4IR in the Home: Maximising the Benefits

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ACKNOWLEDGEMENTS

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Scott Corfe joined the SMF as Chief Economist in 2017. Before joining, he was Head of Macroeconomics and a Director at the economics consultancy Cebr, where he led much of the consultancy's thought leadership and public policy research. His expert insights are frequently sought after in publications including the Financial Times, the Sunday Times, the Guardian and the Daily Telegraph. Scott has appeared on BBC News, Sky News, Radio 4 and a range of other broadcast media.

Scott was voted one of the top three forecasters of UK GDP by Focus Economics in 2016.

FOREWORD FROM THE SPONSOR

I am delighted to support the Social Market Foundation's vital research into the Fourth Industrial Revolution in the home. 4IR marks the moment at which digital innovation and ultra-fast connectivity make the leap from "nice-to-have" to "couldn't-live-without". We are starting to see the power of new technologies to transform our lives, making the things we rely on every day cheaper, greener, and more productive.

Vodafone has a proud history of technological innovation, having grown from a start-up in Berkshire to one of the world's largest telecommunications companies, serving over 400 million customers around the globe. From making the UK's first mobile call in 1985, to being the first UK operator to abolish roaming charges across 50 European destinations, we pride ourselves on being at the forefront of the developments that change the lives of our customers for the better.

This report looks into the ways in which new technologies will change our day-to-day lives, including care, transport, and home life. The technologies coming to market today are ushering in a care revolution, improving the quality of life for vulnerable and elderly people across the UK. These innovations will lead to safer, quieter, cleaner roads. Families will be able to spend more time together, and have more money to spend while doing so.

Already, we are beginning to see the benefits. Our award-winning Internet of Things range for consumers, *V by Vodafone*, provides technologies that help people to drive safer and keep track of the things they care about, such as a pet or a bag. As this report shows, we are at the beginning of a new wave of innovation. With a few simple, practical changes, policy makers can foster the conditions to allow the Fourth Industrial Revolution to take off across the UK, to the benefit of everyone. This report offers a valuable starting point as we look ahead to an exciting future.

Glafkos Persianis – UK Commercial Director, Vodafone

EXECUTIVE SUMMARY

This report examines the potential benefits that could be realised from the rollout of the Fourth Industrial Revolution (4IR) in the household – both at home and travelling to and from it.

4IR refers to the latest technologies which are building on the digital revolution that commenced in the second half of the 20th Century. This includes internet-connected household appliances ("the internet of things"), driverless cars, big data, robotics and artificial intelligence. 4IR is set to dramatically change the way we live, work and travel in the UK – provided the right policy framework is in place.

This report identifies five key benefits from the rollout of 4IR in the home:

1. **A care revolution,** with connected appliances and robots dramatically improving the quality of care in the home.

   o **Connected household appliances will make it much easier for individuals to monitor those in need of care** – helping to identify and reduce accidents, and reduce anxiety associated with not knowing if an individual is safe. We believe subtle and low-cost forms of monitoring will be widely adopted - for example, sensors which can inform an individual if an elderly relative has not turned on a kettle in the morning; a sign of inactivity could indicate that an elderly relative requires help. Other sensors could detect if lights have been switched on, whether an individual has left the house, and whether a relative has left an oven or electric fire switched on.
   o **Care robots ("carebots") are already being developed which can provide those in need of care with mental stimulation, and assistance with tasks such as getting out of bed.** This will enable individuals to live independently, and safely, for longer.

2. **Safer, less congested and cleaner roads (travelling to and from the home).** We expect 4IR to drive many changes in how individuals travel to and from the home. This includes:
   o **The mass adoption of eCall technology,** whereby cars automatically alert emergency services in the event of an accident, providing information such as a vehicle's location.
   o **Increased usage of telematic technologies in cars to reduce insurance costs among safe drivers.**
   o **The introduction of smart road pricing (driven by data analytics) as a replacement for fuel duty in an age of electric vehicles.** Dynamic road pricing, which varies across the day, will help reduce congestion and even out traffic flow.
   o **Driverless cars, including fleets of driverless taxis which can be easily summoned** – increasing the extent to which cars are a service rather than something owned by individuals.
   o **Much safer roads as a result of these advances**. At present road deaths are a major killer – Department for Transport statistics show that there were 1,792 road deaths in Britain in 2016. 24,101 individuals were seriously injured on Great Britain's roads in that year.

3. **Financial savings.** Connected appliances and data analytics will make it easier for individuals to identify waste and take advantage of potential cost savings. For example, smart devices can be programmed to operate only when energy prices are charged at off-peak rates. Data analytics will provide consumers with a growing number of tools, such as smartphone apps, which can provide product recommendations tailored to an individual's needs. For example, an app drawing on smart energy meter data can help guide an individual to the most appropriate energy tariff for their needs.

4. **Gains to leisure time.** As processes such as the weekly grocery shop are automated, and data analytics help individuals with their decision-making and financial planning, we expect gains to leisure time to be realised.

5. **A revitalised sharing economy,** with connected appliances being increasingly available on a "to borrow" rather than a "to own" basis. As depreciation and usage of connected devices will be easier to monitor, we expect a wider range of companies to provide sharing economy services in the future.

At the same time, we identify a range of challenges to realising these benefits:

o **Infrastructure challenges**. The bedrock of the 4IR is high quality infrastructure. Yet, the UK is falling behind other countries in this respect. Full fibre broadband penetration in the UK stands at just 3%, with most households relying on dated copper connections to access the internet. This is in sharp contrast to countries such as Spain and Portugal, where seven in 10 people can access full-fibre broadband[1]. If UK households cannot access high quality, gigabit capable broadband, they risk being unable to fully benefit from the Fourth Industrial Revolution – particularly when it comes to applications and appliances that are relatively data intensive, such as internet-connected televisions.

• **Privacy and safety challenges.** Potential concerns about data security and privacy (the extent to which data is anonymised) need to be addressed. Companies supplying 4IR technologies need to assure consumers about their products' safety and privacy features.

• **Legal challenges –** 4IR will raise many legal questions, such as where responsibility lies if autonomous vehicles are involved in car accidents, or if a robot used in care injures someone. These will need to be addressed over time, though the UK's strong legal services sector could allow it to become a world-leader in advising on the legal issues created by 4IR.

• **Cultural challenges –** cultural concerns about 4IR need to be acknowledged and addressed. In care, for example, it needs to be crystal clear that technology will be used to complement rather than replace care currently undertaken by humans.

• **Distributional challenges –** done right, 4IR can improve outcomes for some of the poorest and most vulnerable in society, for example by generating financial savings and making it easier for individuals to live safely and independently. However, it could also worsen outcomes and increase inequality – for example, if 4IR leads to increased price discrimination whereby those on lower incomes are charged more for products such as energy.

• **Competition issues –** it is crucial that 4IR evolves in a way that retains a competitive consumer market. The growth of tech giants into an increasing proportion of our daily lives raises questions around potential abuse of market power. Regulators will need to keep this in check.

To ensure the benefits of 4IR are maximised, and the challenges minimised, we provide ten policy recommendations to government:

1. **Develop a pan-government 4IR working group to develop a clear action plan for driving forward the Fourth Industrial Revolution in the UK,** with sub-committees for infrastructure, the business environment, homes and health & social care, as well as potentially other areas. We propose that it is chaired by the Minister of State for Digital and Culture (Currently Matt Hancock).

2. **Develop a broad 4IR infrastructure strategy that takes account of all relevant aspects of infrastructure** – such as fixed and mobile connectivity, roads, car design, public transport, energy infrastructure and planning requirements.

3. **Develop a forward-looking strategy for motoring taxation fit for an age of electronic and autonomous vehicles** – specifically through the introduction of a road pricing scheme to offset declining fuel duty revenues. To ensure political acceptance and minimise public opposition, the strategy should work on the basis that new forms of motoring taxation will seek to *preserve* tax revenues from motorists, rather than raise *additional* revenues for the Exchequer.

4. **Develop a 4IR housing strategy, in association with housebuilders, to ensure that homes being built are "4IR-ready"** – for example, with electric vehicle charging points, appropriate road layouts and secure drop-off points for online deliveries. The strategy should consider the role that the planning system can play in ensuring that homes built are 4IR-ready.

5. **Develop a strategy in association with local authorities and housing associations to examine the extent to which 4IR technologies can deliver better outcomes for social housing tenants** – such as through the development of a self-financing "sharing economy" run by social landlords to financially help those on lower incomes (for example, allowing tenants to borrow leisure equipment and power tools owned by the social landlord, at a reasonable price).

6. **Ensure the Competition and Markets Authority (CMA) has sufficient resource and remit, post-Brexit, to deal with the emerging competition challenges posed by new technologies.**

7. **Task regulators with developing a clear set of recommendations around the use of open, shareable data in markets beyond banking – ensuring the rise of big data benefits, rather than harms, consumers.**

8. **Work with the Care Quality Commission to develop clear ethical principles and standards around the usage of technology, such as robots and connected appliances, in the provision of care.** This should include a principle that technology will be used to complement, rather than replace, care given by humans.

9. **Ensure consumer panels are used to inform the action plans and strategies developed by the 4IR working group.** The consumer panels should include individuals from a wide range of backgrounds, and must include those on low incomes, the elderly and the disabled, to ensure the needs and concerns of these individuals are represented in policymaking related to 4IR.

10. **Any switch-off of broadcast television should be contingent on increasing broadband connection rates of the overall population and older households in particular.** Switching off broadcast with a shift towards internet-on-demand television risks alienating some members of the public, highlighting the need for engagement via consumer panels as well as efforts to continue to increase the rollout of high speed broadband access across the country

CHAPTER 1: INTRODUCTION

The Fourth Industrial Revolution (4IR) is a term that is gaining mainstream use as the technology that underpins it is becoming more and more relevant in our day-to-day lives. Yet many of us do not know what the Fourth Industrial Revolution is, or are confused by the terms used to describe the technologies that comprise 4IR – the internet of things, big data and machine learning, for example. This report seeks to address this issue.

A simple way to consider progress is that:

1. The First Industrial Revolution saw water and steam used to power and mechanize production.
2. The Second used electric power to create mass production.
3. The Third used electronics and information technology to automate production.
4. The Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century.

4IR is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres – artificial intelligence, big data, machine learning and "the internet of things" which is seeing an increasing proportion of household and business appliances connected to the internet.

According to the World Economic Forum, there are three reasons why today's transformations represent more than a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: speed, scope, and systems impact. On speed, when compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. In scope, it is disrupting almost every industry in every country, with robotics and artificial intelligence potentially changing the types of jobs available in our economy dramatically – and the skills needed to perform them. The breadth and depth of these changes could transform the entire system of production, management, and governance.

Undoubtedly, embracing 4IR is vital to the UK's economy. The revolution is global, and the UK needs to be at the cutting edge of progress, not lagging behind. UK politicians and policymakers need to enhance their understanding of what 4IR is in practice, what the benefits are and how they can support it. This report aims to help achieve this.

Despite the potentially profound implications of the Fourth Industrial Revolution, it is often difficult to understand the likely benefits for UK households and businesses – are these technologies genuinely going to radically transform our lives? Or are they overhyped gimmicks, little more than solutions looking for problems to solve? Furthermore, how much weight should we place on some of the concerns expressed about 4IR – such as risks associated with data privacy and the prospect of robots and artificial intelligence replacing humans in the workplace?

Much of the public uncertainty around 4IR revolves around the fact that a lot of the discussion to date has been geared towards a relatively tech-savvy audience. Limited efforts have been made to explain the benefits and challenges of 4IR to a lay audience, or to provide a wide range of concrete, tangible examples of how 4IR will affect the "typical" household or business in the UK and elsewhere.

Given this, the Social Market Foundation is producing a series of reports on the Fourth Industrial Revolution aimed at a non-technical audience. Rather than producing reports on different types of 4IR technology – such as the internet of things, big data and artificial intelligence – we are producing reports exploring the application of 4IR technologies in different *contexts.* That is, we are seeking to understand the implications of 4IR on the household, the workplace, in healthcare, in schools and in other types of public service. By adopting this approach, we hope to provide a credible and clear picture of how 4IR could change our day-to-day lives, for better or worse.

This first report examines 4IR in the *household* – how emerging technologies have the potential to dramatically change the way we care for family, manage our finances, use home appliances and travel to and from the house. As well as the benefits to households, we explore potential challenges and concerns associated with 4IR in the home. We also consider the role that policymakers need to play in ensuring that we maximise the numerous benefits of 4IR technologies, while at the same time limiting or eliminating the prospective downsides.

The structure of the report is as follows:

- **Chapter 2** examines the benefits of 4IR in the household.
- **Chapter 3** examines the benefits of 4IR for private road transport to and from the home.
- **Chapter 4** explores the challenges to realising these benefits.
- **Chapter 5** examines the role that policymakers can play in maximising the benefits of 4IR, providing a series of recommendations.
- **Chapter 6** draws conclusions from the preceding the analysis.

How do we define 4IR?

Definitions of the types of technologies comprising the Fourth Industrial Revolution vary from source to source, though in this research our focus lies on:

- **The internet of things** – household appliances that are connected to the internet, enabling them to send and receive data. Examples include "smart" washing machines and thermostats which can be controlled remotely, for example via a smartphone.
- **Big data** – the use of large datasets (e.g. of consumer behaviours) created and analysed using new technologies.
- **Artificial intelligence** – complex algorithms capable of decision-making and learning over time.
- **Robotics –** the use of machines to automate tasks.
- **Autonomous vehicles** such as "driverless cars".

CHAPTER 2: BENEFITS OF 4IR IN THE HOME

This chapter explores the potential benefits that could be realised through the adoption and increased uptake of 4IR technologies in the home. We believe 4IR has significant potential to make people's lives easier.

While some of the gains from 4IR may materialise over time, others are already in many of our homes. The speed with which some technologies will be adopted – for example within health and social care – will depend in part on the extent to which government is committed to driving growth in 4IR technologies through investment in infrastructure and incentives to encourage research and innovation.

A care revolution

4IR has the potential to dramatically change the way care is given, especially for the elderly, the young and the disabled. The internet of things and robotics have the potential to support people and help them live independently for longer. Technology can make it easier for individuals to monitor the safety and health of family and friends.

Looking out for family

The internet of things is set to make it much easier for individuals to check on the wellbeing of elderly relatives, and other family members with care needs.

We believe subtle and low-cost forms of monitoring will be widely adopted - for example, sensors which can inform an individual about whether or not an elderly relative has turned on a kettle in the morning; a sign of inactivity could indicate that an elderly relative requires help. Other sensors could detect whether or not lights have been switched on, whether an individual has left the house, and whether a relative has left an oven or electric fire switched on.

Such sensors are being developed and refined. For example, UK-based company Intelesant has created a system, called Howz[2], which detects which home appliances are in use and how long they are switched on for, similar to how a smart meter works. It also collects data from light and temperature monitors, and sensors that detect whether doors are open or closed.

Health-tracking "wearables" such as smart watches could alert a care worker or family member if an individual is showing signs of a medical emergency – for example an abnormally high or low pulse reading. Connected devices can be used to check that an individual has taken correct dosages of medication.

Such remote monitoring could improve the welfare of both carers and individuals needing care. Being able to check a relative's health from afar can greatly reduce anxiety for family members concerned about an individual's wellbeing – particularly if they live relatively far away from the individual. For the person potentially in need of care, subtle monitoring tools can enable them to live independently and face less intrusive care than would otherwise be the case.

For those with intensive care requirements, internet-connected cameras and audio equipment can allow relatives and care workers to monitor their wellbeing. For some individuals, however, such an intense level of monitoring could be regarded as intrusive and we would not expect this to be the most widely used way in which 4IR is adopted in a care context.

Care-bots

Looking further ahead, we believe robots are likely to play a role in helping individuals live independently at home for longer, and in helping provide therapy and mental stimulation to individuals.

One example of a care-bot currently being used in Japan is Paro, a baby seal-shaped robot inspired by animal therapy. The purpose of the robot is to help those with mental issues such as dementia feel more socially engaged, stimulating brains through physical interaction such as stroking and hearing sounds. Academic studies have identified benefits which justify investment in Paro, with "clear evidence that [it] can have a positive impact that warrants further exploration"[3]. Findings support the use of Paro as a therapeutic tool, revealing improvements in emotional state, reduction of challenging behaviours, and improvement in social interactions of care home residents.

In the UK, a robotic dog called "Biscuit" has been used in a care home in Bournemouth to provide similar stimulation and therapy – helping to reduce stress and anxiety among people with dementia[4]. While Biscuit is currently being used in a care home context, in the future we could see such robots being used in individuals' homes.

Figure 1: Paro – a care-bot

As well as providing therapy and mental stimulation, robots may start to be used in the home to help individuals carry out a range of day-to-day tasks such as getting out of bed, getting dressed, cleaning and preparing meals. Japan is currently leading the way in this area. For example, Toyota is working on developing robots that can care for the elderly and handle very frail individuals safely. There is increasing interest in the use of robotics in Japan as the country's economy struggles from an ageing population and declining human workforce[5].

While the challenges associated with an ageing population are particularly acute in Japan, we expect other developed markets with ageing populations, including the UK, to explore the role of robotics in areas such as care over the coming years.

Figure 2: A care-bot in action

More convenient and independent living

We expect to see increased use of "internet of things" devices among the elderly and the disabled. As well as the monitoring tools discussed earlier, these technologies also can increase convenience and safety among individuals that are impaired in some way.

For example, smart speakers, such as Amazon's Alexa, Apple's Homepod and Google Home may be of use for those with arthritis or other illnesses which limit their ability to control devices with their hands. For these individuals, being able to choose music, control lighting and make a phone call using audio commands may be much more convenient. Similarly, such technologies bring a wealth of benefits to those that are not physically mobile, enabling them to operate a wide range of connected household appliances using a smart speaker or a smart phone.

Financial savings for consumers and for Government

We expect artificial intelligence, the internet of things and data analytics to translate into financial savings for consumers in the long term. As the technology becomes mainstream so the cost will fall. It will not simply be a case of buying a high-end "connected" fridge, or dishwasher, or tumble-dryer; all of these household appliances will be connected as a supplier standard.

High levels of waste – such as unconsumed food and overuse of energy – leave households facing higher-than-optimal living costs.4IR has the potential to lead to better financial outcomes for consumers, with technology making it much easier for households to make informed and optimal financial decisions – for example, in establishing the best prices for goods and services, ensuring that resources such as energy and food are best used.

Connected household appliances, which track an individual's usage of products and behavioural patterns, could generate a range of financial savings. Smart appliances, which can gather information on prevailing energy prices at a given point in time, can be set-up to operate when energy prices are at their lowest. For example, a connected washing machine or dishwasher could be programmed to operate at a point in the day when energy prices are relatively low.

Smart appliances could also make behavioural recommendations to consumers. For example, a connected fridge could in theory advise an individual on how to make savings in terms of grocery

purchases, by comparing prices across online supermarkets. A smart fridge camera has been developed[6] which can help an individual establish what food their fridge contains, and the expiry dates on this food – thus helping to minimise food wastage. Smart fridges could conceivably provide recipe recommendations for individuals which help them to prepare meals with ingredients that are reaching their expiry date.

For relatively homogenous products such as energy, it is even conceivable that connected smart meters in the future will be able to *automatically* switch individuals onto better energy deals, based on the prices being offered by suppliers at a given point in time as well as an individuals' consumption patterns.

Automatic switching mechanisms built into household appliances could increase the degree of price competition in markets such as energy dramatically, leading to a strong increase in consumer switching rates. At present, competition in the energy market is suppressed by the fact that many consumers are disengaged from the market and unlikely to switch supplier even in the event of significant price rises – technological innovation can overcome this.

Beyond consumers, we expect usage of 4IR in the home to offer the prospect of a range of financial savings for government – important in an age where public finances are likely to be under pressure for multiple reasons: an ageing population and increased demand for health and social care services, for example. Firstly, 4IR technologies have the potential to provide the government with healthcare savings – for example, from using connected devices to check individuals are taking medication, and notify them when they have failed to take prescribed dosages. Evidence suggests that non-compliance with prescriptions carries with it significant healthcare costs across the globe. In the US, for example, a study suggests that improved medication adherence among patients with diabetes could result in over one million avoided emergency department visits and hospitalisations in the US annually, resulting in potential savings of $8.3 billion each year[7].

In social care, using robotics and connected appliances to better monitor those with care needs may help reduce hospital admissions – as discussed, these tools can be used, for example, to alert a carer if the person with care needs has left an appliance such as an oven or heater turned on. Potential accidents, and associated costs, can thus be averted.

Gains to leisure time

4IR technologies will build on the gains to leisure time realised through technological innovation in the 20th Century, which saw widespread adoption of time-saving appliances such as washing machines, dishwashers and vacuum cleaners.

While household technological innovation in the last century increased leisure by reducing time spent undertaking *physical* tasks in the home, such as time spent laundering clothes, we expect the leisure time gains from 4IR to be of a different type. Although outstanding physical tasks such as cleaning the kitchen and ironing clothes could conceivably be done by robots in the future, it is difficult to see this becoming a widespread reality over say the next 15 years. Such tasks would require remarkably dextrous robots capable of understanding many aspects of the home environment.

Instead, the leisure gains from 4IR in the household over this time period are likely to be from reduced time spent shopping, and reduced time spent decision-making and financially planning. We expect the internet of things to drive continued growth in online retail, with an increasing proportion of households opting to have groceries delivered to their home. For example, one could imagine widespread adoption of smart fridges which automatically order food when stocks are running low. Already connected fridges developed by companies such as Samsung are capable of ordering groceries and these technologies are set to develop further over the coming years.

Figure 3: A smart fridge

As discussed earlier, smart technologies are expected to help guide consumers through and automate processes such as finding the best energy and banking deals, and deciding on the cheapest time of day to operate a washing machine or dishwasher. By reducing decision-making time through use of computation, data analytics and automation, households should find themselves with additional leisure time.

Sharing economy 2.0

4IR could usher in a much more developed "sharing economy", where households increasingly borrow, rather than own, the goods and services that they wish to use.

The sharing economy could offer significant financial gains to UK households. Many of us own a range of appliances – such as power tools, leisure equipment (e.g. bikes) and cars – which we do not use on a regular basis. Given this, it would often make much more sense financially and environmentally to be able to borrow these goods from individuals or companies, when we need to use them, at a relatively modest cost.

While sharing economy platforms already exist on the internet, beyond AirBnB and Zipcar these have failed to gain significant take-up and acceptance to date.

We believe that the internet of things has the potential to recharge the sharing economy, leading to wider applications of product sharing – with more businesses providing goods available on a "to borrow" rather than a "to own" basis. Being able to monitor asset depreciation and damage, via the internet, will provide owners of these assets with greater reassurance about how their goods are being used by others, and will help ensure that they are able to make appropriate claims for any damage incurred when a good is being lent out. Connected appliances are thus much better suited for the sharing economy than unconnected devices – which are often hard to trace and monitor.

CHAPTER 3: BENEFITS OF 4IR ON THE ROAD

Outside of the house, 4IR has the ability to dramatically change the way individuals travel to and from where they live, with the rise of car clubs, telematics and autonomous vehicles. 4IR will also change the way individuals use public transport – something we will discuss in a future report on 4IR and public services. In this report, we focus on the most widely used method of travelling to and from the home – the car.

The car industry is evolving from one providing goods (vehicles) to households to one providing services; for example the past decade has seen a sharp increase in the proportion of individuals leasing rather than owning their cars. At the same time as the rise of leasing, car-sharing services such as Zipcar have enabled people living in urban areas to minimise the costs associated with car usage – hiring a car when they need to use one, rather than owning a car that is rarely used. Uber has dramatically changed the taxi landscape, bringing in a new era of convenience for individuals who can now summon a taxi using their smartphone.

Further change is set to come in over the coming years, with the rise of autonomous and electric vehicles. The UK Government has announced plans to ban sales of new diesel and petrol vehicles by 2040[8] and there have been calls for this to be brought forward to an earlier date[9]. Ultimately, the way we travel to and from the home could be very different 20 years' time – and offer a range of benefits to both UK Households and government. This includes cheaper travel costs, less congested roads and lower levels of air pollution.

Connected cars

Cars are becoming increasingly connected. Safety is a key reason for this – cars can now notify the emergency services if a vehicle is involved in an accident which has led to air bags being deployed. Already, this type of technology is being rolled out. For example, "Porsche Connect" and "BMW Emergency Call" provide emergency call services whereby the connected vehicle transmits data– such as the location of the vehicle – in the event of an accident. The European Union eCall Directive means that, from 2018, all new models of car in the European market will be mandatorily equipped with emergency call technology. This is thus set to be a mass market form of connected automotive technology and the European Commission's Impact Assessment for the directive expects 100% penetration to be achieved by 2035[10].

There is also huge potential for telematic devices, which monitor driving patterns, to become increasingly prevalent. At present such devices in the UK are largely used by younger drivers; insurance companies offer discounts for motorists that are willing to install a "black box" in their car which monitors their driving patterns and checks that they drive in a safe manner. As well as reducing insurance costs for some drivers, widespread adoption of telematic devices could reduce road deaths as motorists are encouraged to drive more safely.

Telematic devices may benefit motorists in other ways. For example, by tracking vehicle mileage, telematics can reduce the extent to which cars are clocked in the UK (having their milometers adjusted downward to underestimate vehicle usage). Individuals do this in order to sell vehicles at a higher price, or in the case of leased vehicles to avoid extra charges associated with higher levels of mileage. Consequently, car buyers are inadvertently purchasing inferior quality cars at excessive prices. Telematics can reduce such instances of fraud and ensure individuals have more accurate details about the cars that they are buying, selling and leasing.

Expanding rollout of telematic devices in vehicles may require intervention from UK policymakers, to ensure that such devices are found in more vehicles beyond those owned by young drivers. In Italy, for example, legislation was introduced in 2012 making it compulsory for telematics boxes to be fitted in all new cars, as a response to the rising number of fraudulent whiplash claims in the country which was leading to higher insurance costs. In Italy, provision of telematics insurance is required by law to be cheaper than non-telematics insurance[11], to encourage uptake.

Smart road pricing

One implication of a shift towards electric vehicles is that the government is set to lose a substantial pool of tax revenues currently associated with car ownership and usage. In the 2018/29 fiscal year, the Office for Budget Responsibility (OBR) expects fuel duty revenues for the government of about £28bn – about 4% of all government current tax receipts. As petrol and diesel vehicles are phased out, this source of revenue is set to disappear – highlighting the need for new forms of tax revenue from motorists.

One option is for the government to increase vehicle excise duty ("road tax"), including for electric vehicles, to ensure a continued flow of revenues from motorists. But this would be a highly inefficient way of raising revenue. Critically, as vehicle excise duty does not vary according to how much an individual uses the road network, both heavy and light users of the roads would face equal levels of taxation.

A new system of road pricing seems, from an economic perspective, by far the best long-term form of motoring taxation. Under road pricing, an individual pays a fee to use a stretch of road – potentially a per-mile charge. The level of road pricing would vary depending on the time of day and the location. City and town centres may face higher road prices, for example, to reflect higher levels of demand to use roads in these areas. Similarly, road pricing would be higher in the "rush hour" to reflect greater levels of demand.

As well as making up for tax revenues lost from the elimination of road fuel duty, road pricing could decrease congestion on the road network. By varying road prices according to the time of day, individuals would be encouraged to (if they can) use the road network when prices are cheapest and the roads are less congested. This should in turn lead to a greater spread of traffic throughout the day, reducing the bunching of traffic around rush hours.

Already, basic forms of road pricing exist in the UK – such as toll roads and bridges, and the London Congestion Charge. What we envision is a much more widespread form of road pricing with more dynamic pricing. For example, the pricing structure of the London Congestion Charge is relatively crude, with times where motorists must pay the charge, and times when motorists are exempt from the charge (such as at night and at the weekend). We expect big data analysis of traffic flows and road demand to bring in road pricing which varies throughout the day and depending on prevailing circumstances on a given day – for example, road user charges may be reduced on a day where traffic is unusually quiet.

The long term need for a sophisticated road pricing system across the UK is likely to increase the extent to which vehicles are connected – for example, vehicles may need to be fitted with "black box" devices which report on the road prices prevalent in a particular area, so motorists can make informed decisions about where to drive. Such devices, which would be receiving dynamic pricing data on the road network, could provide guidance for motorists on routes they can take to reduce road charges.

Driverless cars

Further ahead, we expect to see increased usage of autonomous vehicles such as driverless cars. Autonomous vehicle technologies are currently being trialled by a range of companies including Uber, Apple and Google.

The benefits of autonomous vehicles are numerous. Firstly, once autonomous driving technology is fully developed it is likely to dramatically increase the safety of private motoring. At present road deaths are a major killer – Department for Transport statistics show that there were 1,792 road deaths in Britain in 2016. 24,101 individuals were seriously injured on Britain's roads in that year. The figures for road deaths around the world are truly staggering; World Health Organisation estimates suggest that there were 1.25 million road deaths worldwide in 2010; which amounts to about one person being killed every 25 seconds.

Figure 4: The cost of human error. Annual numbers of individuals killed and seriously injured on Britain's roads.
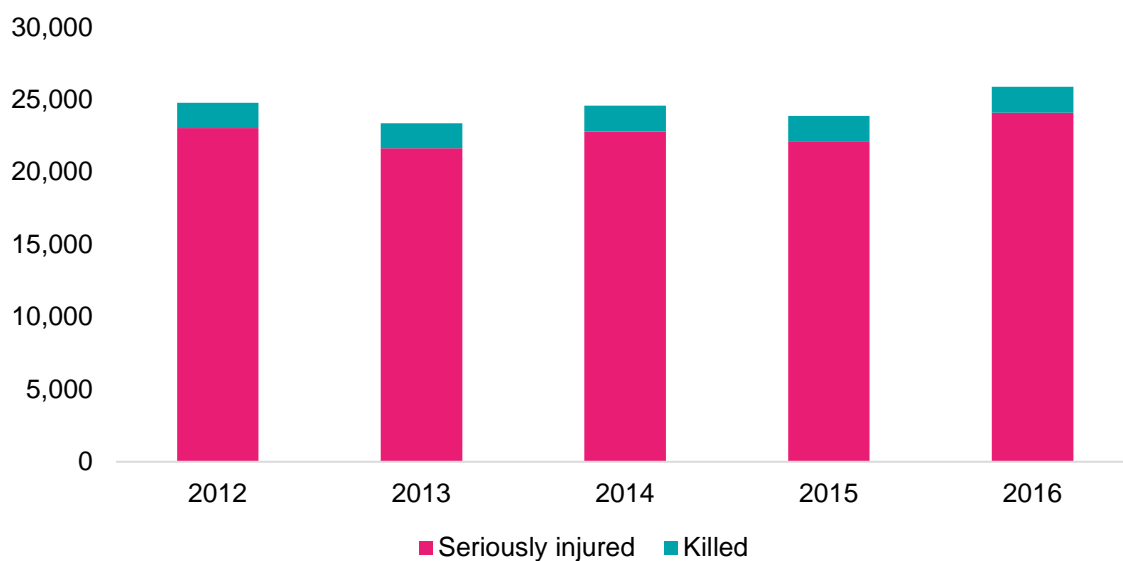
Source: Department for Transport

With many accidents related to human error, including humans driving under the influence of substances such as alcohol, increased use of automation in transport has the potential to eliminate the overwhelming majority of road deaths and injuries in the UK.

We also expect autonomous vehicles to increase the efficiency with which cars are used, with these vehicles being offered largely as a service rather than something owned by an individual household (commonly described as "Mobility as a Service"). At present, individual cars spend the overwhelming majority of their time idle – research by the RAC Foundation found that the average car is parked at home for 80% of the time, parked elsewhere for 16% for the time and only on the move for 4% of the time[12]. We could imagine, instead, a world with fleets of autonomous vehicles which can be hired using a mobile phone app. Once an individual has been dropped off, the autonomous vehicle would then proceed to pick up its next passenger – a "driverless Uber" service. This approach to motoring could greatly reduce congestion and curb the total number of vehicles in the UK by making much better use of vehicles. A fleet of driverless taxis could be nearly constantly in use (at least during the day), taking individuals to and from destinations and spending relatively little time parked.

CHAPTER 4: WHAT ARE THE CHALLENGES TO ACHIEVING THESE BENEFITS?

4IR has the potential to dramatically improve our home lives but there are challenges both in terms of how people feel about the increasing role of technology and how physically to roll it out. This chapter discusses these issues.

Infrastructure challenges

The bedrock of the 4IR is high quality infrastructure. Yet, the UK is falling behind other countries in this respect. As the Chief Executive of Ofcom, Sharon White, noted in 2017, full fibre broadband penetration in the UK stands at just 3%, with most households relying on dated copper connections to access the internet. This is in sharp contrast to countries such as Spain and Portugal, where seven in 10 people can access full-fibre broadband[13]. If UK households cannot access high quality, gigabit capable broadband, they risk being unable to fully benefit from the Fourth Industrial Revolution – particularly when it comes to applications and appliances that are relatively data intensive, such as internet-connected televisions.

With respect to electronic and autonomous vehicles, there are numerous infrastructure requirements that need to be put in place before these become a widespread technology. Depending on the level of sophistication and intelligence of autonomous vehicles, there may be a need for roads to be redesigned into a format that is easier for an autonomous vehicle to navigate. Much of the UK's road network is relatively old, and complicated road layouts may prove difficult for autonomous vehicles to navigate. Similarly, complicated junctions and signposts may need to be simplified for autonomous vehicles. As we discuss in the next chapter, there is a key role for government to play in ensuring that the road network is fit for the future.

Privacy and security

4IR will dramatically increase the amount of data collected on individuals' activities and consumption patterns, raising understandable questions around data protection and individuals' rights to privacy. By some estimates, by 2020 there will be at least four internet-connected devices for every person on Earth[14].

Without proper safety protocol in place, personal data collected by connected household appliances is at risk of being illegally acquired by hackers. It is crucial that the internet of things is secure and that past mistakes are not repeated; in 2015 for example security researchers discovered a potential way of stealing users' email details from a smart fridge[15].

As well as safety, individuals need assurance about how their data is being used – what data is being collected? What is the purpose of the data collection? And whom is the data being shared with? Where my data is being used, is it being appropriately anonymised? These are all valid questions for an individual to ask when using an internet-enabled device. Yet, all-too-often individuals are largely in the dark about how their data is being used, and indeed about who actually owns the data being collected on them – do they own the data or is it owned by the company collecting the data? Such information has until now often been hidden in company small print rather than made clear to consumers, though EU General Data Protection Regulation (GDPR) is set to lead to greater transparency on this front.

In addition to better data transparency, we expect GDPR to provide much stronger incentives to ensure 4IR devices are secure. Under the regulation non-compliance penalties are high – standing at up to €20m or 4% of annual turnover. This should help prevent past data breaches being repeated in the future.

Legal implications of 4IR

4IR raises a number of interesting legal questions, which will need to be addressed as use of these technologies becomes widespread.

In particular, wider use of robots and autonomous vehicles raises questions around where *responsibility* lies. If an autonomous vehicle is involved in a car accident, who is ultimately to blame for the accident? Similarly, if a care company deploys robots to assist elderly individuals at home, where does blame lie if that robot injures an elderly person? With the care company or the robot manufacturer? If connected household devices make bad purchasing decisions on a consumer's behalf, should consumers expect some form of compensation?

Connected technologies and robots introduce a new party – the technology manufacturer - into a range of relationships, potentially dramatically increasing the legal complications associated with establishing responsibility. Along with many other things, 4IR could shake up some aspects of our legal landscape, and legal complications could potentially be a challenge to rolling out some of these technologies.

At the same time, it is important to note that, with the UK being a key global provider of legal services, there is a significant opportunity for UK-based companies to develop a leading role advising on such legal issues. According to research by The City UK[16], four of the ten largest law firms in the world, based on gross fee revenue, have their main base of operations in the UK. Over a quarter (27%) of the world's 320 legal jurisdictions use English Common Law. This is a strong basis for the UK to establish itself as a world-leader on the legal implications of 4IR.

Cultural challenges

We note that there are likely to be significant cultural challenges to rolling out some 4IR technologies in the household – particularly with respect to the use of 4IR in care.

With care, we note that there are likely to be concerns about robots and monitoring tools replacing face-to-face interaction with humans. Human contact clearly has to play a crucial role in any form of care provision, given the need to reduce loneliness among the elderly. Research by Age UK in 2014 suggested that over one million older people say they are always or often feel lonely[17] - highlighting a need to increase, rather than diminish, human interaction among older individuals.

4IR technologies must be seen as *complements* to human interaction, rather than *substitutes.* In particular, 4IR technologies have the potential to free up care workers and family members to spend more time interacting with individuals in need of care in more meaningful and fulfilling ways. For example, if robots can be used to help individuals get out of bed and to get dressed, care workers and family members can be freed up to spend more time socialising with those in need of care. Furthermore, increased use of video calling can improve the ability of individuals to regularly interact with family members in need of care.

We believe that 4IR technologies must be introduced gradually and with the full buy in and consent of care workers and individuals. This remains one of the biggest barriers and one that is within the gift of government to begin to change. A push from central government to educate and engage with the individuals affected can ease concerns about 4IR in contexts such as care – as we discuss in the next chapter of this report.

Another cultural challenge to realising the full benefits of 4IR in the home relates to road pricing. While road pricing carries with it a range of economic and social benefits, and seems inevitable in the long run given the disappearance of fuel duty revenues for the government in the future, we note likely public resistance to introducing it. This is especially likely if many members of the public believe that it is going to be used by the government to raise more revenue from motorists. It is thus crucial that policymakers are clear that plans to introduce road pricing will be revenue neutral rather than revenue raising for the government.

Having said that, recent survey evidence in London suggests that a significant proportion of the public acknowledges the benefits of road pricing – at least in the capital. Research by the London Assembly shows that over half of road users support road pricing in London, as a replacement to the Congestion Charge, with only a fifth opposed. Compared with the Congestion Charge, road

pricing would be more focused on areas of congestion, at the times congestion occurs – so many motorists driving in Central London stand to benefit from its introduction[18].

Distributional challenges – will all benefit from 4IR?

While the Fourth Industrial Revolution offers a host of benefits to individuals using new technologies, there is a risk that the benefits of 4IR will not be spread out across society – potentially exacerbating existing problems associated with inequality.

The most obvious way in which 4IR could widen inequality is if technologies are set at a price point that is only accessible to those on higher incomes. If autonomous vehicles, care-bots and connected household appliances are beyond the financial means of individuals on lower incomes, then the benefits will accrue among richer members of society. Having said that, we would expect many 4IR technologies which are relatively expensive today – such as connected fridges and washing machines – to become mass market and much more affordable.

Another way that 4IR could theoretically lead to worse distributional outcomes is through *data*. By collecting data on individuals' preferences and spending patterns, the internet of things could pave the way for more price discrimination across goods and services – increasingly charging consumers different amounts depending on their estimated price sensitivity. We know from our research[19] that there are some markets such as energy where low-income consumers are less price sensitive and less likely to switch supplier than high income consumers. It is crucial that the Government and regulators work to put the right safeguards in place to ensure low income households do not lose out in these ways.

Beyond low income consumers, there is a risk that big data and algorithms underpinning some forms of technology could lead to worse outcomes for other segments of society. As Professor Noel Sharkey, Co-Director of the Foundation for Responsible Robotics, has noted, there is a concern that robotic artificial intelligence could make decisions about an individual based on factors such as sex and race[20] – raising a range of ethical questions and issues for policymakers and businesses to address. Having said that we note that artificial intelligence also has the potential to reduce discrimination, by ensuring that decision-making is driven by data rather than personal prejudices – done right, we can use technology to create fairer outcomes in society.

Competition issues – should we be worried about the rise of big tech?

One potential concern with the rollout of 4IR technologies is the implications for competitiveness in the economy. As tech firms become increasingly embedded in more and more of our daily lives – there is a risk of consumers becoming locked into a particular product eco-system.

For example, a technology company offering household appliances, smart phones and autonomous vehicles could make it very hard for consumers to walk away from the company – by offering bundled services or limiting the degree of cross-compatibility with other technology providers, for example.

Concerns about anti-competitive practices by technology companies are hardly new, as evidenced by the widespread debate about the competition implications of Microsoft's decision to bundle the Internet Explorer web browser with its Windows operating system in the 1990s. What is new with 4IR is the potential scale of anti-competitive practices that could take place. With tech companies such as Google, Amazon and Apple entering an ever-greater number of product areas – from cars to household appliances to music – the market power and practices of these companies deserves greater scrutiny. If competition in the market is undermined, consumers will fail to benefit fully from the Fourth Industrial Revolution.

Creating a technological environment with common standards and cross-compatibility across provider eco-systems is key. There are big roles for government and regulators to play in ensuring that the market for technology is competitive and fair, and does not work against consumers' interests.

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CHAPTER 5: WHAT CAN POLICYMAKERS DO?

The previous two chapters have explored the potential benefits and challenges associated with rolling out 4IR in the household. Realising these benefits, and overcoming some of the challenges is mission critical for the UK economy. The Government therefore has a significant role to play in terms of championing the revolution but also ensuring the foundations are in place for success. Without the right policies and supporting environment in place, the UK risks falling behind other nations in terms of its adoption of new technologies – to the detriment of households, businesses and consumers.

As the Prime Minister made clear in her speech to Davos in January 2018, "technological advances continue to revolutionise the possibilities for humanity and we must have the international frameworks in place to ensure everyone can benefit from them". At the highest level this is true and the Government has a responsibility as we move through Brexit to ensure the UK is best placed – and indeed leading the way where possible – in terms of our international standing for 4IR.

On the domestic level, the Secretary of State for Digital, Culture, Media and Sport, Matt Hancock, outlined at Davos the need for government to support the Fourth Industrial Revolution, through smarter regulations, adopting digital transformation and ensuring that 4IR evolves in a way that gets the ethics right[21]. The speech is welcome and sets a clear tone for progress. Below are a number of practical policy recommendations that we believe will help ensure the successful roll out of these technologies. These are measures that are within the Government's grasp and that we believe should be considered as part of the ongoing development of the Industrial Strategy.

Developing a pan-government 4IR working group

We recommend the establishment of a pan-government working group to develop and push forward new policies that would help support 4IR and ensure the UK becomes a world leader in this space. The working group should develop a strategy and clear action plan to ensure these ambitions are realised.

We propose that it is chaired by the Minister of State for Digital and Culture (Currently Matt Hancock). The working group should operate with a number of sub-committees each chaired by a Government Minister. These should include:

- **Infrastructure** – Margot James MP, Minister for Digital and the Creative Industries
- **Homes** – James Brokenshire MP, Secretary of State for Housing, Communities and Local Government
- **Business environment** – Greg Clark MP, Secretary of State for Business, Energy and Industrial Strategy
- **Health and social care** – Caroline Dinenage MP, Minister of State at the Department of Health and Social Care

We expect the working group and its sub-committees to feature senior officials, industry representatives and, where appropriate, individuals from organisations that represent consumers' interests – such as Citizens Advice, Age UK and Carers UK. As we discuss later in this chapter, there is also scope for consumer panels to feed into the development of government strategy on 4IR.

Recommendation 1: Develop a pan-government 4IR working group to develop a clear action plan for driving forward the Fourth Industrial Revolution in the UK.

Infrastructure for 4IR

The infrastructure sub-committee of our proposed 4IR working group would have a key role to play in ensuring the full benefits of 4IR come to fruition. This includes, but is not restricted to, the underlying telecommunications infrastructure driving 4IR.

Telecommunications infrastructure

The uptake of 4IR technologies in the home, and elsewhere, will depend heavily on whether the supporting telecommunications infrastructure for these technologies is available. The Government has already announced a number of plans to improve connectivity in the UK, which should support more widespread adoption of technologies such as connected home appliances. For example, the 2018 Spring Statement saw the Chancellor making the first allocations of the £190 million local full fibre broadband challenge fund announced at the Autumn Budget as well as confirming £25 million for 5G mobile connectivity testbeds.

Furthermore, recent years have seen a significant improvement in some aspects of the UK's telecommunications infrastructure. For example, a recent report from Ofcom showed a 28% increase in average household fixed broadband download speeds over the year to November 2017[22].

However, despite these recent announcements and developments, there is still a long way to go in improving connectivity in the UK, as we highlighted in the previous chapter of the report. Action plans and cost-benefit analyses should be developed by government to explore the best and most cost-effective ways of rolling out better broadband and mobile connectivity across the country. This includes the rollout of full fibre-to-the-premises (FTTP) broadband to a wider audience. As we discussed in the previous chapter the UK currently stands far behind other countries such as Spain in terms of access to full fibre broadband.

These action plans should be informed by expert insights in the telecommunications industry, as well as the views of end users of telecommunications infrastructure – households, businesses and government.

The infrastructure sub-committee of the 4IR working group should explore relatively affordable "quick wins" that could be adopted rapidly by the government to support 4IR – for example, via the installation of mobile antennae on public sector buildings to boost coverage. "Small cells" which boost mobile capacity could be installed on public infrastructure such as street lighting – something that will be increasingly important with the mass rollout of connected cars requiring access to a mobile signal.

Thinking beyond the obvious – roads and town planning

While improving broadband and mobile connectivity is crucial it is only part of the infrastructure requirements needed to make all of the benefits of 4IR a reality. It is essential that the government does not lose sight of the broader requirements needed to achieve widespread adoption of 4IR technologies – from the way our roads are designed to how our towns are planned.

While the 2017 Budget saw the Chancellor announcing regulatory reforms allowing the testing of self-driving vehicles on UK roads, there has been very little discussion by policymakers on the need to ensure that the UK is developing a *road network* that is well-suited to autonomous vehicles. Worryingly, this suggests that much-needed thinking about the broader requirements of 4IR is not taking place. This needs to change.

The autonomous vehicle revolution will fail to take off without careful consideration of our road infrastructure. Policymakers should be exploring ways of optimising and future-proofing the road network for driverless cars, which take account of their potential strengths and weaknesses. For example, autonomous vehicles, in the near-term at least, may struggle to interpret the hand gestures of construction workers telling a car were to go or whether to stop – requiring a rethinking of how we go about road maintenance. If autonomous vehicle cameras struggle to "see" traffic

light signals under certain lighting conditions, this may require a rethink of lights and how they communicate with vehicles. Autonomous vehicles may perform better under a simplified grid road network rather than a convoluted and complex one – with implications for town planning.

In addition, as discussed, the rollout of electronic and autonomous vehicles will require government to dramatically change the way motorists are taxed – with a shift away from fuel duty towards some kind of road pricing system. For such a system to be accepted by motorists, it is crucial that they are assured that new types of motoring taxation will be devised on a revenue neutral basis, rather than a way of raising more revenue from motorists. Without such assurances, political barriers may prevent the full benefits of 4IR on the roads from being realised.

Recommendation 2: Develop a broad 4IR infrastructure strategy that takes account of all relevant aspects of infrastructure – such as telecommunications, roads, car design (such as requirements for telematic boxes), public transport, energy infrastructure and planning requirements.

Recommendation 3: Develop a forward-looking strategy for motoring taxation fit for an age of electronic and autonomous vehicles – specifically through the introduction of a road pricing scheme to offset declining fuel duty revenues. To ensure political acceptance and minimise public opposition, the strategy should work on the basis that new forms of motoring taxation will seek to preserve tax revenues from motorists, rather than raise additional revenues for the Exchequer.

Housing and 4IR

Uptake of 4IR and its associated benefits can be enhanced through housing policy. The proposed housing sub-committee of our 4IR working group should work with housebuilders to ensure that houses built over the coming years are "4IR-ready", and explore the extent to which the planning regime should encourage or mandate the rollout of 4IR-ready design in new homes. Furthermore, there is scope for the government to engage with social landlords and explore the extent to which 4IR can provide better financial outcomes for the relatively low income individuals living in social housing.

Building 4IR-ready homes

We need to ensure that homes being built today are future-proofed and "4IR-ready". The government should explore the extent to which 4IR-readiness should be reflected in planning requirements for homes.

4IR-readiness in the home could entail a number of planning requirements, including:

- Requiring large housing developments to have car sharing facilities.
- Introducing new requirements for electric car charging points in new developments.
- Ensuring, where possible, new homes have access to full fibre-to-the-premises broadband.
- Increasing mobile connectivity in developments through booster antennae.
- Fitting some connected household devices, such as smart thermostats, as standard.
- Encouraging developers to create new online delivery points in homes – creating a secure drop-off facility which can securely receive goods ordered online when an individual is not at home.
- Ensuring road layouts in new developments are "autonomous vehicle friendly"
- The rollout of energy monitoring technologies in homes.

By having 4IR-readiness at the heart of the planning system, policymakers can help maximise the benefits of these technologies and ensure more widespread adoption across households.

Ensuring all gain – a key role for social landlords

There is a role for social landlords – housing associations and local authorities - in ensuring lower income households benefit, rather than lose out from, the Fourth Industrial Revolution.

Social landlords, could be encouraged to become "market leaders" in terms of utilising 4IR technologies in the home – such as by fitting electric car charging points near homes, rolling out car clubs on housing estates and exploring the extent to which connected household appliances can be used to support individuals requiring care. Social landlords can also encourage tenants to take advantage of the open data revolution – using apps and online services which help them reduce their energy and banking costs, for example.

Social landlords could also encourage the adoption of a more widespread sharing economy, with social landlords owning connected assets such as leisure equipment, bicycles and power tools which can be borrowed by residents at reasonable cost. If demand for such shared assets at a reasonable price is there, this sharing economy could conceivably by self-financing over time. As discussed earlier, the internet of things will see an increasing proportion of devices which are able to send and receive data, making it much easier for an organisation like a social landlord to roll out such a sharing scheme. Lower income individuals, such as those in social housing, stand to benefit the most from the development of a sharing economy given its ability to curb the costs of living.

> **Recommendation 4:** Develop a 4IR housing strategy, in association with housebuilders, to ensure that homes being built are "4IR-ready". This should include consideration of the role of the planning system in encouraging the development of 4IR-ready homes.
>
> **Recommendation 5:** Develop a strategy in association with local authorities and housing associations to examine the extent to which 4IR technologies can deliver better outcomes for social housing tenants – such as through the development of a self-financing "sharing economy" run by social landlords to financially help those on lower incomes (for example, allowing tenants to borrow leisure equipment and power tools owned by the social landlord, at a reasonable price).

Business environment for 4IR

As discussed in the previous chapter of this report, one of the challenges with 4IR will be ensuring that it develops in a way that maintains competition in consumer markets, rather than a way in which a small number of larger tech companies have excessive market power and control a growing proportion consumers' lives. It is becoming increasingly important that government and regulators get a grip on the changing business environment and competition dynamics created by new technology

With data increasingly becoming the most important asset of businesses, policymakers also need to ensure that data collection and usage evolves in a way that benefits consumers – being safe, transparent and usable in a way that enhances rather than restricts competition.

A competition regime fit for the future

The rise of large tech companies spanning an increasing proportion of our total expenditure – from cars to household appliances to telecoms - has substantial implications for competition policy. It is crucial that the Competition and Markets Authority (CMA) is prepared to tackle potentially highly complex competition issues relating to tech companies.

In 2017, the CMA noted the need to strengthen its ability to handle investigations involving technology[23], especially given that Brexit could leave the UK having to deal with "big digital cases" that are currently within the remit of the European Commission. After Brexit, the CMA will no longer belong to the European Competition Network, which brings together national competition bodies and the European Commission. That means the CMA is likely to take a far more prominent role in both market and cartel cases involving multinationals where UK consumers are affected.

The CMA is building a new technology team to strengthen its ability to keep pace with the use of algorithms, artificial intelligence and big data in business. This is a step in the right direction, and it is important that the CMA continues to develop its capacities in this area, given its growing importance. In 2016 the CMA fined a posters and frames vendor £160,000 for agreeing with a competitor that they would not undercut each other for items sold on the Amazon UK website, effectively engaging in cartel activity. In 2017, the CMA launched an investigation into hotel booking websites, highlighting concerns that the algorithms used by these websites to find the "best deals" for individuals are potentially misleading. We expect increased use of big data, algorithms and the internet of things to lead to similar competition cases in the future.

Post-Brexit, it is crucial that the CMA continues to develop its technology team as the Fourth Industrial Revolution gathers pace, and that it is able to understand, measure and respond to complex competition issues related to these technologies.

Getting international support on competition issues involving technology will be crucial. Large tech companies span borders and a joined-up approach across markets will be critical in tackling some of these issues. The UK's post-Brexit competition regime needs to acknowledge the need for international cooperation when dealing with such matters.

Data transparency, portability and standards

4IR is set to dramatically increase the amount of data gathered from UK households. It is thus crucial to ensure that this data is secure, and not at risk of being illegally acquired by other parties. Ownership and transparency of data usage are also important, and this needs to be a focus of policymaking too.

At the least, we need to move into a world in which individuals have a greater degree of transparency about what data is being collected on them, and how this data is being used. We need to ensure issues of data ownership and usage are conveyed explicitly, and in plain English, rather than consigned to the small print of contracts. The implementation of General Data Protection Regulation (GDPR) in 2018, which introduces new transparency requirements, should go some way towards making issues of data usage more transparent.

It is also important that individuals have the ability to access and remove any data collected on them, and here too GDPR introduces new rights for individuals. GDPR will require data controllers to provide "data portability" when accounts are closed – allowing individuals to potentially use this data to more easily switch supplier and locate a better deal on the market.

There is a key role for regulators in establishing data standards – ensuring individuals can access and share personal data in a format that can be easily used by other companies and third party apps/web tools such as price comparison websites. Done right, data can enhance competition – paving the way for the development of new internet-based tools which can recommend alternative products for consumers based on their consumption and expenditure patterns. The rollout of Open Banking in the UK intends to pave the way for a more competitive banking market through this channel – allowing individuals to share their account data securely with other parties. These parties can then recommend products, such as loans and overdrafts, that are well suited to an individual's requirements and circumstances.

The government and regulators should explore the extent to which the principles of Open Banking could be applied to other markets, as a way of driving up competition in these markets.

We note the importance of striking a balance between data protection, and transparency, and retaining an environment in which tech companies feel confident to innovate. There is a risk that, if data requirements become too onerous, and the fines associated with non-compliance become too great, then tech companies may be deterred from experimenting, innovating and developing new products. As mentioned in the previous chapter, GDPR carries with it high penalties for non-compliance – up to €20m or 4% of annual turnover. While this will provide a strong incentive for companies to adhere to data legislation, it also risks making companies much more risk averse in

how they use data. Government and regulators will need to liaise with consumers to ensure an appropriate balance is struck.

> **Recommendation 6:** Ensure the CMA has sufficient resource and remit, post-Brexit, to deal with the emerging competition challenges posed by new technologies.
>
> **Recommendation 7:** Task regulators with developing a clear set of recommendations around the use of open data in markets beyond banking.

Health and social care

Robotics and the internet of things have the potential to revolutionise the way we look after the unwell and those in need of care – at home and elsewhere. But, as discussed in the last chapter, there are understandably likely to be some concerns about the rollout of some of these technologies – particularly around the extent to which they could replace rather than complement human-based care.

Policymakers and businesses can overcome these concerns by providing consumers with assurances, and adopting strong, clear ethical principles.

Principles of 4IR in care

We would expect the health and social care sub-committee of our proposed 4IR working group to work closely with the Care Quality Commission (CQC) in developing key ethical principles around the use of tech in care.

The CQC produces a set of fundamental standards below which care must never fall[24]. These include the need to access care or treatment tailored to an individual's needs, the requirement to be treated with dignity and respect, and the need for individuals (or those legally acting on their behalf) to provide consent before any care or treatment is given to them.

The 4IR working group should consider the extent to which these fundamental standards should be expanded to account for technological developments in the care sector. For example, they could discuss the inclusion of a principle that "robots and technology in care will be used to complement, rather than replace, human-based care". This will help provide individuals with greater guarantees about the use of tech in this element of their lives.

Consumer panels – ensuring households are consulted

To ensure the benefits of 4IR in the household are maximised, it is crucial that consumers are consulted on these technologies by policymakers – particularly when it comes to potentially sensitive areas such as the use of robotics in social care.

Consumer panels consisting of individuals from a wide range of backgrounds should form a core part of any strategic planning around technology which will have an impact on UK households – to ensure consumer concerns are addressed in the policymaking process.

When considering the role of robotics and the internet of things with respect to care, it is crucial that those in need of care are consulted so their concerns can be gauged and an appropriate way forward can be implemented. As we have discussed, this is a delicate subject area. While technology can make it much easier for individuals to live independently for longer, there is a risk of it being deemed intrusive and there are concerns about increased levels of loneliness if technology replaces human interaction. Consumer panels can ensure an appropriate balance is struck. Ultimately, there is a role for government in sponsoring dialogue with consumers on the role of technology in society.

By including individuals from a range of backgrounds on consumer panels, such as the disabled, those on low incomes and the elderly, we can better ensure that technology evolves in a way in

which everybody can benefit – for example by ensuring that products suitable for individuals with disabilities are developed. Consumer panels can also be used to gauge the implications of likely developments from new technologies, such as the prospect of broadcast TV being largely suspended in the future, replaced by internet-driven on-demand television. Such a move risks leaving behind those that are not very digitally engaged (see Case Study box below) – something that policymakers should strive to avoid. If consumer panels and surveys reveal that many households stand to lose out from a measure such as the switch-off of broadcast television, then safeguard measures and assurances should be put in place. For example, the government could commit to ensuring that any switch-off of broadcast television would only occur once fast broadband access across the country has dramatically increased, particularly among older segments of the population.

Recommendation 8: Work with the Care Quality Commission to develop clear ethical principles and standards around the usage of technology, such as robots and connected appliances, in the provision of care. This should include a principle that technology will be used to complement, rather than replace, care given by humans.

Recommendation 9: Ensure consumer panels are used to inform the action plans and strategies developed by the 4IR working group. The consumer panels should include individuals from a wide range of backgrounds, and must include those on low incomes, the elderly and the disabled, to ensure the needs and concerns of these individuals are represented in policymaking.

Recommendation 10: Any switch-off of broadcast television should be contingent on increasing broadband connection rates of the overall population and older households in particular. Switching off broadcast with a shift towards internet-on-demand television risks alienating some members of the public, highlighting the need for engagement via consumer panels as well as efforts to continue to increase the rollout of high speed broadband access across the country.

CASE STUDY – BBC broadcasting and the need to engage with consumers

Changes in the way people watch television offer useful lessons in how the shift to new technology in the domestic setting can be managed, and present challenges that are fast approaching policymakers.

The consumption of television content is rapidly shifting away from "linear" programming delivered by broadcast signals and towards on-demand content delivered online.

According to Ofcom[25], average daily TV viewing times fell by from 242 minutes in 2010 to 212 minutes in 2016, a decline of 30 minutes or 12%.   The decline was greatest among adults aged 16-24 and children aged 4-15. for whom viewing dropped by around a third.

The profile of TV viewers has become older with adults 55+ now making up just under half (48%) of the total TV audience compared to 38% in 2006

Meanwhile, consumption of on-demand TV supplied by Netflix, Amazon Prime and the BBC Iplayer has risen sharply, with younger consumers driving the trend.

These trends raise questions about how long the BBC will maintain its broadcast signal and schedule, as the Corporation itself has suggested.

The BBC's 2018 Annual Report[26] said:

"Today most of our audiences still enjoy the BBC's programmes and services in a traditional broadcast schedule. The majority will continue to do so – at least for some time. But rapid

technological changes driven, in particular, by the internet and mobile devices mean that, more and more, audiences are choosing to enjoy what they want, whenever they want, wherever they are.

"We are approaching the time when this will become the main route to what the BBC does. It will not come immediately, but already it is happening far quicker than many predicted."

Sooner or later, a question must be answered: Should the BBC end its broadcasting operations and shift to an online-only model, as it has already done with BBC Three content?

We note that, legally speaking, the BBC's commitment to continue to distribute its television content by broadcasting lasts only as long as the current charter period, which ends in 2027. Given the current rate at which consumption is shifting, we forecast that the next charter period will see at least the start of the BBC's move to online-only distribution of content.

Previous experience of major changes in broadcasting hold lessons for how the adoption of new technologies can handled well or badly.

The switch-off of analogue TV signals offers a relatively positive example. It began with trials in 2005 and was only completed in 2012.

A less positive example was the failed attempt to switch off FM radio signals. In 2009, a Government paper suggested that analogue radio signals could be ended by 2015 as consumers switched to DAB radio. [27]

Amid continued concern from users, the Coalition Government in 2013 maintained the aspiration to end analogue signals, but suggested that the switch-off would be delayed until the end of the decade.

In March 2018, the BBC said it wanted to maintain a "mixed economy" in radio for the foreseeable future, effectively abandoning any plan to switch off analogue signals.

Given the importance of the BBC to national life, it is vital that any move to online-only distribution of television takes place slowly, with extensive public consultation and information. One in ten UK households does not have internet access, and households with one adult aged 65 and over only 61% had internet access in 2017[28]. Households in rural areas are also most likely to report that slow connection speeds make it impractical to consume television online.

To prepare for any move to an online-only BBC, engagement with older people, rural communities and others who are less likely to consume television online should begin before the formal charter renewal process. Ministers should actively engage with this debate as early as possible and start a conversation with the public about the future of BBC television delivery.

CHAPTER 6: CONCLUDING REMARKS

This report has explored the implications of the Fourth Industrial Revolution in the household, and identified a number of areas in which the technologies which comprise the Revolution – big data, robotics, the internet of things and artificial intelligence, can reshape our lives for the better.

We believe the greatest benefits from 4IR technologies in the household lie in their ability to radically reshape the way we care for relatives, and the way we travel to and from the home. "Care-bots" and connected household appliances could make it much easier for individuals to check on the wellbeing of relatives in need of care, and make it easier for individuals to live independently for longer. Connected household appliances could usher in an age of much greater convenience for individuals that struggle to use conventional appliances – such as those with arthritis.

The rise of electric cars and autonomous vehicles looks set to see cars increasingly becoming a "service" rather than a "good", with these technologies leading to increased usage of car sharing facilities. Car sharing could dramatically reduce the costs associated with vehicle usage, as well as easing congestion and reducing the environment impact of vehicles. Electric vehicles will also pave the way for a dramatic shift in motoring taxation, with dynamic road pricing replacing fuel duty. Road pricing would curb congestion by encouraging individuals to use roads at cheaper, off-peak times. By varying road prices in different locations, individuals can also be encouraged to travel using less congested routes.

Other benefits of 4IR include potential financial savings for households, increased leisure time and the development of a more professionalised "sharing economy" which sees households shifting away from the conventional ownership model for items such as power tools, bicycles and leisure appliances.

Realising these benefits is not without its challenges, including data protection concerns, insufficient infrastructure and cultural barriers associated with some of these technologies – such as potential fears related to the use of robotics in the care sector.

Overcoming these challenges will require action from policymakers, and we have set out a series of recommendations in this report. Government needs to ensure the UK has the right planning, road and telecommunications infrastructure to allow households to take full advantage of 4IR technologies. Further, local authorities and housing associations should consider becoming market leaders in rolling out 4IR technologies in peoples' homes.

The interests of consumers in the Fourth Industrial Revolution need to be well-represented. This report recommends the adoption of consumer panels to ensure the views of UK households are considered on issues such as the role of robotics in social care. Furthermore, it is crucial that the Competition and Markets Authority continues to expand its role to focus on digital competition issues, particularly following Brexit, which will see the CMA dealing with cases that are currently under the remit of the European Commission. Policymakers need to ensure the 4IR ecosystem of products is a competitive and cross-compatible one, not one dominated by monopolies and cartels that lock you into a particular product eco-system – this is essential if the full benefits of 4IR are to be realised.

ENDNOTES

[1] https://www.theregister.co.uk/2017/12/04/bt_told_to_up_its_game_on_fibre_investment_by_ofcom/

[2] www.howz.com

[3] Birks et al (2016), *Robotic Seals as Therapeutic Tools in an Aged Care Facility: A Qualitative Study,* Journal of Aging Research

[4] http://www.bbc.co.uk/news/av/uk-england-dorset-43479791/robotic-dog-in-dorset-care-home-helps-elderly-residents

[5] https://www.reuters.com/article/us-toyota-robots/japan-automakers-look-to-robots-to-keep-elderly-on-the-move-idUSKBN17E0C8

[6] https://www.theguardian.com/environment/2017/aug/12/food-waste-smart-homes-fridge-cameras

[7] https://www.ncbi.nlm.nih.gov/pubmed/22869663

[8] https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017

[9] http://www.bbc.co.uk/news/uk-politics-43405684

[10] http://www.eena.org/download.asp?item_id=111

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/479202/provision-telematics-research-report.pdf

[12] https://www.racfoundation.org/research/mobility/spaced-out-perspectives-on-parking

[13] https://www.theregister.co.uk/2017/12/04/bt_told_to_up_its_game_on_fibre_investment_by_ofcom/

[14] https://futurism.com/by-2020-there-will-be-4-devices-for-every-human-on-earth/

[15] https://www.theregister.co.uk/2015/08/24/smart_fridge_security_fubar/

[16] TheCityUK, *"UK Legal Services 2016"*

[17] Age UK Evidence Review: Loneliness in Later Life

[18] https://www.london.gov.uk/press-releases/assembly/congestion-charge-needs-urgent-reform

[19] For example, SMF (2015), *"Bargaining on a Low Income"*

[21] https://www.gov.uk/government/speeches/reimagining-policy-making-for-4ir-closing-speech

[22] Ofcom (May 2018), *"UK Home Broadband Performance"*

[23] https://www.ft.com/content/349103ba-c631-11e7-b2bb-322b2cb39656

[24] http://www.cqc.org.uk/what-we-do/how-we-do-our-job/fundamental-standards

[25] https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/cmr-2017

[26] http://downloads.bbc.co.uk/aboutthebbc/insidethebbc/howwework/reports/pdf/bbc_annual_plan_2018.pdf

[27] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228844/7650.pdf

[28] https://www.ons.gov.uk/peoplepopulationandcommunity/householdcharacteristics/homeinternetandsocialmediausage/bulletins/internetaccesshouseholdsandindividuals/2017