging the commercialisation of 4IR technologies so that British innovations become British businesses that create new jobs and export products and services around the world.

- 10. National Research Institute or Catapult Centre for Robotics and Autonomous Systems.** The founding of the Government’s Centre for Connected and Autonomous Vehicles (CCAV), and the Catapult Centres, are positive steps forward. The Government should now work with academia and industry to establish a new National Robotics and Autonomous Systems Institute, as recommended by Research Councils UK, Innovate UK, and the House of Commons Science and Technology Select Committee.²⁴

The Chancellor’s recent announcement of a further £220million to support tech innovation and “nurture the tech transfer offices that put universities and entrepreneurs together to get the science from the lab and into the factory,”²⁵ is a positive sign that the importance of targeted public investment in 4IR research and development, and the commercialisation of 4IR technologies, is well understood at the heart of Government.

24 House of Commons Science and Technology Select Committee “Robotics and Artificial Intelligence – Fifth Report of Session 2016-17” (House of Commons (HC 145), 12 October 2016) p. 31

25 Hammond, Philip “An economy that works for everyone” op. cit.

- 11. Regional test-beds for 4IR products and services (e.g. autonomous vehicles).** The Government's announcement that driverless car projects will take place in Bristol, Greenwich, Milton Keynes, and Coventry,²⁶ is a positive development in the UK's 4IR testing ecosystem. Encouraging specific areas of the country to specialise in specific 4IR sectors and products will encourage economic growth outside London, and ensure Britain's overall 4IR ecosystem develops more quickly. Geographic areas that specialise in an industry, for example Silicon Valley (for technology) and the City of London (for finance) develop expertise and economic growth more quickly.

Britain should take early opportunities to test 4IR innovations, including the use of unmanned aerial vehicles (UAVs) and data-driven AI management systems in other transport infrastructure. Amazon partnering with the Civil Aviation Authority (CAA) to explore the viability of drones delivering parcels to homes and businesses is welcome.²⁷

- 12. Continued investment in digital infrastructure,** which is as essential to Britain's future economic growth as railways were in the age of steam. This should include a new phase of the fibre-optic broadband rollout designed to target the copper bottleneck between street cabinets and our homes and businesses (fibre-to-the-premises), as well as 5G mobile internet, and support for other networking technologies.

Following the excellent progress made since 2010, the Government must ensure that Britain continues to be a world leader in digital connectivity throughout the 2020s and beyond. This will secure long-term advantages for Britain's economy and encourage inward investment. The Digital Economy Bill in the last Queen's Speech is a welcome step forward.

26 Innovate UK "Driverless cars: 4 cities get green light for everyday trails" (4 December 2014) available online here: <https://www.gov.uk/government/news/driverless-cars-4-cities-get-green-light-for-everyday-trials>

27 The Guardian "Amazon to test drone delivery in partnership with UK government" (26 July 2016) available online here: <https://www.theguardian.com/technology/2016/jul/25/amazon-to-test-drone-delivery-uk-government>

- 13. Promoting Britain as a great place to develop 4IR technologies and encouraging British 4IR exports.** The Department for International Trade should incorporate the 4IR into its hugely successful “Britain is Great” and “Exporting is Great” campaigns. The UK is a top destination for Foreign Direct Investment (FDI), and we must ensure that this continues after we leave the EU, by promoting Britain as a pro-innovation, pro-enterprise, free market economy with all of the right characteristics to turn futuristic technologies into profitable businesses.

Moreover, 4IR businesses in the UK should be encouraged to export, and assisted with selling their products into foreign markets, for example through trade finance, so that we can leverage our 4IR expertise for economic growth, and bolster our status as a trading nation.

- 14. Support for lifelong learning to give people the skills they need to take up 4IR jobs** and keep the labour market flexible enough to react to sector-wide restructuring resulting from innovations in AI and autonomous systems. This should include continued investment in adult education, and tax relief for businesses offering in-work skills training or support for higher education. Lifelong education and skills training, particularly for those employed in at-risk job roles that are vulnerable to automation, will help businesses prepare Britain for the 4IR and add value to their own workforce.

Britain should also focus the welfare system on retraining and up-skilling workers who lose their jobs, so they can move up the 4IR value-chain. The Government should commission research into how the benefits system can better support those who become unemployed due to structural changes in an entire industry or skillset.

- 15. A review of how well the education system is preparing Britain for the 4IR.** Several recent reports by the House of Commons Science and Technology Select Committee have concluded that the UK is facing a digital skills gap,²⁸ and this gap has featured prominently in recent work by techUK,²⁹ who conclude that the Big Data revolution, which is a key pillar of any 4IR economy and is expected to add £241bn to UK GDP by 2020, is at risk from critical skills shortages. Moreover, a recent survey by EEF (the manufacturers' organisation) found that 61% of manufacturing businesses say they should be adopting digital technologies to boost productivity, but they identify skills shortages as the biggest barrier to embracing the 4IR.³⁰

If the UK is to make a success of the 4IR, the Department for Education must continue working to ensure key digital and STEM skills are introduced early in the curriculum and sustained throughout the education system and into the workplace. It is also essential that we do not neglect the creative skillsets that will be more resistant to automation by robotics and machine learning.

This effort should include incorporating digital technologies and cloud-based collaborative learning into teaching methods, so that children start to learn digital skills at an early age. Continued engagement between the Department for Education and the education technology (EdTech) sector will be essential in harnessing the 4IR to improve the quality and standards of education and skills training. This should be done in a way that empowers great teachers to deliver a rigorous digitally-enhanced curriculum, rather than imposing top-down technocratic solutions on schools. Government should also look at providing more capital funding for individual schools to run pilot programmes with new technologies.

28 Science and Technology Committee, "Second Report of Session 2016–17, Digital skills crisis, HC 270"; Science and Technology Committee, "Third Report of Session 2016–17, Satellites and space, HC 160," para 48; Science and Technology Committee, "Fourth Report of Session 2015–16, The big data dilemma, HC 468," para 27

29 TechUK "Understanding, Demystifying and Addressing the UK's Big Data Skills Gap" (October 2016) available online here: <https://www.techuk.org/insights/reports/item/9469-the-uk-s-big-data-future-mind-the-gap>

30 EEF *Manufacturing Outlook Survey Q1 2016*

The Department for Culture, Media and Sport's announcement in October 2016³¹ that the Digital Economy Bill will provide free, basic digital skills training to adults in England who need it is very welcome. This is part of the Government's ambition for the UK to be one of the most digitally-skilled nations in the world, giving us a head start in leading the 4IR-centred global economy, and a positive step.

- 16. A new, standing Commission on Artificial Intelligence at the Alan Turing Institute**, as recommended by the House of Commons Science and Technology Select Committee "to examine the social, ethical and legal implications"³² of AI and autonomous systems. However, while it is vital that we start the process of developing principles to govern AI, and consider how regulation might be implemented in the future, Government must resist any calls for aggressive limits on innovation.

Indeed, techUK has argued that "over-regulation or legislation of robotics and artificial intelligence at this stage of its development, risks stalling or even stifling innovation. This could in turn risk the UK's leadership in the development of these technologies". Other countries will not hesitate to seize the economic advantages of products and services augmented by AI, and the Government must swiftly prioritise pro-innovation policies that encourage the development and deployment of these technologies here in Britain.

- 17. Strong legal protections for innovation** through patents and other intellectual property (IP) mechanisms. The 4IR will strongly emphasise IP, as trade in ideas and creative skills becomes ever more important to Britain's comparative advantages in the global economy. Advances in 3D printing and other 4IR manufacturing technologies will make it possible for physical products to be pirated, not just digital content.

31 DCMS "Government plans to make the UK one of the most digitally-skilled nations" (1 October 2016) available online here: <https://www.gov.uk/government/news/government-plans-to-make-the-uk-one-of-the-most-digitally-skilled-nations>

32 House of Commons Science and Technology Select Committee "Robotics and Artificial Intelligence – Fifth Report of Session 2016-17" (House of Commons (HC 145), 12 October 2016)

18. **A flexible regulatory environment** that encourages early adoption and does not restrict the integration of new technologies into Britain's economy. For example, with driverless cars and drones set to dramatically transform the transport and logistics industry, the Department for Transport and its regulatory agencies will need to have a flexible and agile approach to the implementation of these technologies by British businesses.
19. **A nation-wide focus on cybersecurity.** As Britain becomes increasingly reliant on AI systems, sophisticated robotics, and high levels of digital connectivity, cybersecurity will be a predominant concern. Government research has found that two thirds of large UK businesses were targeted by cyber-attacks in 2015.³³ Close collaboration between the Government, industry, and academia, will be essential if British intellectual property and infrastructure are to remain secure, and it is positive that the Government is investing £1.9bn in the protection of UK cyberspace.³⁴ Recent cyber-attacks on popular websites like Twitter and Spotify, using connected devices from the "Internet of Things" to take down some of the most widely used websites in the world, demonstrate the pressing need to focus on cybersecurity in connected 4IR devices.³⁵
20. **Government procurement of British-made 4IR products and services** to encourage the development of new technologies is key. Britain is already successful at "pushing" and encouraging technological development and the invention of new products by providing funding to initiate research and development projects. However, more needs to be done on the next stage – "pull through" – ensuring innovative 4IR products and services have a market and buyers, whether domestic (through Government procurement) or international (via exports to foreign governments and buyers). Supporting British-produced 4IR exports is crucial in a post-Brexit environment.

33 DCMS "Cyber Security Breaches Survey 2016" (11 November 2015) available online here: <https://www.gov.uk/government/publications/cyber-security-breaches-survey-2016>

34 Hancock, Matt "Minister for Digital and Culture addresses CBI conference" (14 September 2016) available online here: <https://www.gov.uk/government/speeches/minister-for-digital-and-culture-addresses-cbi-conference>

35 BBC News "'Smart' home devices used as weapons in website attack" (22 October 2016) available online here: <http://www.bbc.co.uk/news/technology-37738823>

Government should use its procurement power to buy British when it comes to 4IR products. Other advanced economies, such as Israel, already play a key role in helping new sectors develop, and our government should do the same. News that our Ministry of Defence has launched a new £800m Defence Innovation Fund,³⁶ to finance the development of lasers, drones and other new devices, is welcome, and a good example of the Government's renewed focus on supporting innovation in new technology.

Each Government department should be required to publish its support for UK innovation annually, including how procurement budgets and practices have been used to support British-made 4IR goods. The NHS Accelerated Access Review, published in October 2016,³⁷ which examines how patients can get better access to innovative drugs, devices and diagnostics through the NHS, is an example of how the public sector can be more focused on ensuring it supports Britain's innovation-based economy.

36 MOD "Innovation Initiative to bring future-tech and ideas to the Armed Forces" (12 August 2016) available online here: <https://www.gov.uk/government/news/innovation-initiative-to-bring-future-tech-and-ideas-to-the-armed-forces>

37 Accelerated Access Review Final Report available online here: <https://www.gov.uk/government/publications/accelerated-access-review-final-report>

Chapter 4:

Mastering the Revolution

We must act now to ensure that our political, business, and economic structures can adapt to the 4IR, and harness those changes to drive economic growth in Britain's future economy. As a pro-business, free market political party, Conservative policy must embrace the 4IR; but as a One Nation government we must also make sure that nobody is left behind as disruptive technologies reshape our economy and society. The twenty recommendations to Government set out in this report are designed to help us achieve these goals, building on Britain's past success and securing our future prosperity.

Britain led the world as the First Industrial Revolution took off, and throughout history Britain has adopted a pro-innovation approach to technological development. From farming mechanisation to domestic labour-saving devices in the centuries that followed, to the "Big Bang" in the City, we did not allow fears about the future to stunt the economic and social progress which brought about greater productivity, new jobs, lower production costs, and benefits to consumers as well as producers. We soon realised the folly of requiring drivers of early cars to be preceded by a man carrying a red flag. We must adopt the same, forward-thinking approach when it comes to the 4IR.

The Government must take a positive and pro-active approach by placing the 4IR at the heart of its new Industrial Strategy, so we can usher in a manufacturing renaissance in this country and Britain can once again lead the world in a new industrial revolution. Re-industrialising Britain means embracing the 4IR.

Investment in education and digital infrastructure must remain strategic priorities, as connectivity and a highly-skilled workforce will be the key drivers of economic success in this century and beyond. Britain needs an education system that prepares our people for a world of increasing technological sophistication, with a clear focus on STEM subjects, but we

must not make the mistake of neglecting the creative and design skills that AI will find harder to replicate. Our people – and our economy – must be ready for the *full spectrum* of new jobs, new businesses and new industries that the 4IR will create.

The Government must have a comprehensive and flexible strategy for reacting to widespread changes in the labour market. The Treasury and the Department for Work and Pensions need to examine how well the current framework of working age benefits and taxation can adapt to short-term unemployment in the low and middle income brackets, as well as the availability of adult education and skills training for those needing to change direction later in life.

Whitehall must be pro-active and plan for anticipated changes while also reacting swiftly to unexpected innovation. The public sector has historically been slow to adapt to new technologies, often hamstrung by tradition and bureaucratic inertia. This must change if Britain is to seize the opportunities and mitigate the risks of the 4IR. The UK will also need to adopt a flexible, light-weight approach to business regulation if it is to stimulate economic growth and innovation.

The British people have the talent, drive, and experience, to become world leaders in a future economy empowered by new 4IR businesses and entrepreneurs. If we are to achieve this goal we must embrace technological advances rather than resist them, because other countries will not hesitate to do so. From superpowers such as the United States to agile city-states like Hong Kong, the 4IR offers significant economic rewards to those with the initiative to seize an early advantage.

The global race for success has already begun. So, a clear and immediate focus on mastering the 4IR in Whitehall, in Parliament, and in the private sector, academia and beyond, will ensure that this new industrial revolution consists not of changes that happen to us, but of changes that work for all of us. Only by mastering the 4IR and placing it at the heart of our country's new Industrial Strategy, can Britain win the global race for success.

About Alan Mak MP

Alan Mak was elected as the Conservative Member of Parliament for Havant in May 2015, succeeding former Cabinet Minister David Willetts. He led the first ever debate on the Fourth Industrial Revolution (4IR) in Parliament in September 2016, and launched the APPG for the 4IR in October 2016 as its Founding Chairman.

Alan's main political interests are the economy, business and social mobility. He is Chairman of the APPG for Entrepreneurship and Co-Chair of the Apprenticeships APPG. Before his election, he ran his own small business and started his career as corporate lawyer in the City. He has invested in a number of tech start-ups. Alan read law at Peterhouse, Cambridge University.

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About the APPG

The All-Party Parliamentary Group for the Fourth Industrial Revolution was founded to support and promote the Fourth Industrial Revolution (4IR) in Parliament, and encourage Government, Parliamentarians, academia, the private sector and other stakeholders, to engage with 4IR-related issues.

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