Tech in the Town

How the Fourth Industrial Revolution could transform local government

Scott Corfe

SMF Social Market Foundation

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

FOREWORD FROM THE SPONSOR

Just as technology in our homes and workplaces is changing the way we live and do our jobs, it is also transforming the villages, towns and cities around us. Faster, more reliable mobile coverage, full fibre broadband and the Internet of Things are not only changing how we interact with our public services, but the very fundamentals of how they operate.

The Fourth Industrial Revolution is making it easier and cheaper for decision makers to deliver responsive, high quality services to residents and businesses across the UK. Whether it is CCTV that also measures congestion and pollution, street lights that automatically adapt to the weather, or bins that announce when they need emptying, avoiding unnecessary collections, new technologies are making an impact.

Vodafone is proud to be the global leader in Internet of Things technology, with over 70 million devices connected around the world. Whether it's this extensive grid of connected sensors or our 5G and full fibre networks, we see the difference that these technologies make to people's lives every day. I am delighted to support this report from the Social Market Foundation, which serves as an important intervention in the debate on how best to maximise the benefits of these technologies for all of us.

Anne Sheehan, Enterprise Director, Vodafone

EXECUTIVE SUMMARY

This report explores the role that Fourth Industrial Revolution (4IR) technologies can play in improving the UK's urban areas and local public services. It is the third in a series of SMF reports on 4IR, following our 2018 reports on the use of 4IR in the home and the workplace.

Terms:

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.

Context:

Many communities find themselves in a challenging set of circumstances in 21st century Britain. While local government finances remain under strain after years of fiscal austerity, local authorities are under significant pressure to address a wide range of issues. This includes air pollution, light pollution, congestion, waste and other local-level environmental issues.

Analysis in this report shows that:

- **Local government finances remain under pressure.** Local government has been running a fiscal deficit almost constantly for the past two decades.

- **Local transport infrastructure will struggle as the number of cars on the road is set to increase.** Across England and Wales, the proportion of roads that are heavily congested in the morning peak is set to increase from 11% in 2015 to 17% by 2050.

- **UK roads are in poor shape.** 905,000 potholes were reported on UK roads in the 2017/18 fiscal year, costing councils on average £169 each to address.

- **Local government is struggling to address environmental concerns, including the need to improve household recycling rates.** While 64.5% of household waste was recycled, reused or composted in the East Riding of Yorkshire in 2017/18, just 14.1% of waste in the London borough of Newham was.

- **Growing populations will place pressure on local community infrastructure, to a varying degree across the country.**

Benefits of 4IR in local government

The Fourth Industrial Revolution can address a number of the challenges outlined above. Benefits outlined in this report include:

- **Saving money and reducing light pollution with smart street lighting.** Smart street lighting is currently being explored as a way of reducing light pollution, generating financial savings and offering other benefits to local government.

- **A recycling revolution with smart bins.** This includes bins fitted with fill-sensors, identifying when they require emptying. Smart bins have also been developed which automatically sort recyclable and unrecyclable waste.

- **Improved road quality** via the use of road-repairing drones which can detect potholes and are fitted with 3D printers which are able to spray asphalt into potholes. In addition, telematic boxes and cameras fitted to cars can detect potholes and notify highway maintenance authorities about repair needs.

- **Autonomous public transport.** In Singapore, there are plans to introduce driverless buses on its public roads by 2022.

- **Smarter road pricing and parking charges** which encourage individuals to travel into urban areas when traffic is less congested.

- **The ability to rethink planning and urban spaces.** For example, increasing proportions of inner-city land can be devoted to housing as retail increasingly shifts from being store-based to web-based. Shared smart town/city data (for example on footfall) can help businesses decide where to locate, as well as their opening hours.

Challenges in realising these benefits

While 4IR brings with it a wide range of opportunities for local government, realising these benefits is not without its challenges. This includes:

- **Financing challenges.** 4IR has the potential to offer significant improvements and cash savings for local government, but in several instances there may be significant upfront costs and infrastructure requirements.

- **Public concerns.** For example, recent news stories have raised concerns about "spying bins and cars" with respect to smart, internet-connected technologies.

- **A shortage of digital skills in local government.** In its 2014/15 workforce survey, the Local Government Association found that over two thirds (68%) of local authorities in England had a capability or capacity gap in terms of supporting digitisation.

- **The potential for 4IR to create and exacerbate economic and social problems in local communities.** For example, the decline of high street retail could erode receipts from business rates and parking charges, and isolate the digitally excluded.

The role for policymakers

This report sets out three practical policy recommendations that we believe could encourage more widespread use of 4IR technologies across local communities in the UK – creating a wave of "smart cities" and even "smart towns":

1. **Create a local government "4IR innovation fund" to incentivise the rollout of 4IR technologies** such as smart street lighting, drones, autonomous public transport and

smart bins, and to help build an evidence base on the long-term financial benefits of such technologies.

2. **Explore the role that outcome-based contracts could play in encouraging private sector providers of outsourced services to roll out new technologies.** Under outcome-based contracts, service providers are paid according to the outcomes they deliver, rather than the means with which they reach such outcomes. In the case of waste collection, for example, service providers could be paid to ensure that bins are never overfull. Under outcomes-based contracts, waste collecting firms might be incentivised to roll out bin-fill sensors and only empty bins on an as-needed basis, as a way of saving money.

3. **Dynamic road and parking charges, and new smart bin collection charges, should either operate on a largely revenue-neutral basis, or in a way that generates clear, tangible benefits to households and businesses.** A carrot rather than a stick-based approach to dynamic pricing might be most acceptable to the public. For example, households that produce less waste or recycle more could be awarded some form of Council Tax rebate.

CHAPTER 1: INTRODUCTION

A technological epoque – the Fourth Industrial Revolution (4IR) – is dramatically changing the way we live, work and travel. The rise of automation, robotics, artificial intelligence and data analytics is opening up new possibilities for individuals and companies to realise productivity gains and improve living standards – as discussed in past Social Market Foundation (SMF) reports on 4IR in the home and the workplace[i].

But the potential benefits of 4IR extend beyond the home and work– into the streetscapes of our towns, cities and villages, and the services provided by local government. This report explores the role that 4IR can play in improving our urban areas and local public services – and the policy interventions needed to ensure these benefits manifest in reality.

At present, local government in the UK is just dipping its toes into the water in its use of 4IR technologies. While some local authorities, such as Glasgow City Council and Rugby Borough Council, are being innovative and exploring the benefits of "smart city" technologies, for the most part UK local authorities are not being bold enough in taking advantage of new internet-connected devices, robotics, artificial intelligence and data analytics.

Yet, as we discuss in this report, the benefits of utilising these technologies could be enormous. For example, the initial rollout of smart street lighting, drones, autonomous public transport and bins, in the UK and elsewhere, is already highlighting the potential for automation and internet-connectivity to both enhance public services *and* deliver substantial financial savings for local government.

The Fourth Industrial Revolution comes at a time when local government finances in the UK remain under pressure. Rolling out new technologies – such as smart streetlights and bins – will often require upfront capital investment, raising questions around where such funds will come from. Critically, as we argue in this report, government needs to take a medium-to-long term view on large investments. Evidence shows that they can pay for themselves and generate significant financial *savings* for local government after a number of years.

Other 4IR technologies, such as internet-connected heat sensors which detect ice and enable more efficient road gritting, are much cheaper, paying for themselves more rapidly through cost savings.

Ensuring that investments do indeed pay off will require policymakers to start building a more robust evidence base on the long-term financial implications of new technologies. The use of "4IR innovation funds" for local government, to encourage experimentation and help build this evidence base, could prove invaluable here. In addition, with respect to outsourced services, outcomes-based contracts can create stronger incentives for service providers to adopt new productivity-enhancing technologies.

Done right, the use of 4IR in our communities can deliver a range of benefits for local authorities – and the individuals living in them. This includes more efficient access to services, improved transportation, cleaner streets and better-designed urban environments. There is scope for these technologies, provided they are rolled out across the UK, to help narrow some of the stark economic divides which dog the country.

As recent news stories have highlighted, 4IR will only succeed if it has widespread public support. This means emphasising the benefits of these technologies to households and addressing concerns about the risks – such as intrusive monitoring and increased costs for services such as car parking.

The structure of the report is as follows:

- **Chapter 2** examines some of the challenges facing local government in 21st century Britain.
- **Chapter 3** explores the applications of 4IR technologies in addressing these challenges and delivering other benefits.
- **Chapter 4** examines the challenges associated with realising the benefits of 4IR in local communities.
- **Chapter 5** explores the role for policymakers in maximising the benefits of 4IR in local government.

What do we mean by 4IR?

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:

- The First Industrial Revolution saw water and steam used to power and mechanize production.
- The Second used electric power to create mass production.
- The Third used electronics and information technology to automate production.
- 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.

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** –appliances and devices 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.
- **Connected and autonomous vehicles** such as "driverless cars".

CHAPTER 2: SETTING THE SCENE – THE CHALLENGES FACING LOCAL GOVERNMENT IN THE 21ST CENTURY

Many communities find themselves in a challenging set of circumstances in 21st century Britain. While local government finances remain under strain after years of fiscal austerity, local authorities are under significant pressure to address a wide range of issues. This includes increased demand for social care as the population ages, rising crime in some parts of the country, air pollution and other local-level environmental issues. Transport infrastructure is under pressure, with news stories aplenty about poor public transport, congested roads and "pothole Britain".

There are also questions around how different communities will fare, economically, over the coming decades. There is a risk that while automation, AI and the "data revolution" could kick-start productivity growth in some parts of the country, it could lead to job losses elsewhere and widen the already stark variations in economic performance across the UK. This has implications for local government itself, both in terms of the demand for the services it provides, as well as the tax receipts that it receives. As industries such as retail change dramatically through the rise of the internet, areas which fail to adapt to change risk seeing business rate receipts dry up as traditional high street stores fade away.

As the table below shows, local government is responsible for a wide range of services, many of which are likely to see significant changes and demand pressures over the coming years.

Table 1 Responsibilities of local government

County councils/Unitary authorities	District, borough, unitary and city councils	Parish, community and town councils
Education	Rubbish collection	Allotments
Transport	Recycling	Public clocks
Planning	Council Tax collections	Bus shelters
Fire and public safety	Housing	Community centres
Social care	Planning applications	Play areas and play equipment
Libraries		Grants to help local organisations
Waste management		Consultation on neighbourhood planning
Trading standards		Issuing fixed penalty fines for things such as litter, graffiti, fly tipping and dog offences

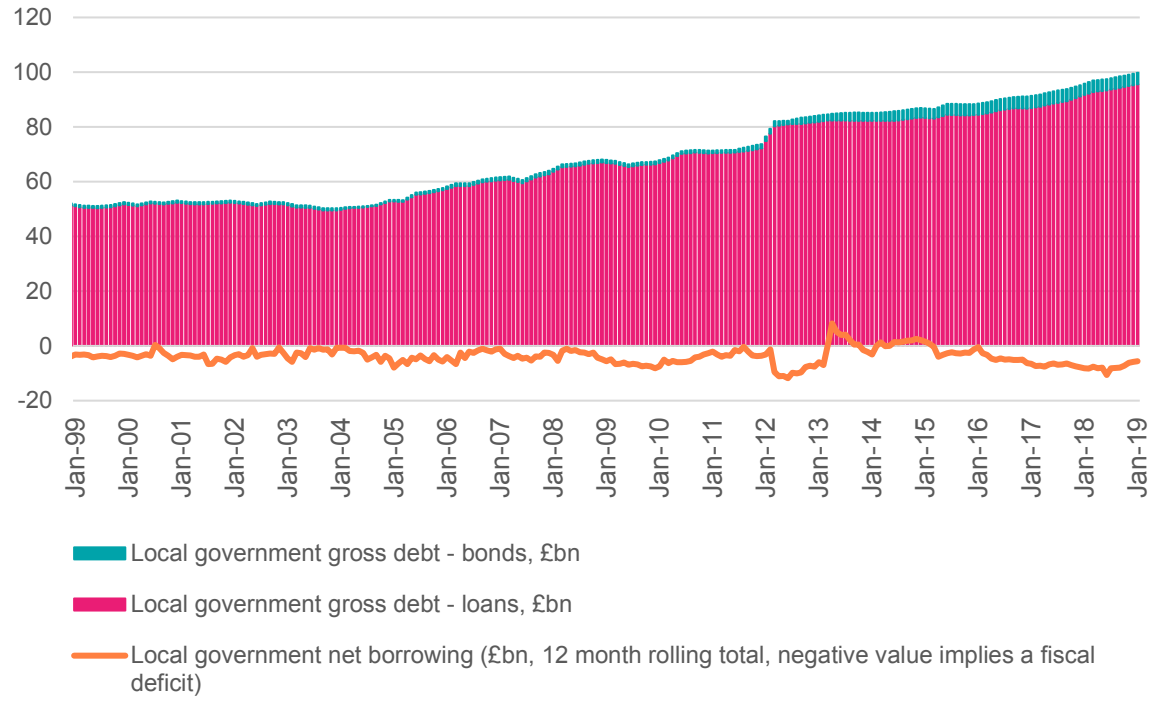
This chapter of the report provides an overview of the challenges and issues that local government is likely to face over the coming years and decades in meeting these responsibilities. In particular, we focus on local government services that have a direct bearing on our local environments – our houses, roads and centres of commerce.

Local government finances under significant pressure

The financial situation in which local communities will need to address substantial economic, environmental and social challenges over the coming decades is difficult. Local government remains in the midst of a significant funding crisis. Over the 12 months to January 2019, net local government borrowing – the extent to which UK local government spending exceeded revenues – stood at £5.6bn. As Figure 1 shows, local government has been running a fiscal deficit almost constantly for the past two decades. Consequently, local government debt levels have been rising, and are set to soon pass the £100bn mark, mostly consisting of loan debt.

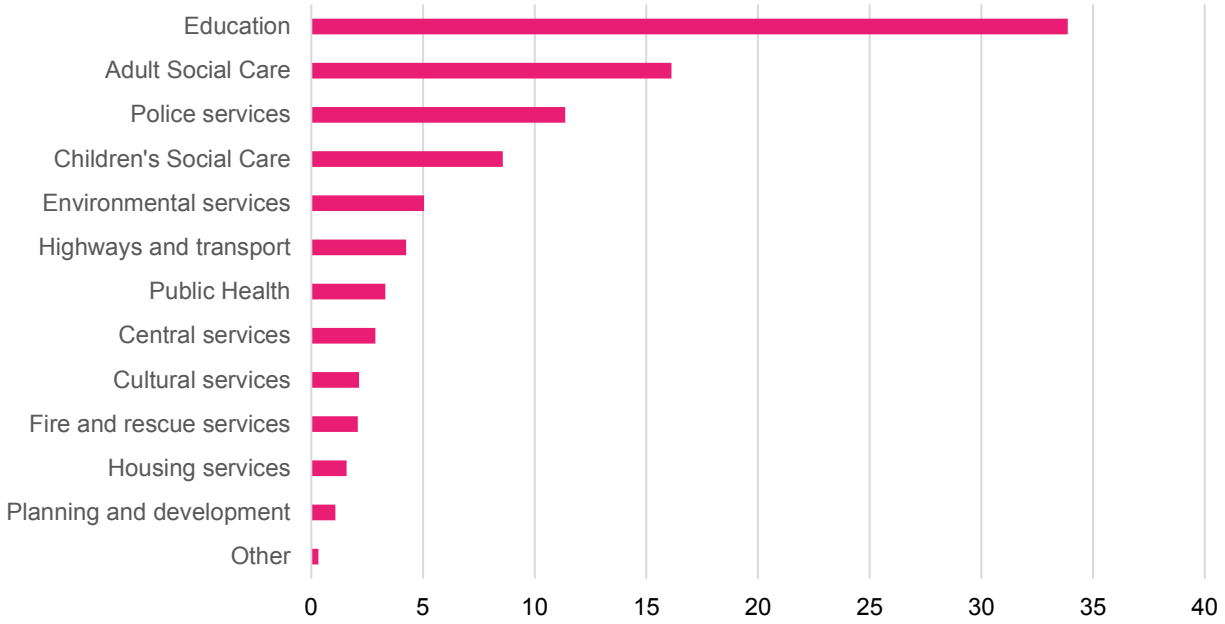
At the same time, many local government services are under pressure. A growing and ageing population, deteriorating roads, and the need to address environmental concerns mean that financial pressures on many services are increasing – not decreasing. Pressures to spend more money on social care, amid an ageing population, mean money for environmental services and transport infrastructure could become increasingly squeezed.

Figure 1 Local government borrowing and debt



Source: ONS, SMF analysis

Figure 2 Estimated net current local authority expenditure, by service, England, 2018-19, £bns



Source: Ministry of Housing, Communities & Local Government

Gridlock Britain - pressures on local transport networks

Travelling – for work, leisure and other purposes – is a key part of our day-to-day lives. Road congestion, high travel costs, delays and overcrowding on public transport can all have a significant negative impact on our wellbeing. Research by the Office for National Statistics shows that those with lengthy commutes tend to have lower levels of happiness and higher anxiety than non-commuters[ii].

Yet, official forecasts suggest commutes across the UK are set to become more stressful. Increasing numbers of cars on the road over the coming years mean that a growing proportion of the road network will be heavily congested, leading to declining average speeds. Across England and Wales, the proportion of roads that are heavily congested (flowing at 80% or more of capacity) in the morning peak is set to increase from 11% in 2015 to 17% by 2050. In Greater London, this proportion is set to rise from 28% to 37%.

Figure 3 Percentage of traffic in heavily congested conditions (flowing at 80% or more of capacity), weekday morning peak

Department for Transport Road Traffic Forecasts, central scenario

Figure 4 Average car speed in England and Wales, weekday AM peak, miles per hour

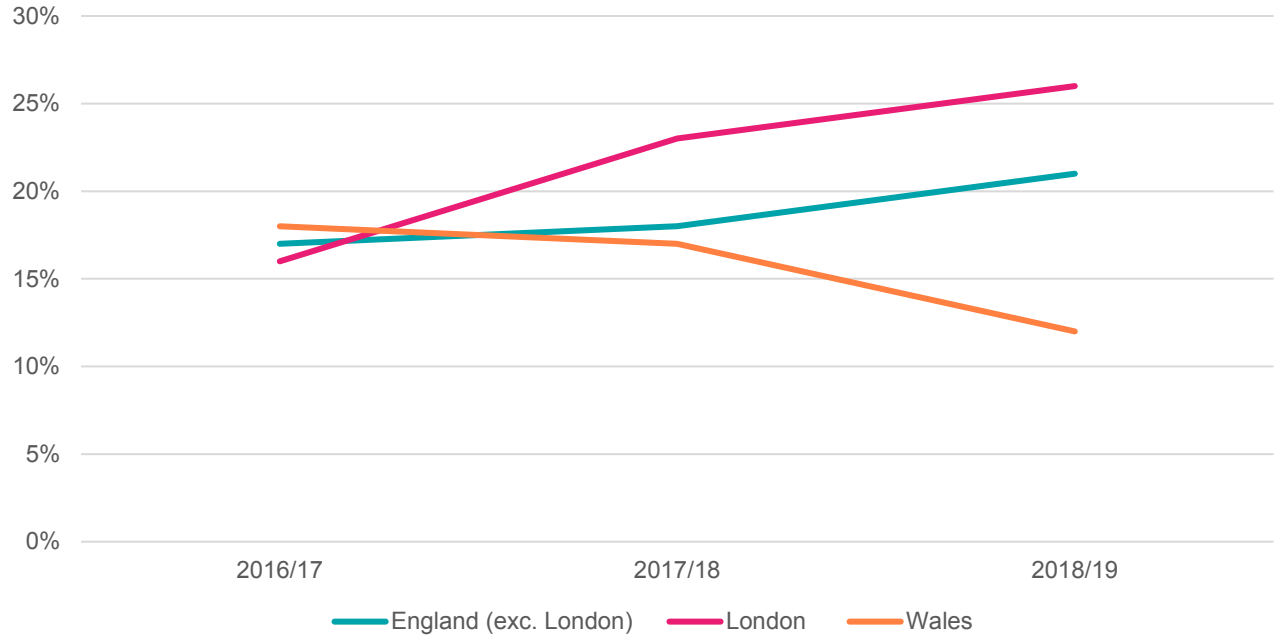
Source: Department for Transport Road Traffic Forecasts, central scenario

Ensuring road infrastructure keeps up with demand will be a key challenge for local government.

As well as building new stretches of road where relevant, the quality of the existing road network will need to be maintained. Already, councils are struggling to do so; a freedom of information request submitted by the price comparison website Confused.com revealed that 905,000 potholes were reported on UK roads in the 2017/18 fiscal year, costing councils on average £169 each to address[iii]. According to the Annual Local Authority Road Maintenance (ALARM) Survey produced by the Asphalt Industry Alliance, a growing proportion of roads in England are in such bad condition that they have less than 5 years' life remaining. In London, over a quarter (26%) of roads are in such a poor state of repair[iv].

The ALARM survey also estimates that, at present, the shortfall in funding provided for carriageway repairs, compared with what is needed, stands at over £650m.

Figure 5 Percentage of roads with less than five years' life remaining



Source: Annual Local Authority Road Maintenance Survey produced by the Asphalt Industry Alliance

Car parking – or rather the lack of it – is also set to become a growing issue for local authorities over the coming years. As well as ensuring an economically and socially optimal number of parking spaces, local authorities will increasingly need to think about the pricing mechanism for parking. As a report by the RAC Foundation noted, there is currently a considerable divergence between current parking charges and "efficient" market-based prices based on the underlying supply and demand for parking[v]. This leads to situations where demand for car parks is either too high (leading to cars circling urban areas in search of spaces) or too low (meaning local authorities are losing out on parking revenue).

Addressing the growing problem of congestion on UK roads will require local (and indeed national) government to do more to encourage alternative modes of travel beyond private cars.

This includes increased use of car sharing clubs, encouraging walking and cycling, and improving the public transport infrastructure in local communities. For many councils across the UK, this will require a dramatic step-change from where they are now in terms of public transport provision – as well as some honest conversations with the public about the unsustainability of our current dependence on private transport.

The need to create greener communities

Increasingly, there is an expectation for local government to address some of the substantial environment issues facing the UK, and indeed the world.

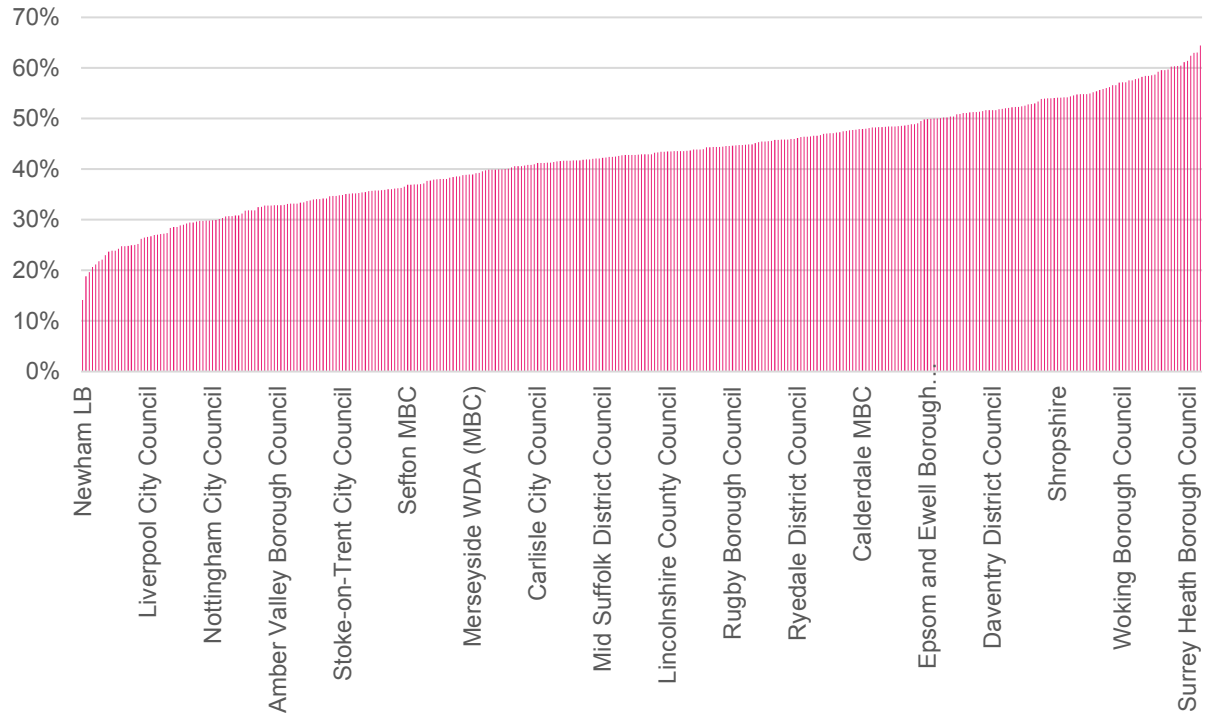
In addition to global warming and climate change, recent years have seen increased concern about air pollution. A recent study published in the European Heart Journal found that emissions are responsible for 64,000 annual deaths in the UK, just 18% less than the 78,000 deaths caused by tobacco[vi].

Beyond air pollution, there are also concerns about the environmental and health impacts of light and sound pollution. While not as widely discussed as air pollution, light pollution has a range of environmental impacts, including disrupting the sleeping behaviour and safety of animals such as birds and bats[vii]. There is also evidence that light pollution has a negative impact on quality of sleep among humans – for example by making individuals fall asleep later and then struggle to wake up in time for work, school and social engagements[viii].

As we discuss in the next chapter of this report, technology is providing new opportunities to monitor and limit air, light and noise pollution going forward, through the use of smart, internet-connected monitoring devices.

Finally, local authorities are under growing pressure to reduce waste and improve rates of recycling. At present there are substantial variations in the amount of waste generated that is recycled across the UK; while 64.5% of household waste was recycled, reused or composted in the East Riding of Yorkshire Council in 2017/18, just 14.1% of waste in the London borough of Newham was. For the UK to match EU ambitions to increase household recycling rates to 50% in 2020, 55% in 2025 and 60% in 2030[ix], such substantial differences in regional recycling rates will need to be reduced.

Figure 6 % of household waste that is recycled, reused or composted, by local authority in England



Source: SMF analysis of Defra waste data

Table 2 Top 10 and bottom 10 local authorities in England, by recycling rate

Top 10 local authorities, by household recycling rate		Bottom 10 local authorities, by household recycling rate	
Local authority	Recycling rate	Local authority	Recycling rate
East Riding of Yorkshire Council	64.5%	Newham	14.1%
Rochford District Council	63.0%	Westminster City Council	18.8%
South Oxfordshire District Council	63.0%	Barrow-in-Furness Borough Council	19.6%
Three Rivers District Council	62.4%	Birmingham City Council	20.7%
Surrey Heath Borough Council	61.4%	Council of the Isles of Scilly	21.2%
Stroud District Council	61.2%	Lewisham	21.8%
South Northamptonshire District Council	60.5%	Wandsworth	22.1%
Vale of White Horse District Council	60.4%	Gosport Borough Council	23.0%
Derbyshire Dales District Council	60.3%	Hammersmith and Fulham	23.7%
Stratford-on-Avon District Council	60.3%	Slough Borough Council	23.9%

Source: SMF analysis of Defra waste data

Growing populations - with associated pressure on public services

The population of the UK is growing. Critically, population growth will not be even across age groups or local authorities – leading to widespread variations in demographic trends over the coming years.

While Tower Hamlets is expected to see its population increase by about a quarter (24%) between 2019 and 2039 (the highest of any local authority in England), the population of Barrow-in-Furness is expected to decline by 9% (the biggest decline of any local authority in England).

Where populations are growing more strongly, local authorities will have to contend with increased pressure on local community infrastructure, such as road and public transport networks. As the government has noted in its Future of Mobility Urban Strategy, increased demand for road travel over the coming years will largely be due to population growth rather than people travelling more miles on average. Indeed the strategy notes that people are travelling less per person now than one or two decades ago[x].

Table 3 Top 10 and bottom 10 local authorities in England, by population growth between 2019 and 2039

Top 10 local authorities, by population growth		Bottom 10 local authorities, by population growth	
Local authority	Expected population growth	Local authority	Expected population growth
Tower Hamlets	23.9%	Barrow-in-Furness	-8.8%
Corby	23.1%	Copeland	-8.3%
Coventry	22.8%	Richmondshire	-4.4%
Havering	21.7%	Isles of Scilly	-4.2%
Barking and Dagenham	21.3%	Hyndburn	-3.1%
Dartford	20.6%	North East Lincolnshire	-1.8%
Aylesbury Vale	20.0%	Blackpool	-1.7%
Hackney	19.3%	South Lakeland	-1.6%
Central Bedfordshire	19.0%	Blackburn with Darwen	-1.6%
Greenwich	18.8%	Tamworth	-1.5%

Source: ONS principle population projections, SMF analysis

CHAPTER 2: HOW CAN 4IR HELP?

The Fourth Industrial Revolution can address a number of the challenges outlined in the previous chapter of the report – as we discuss here. From smart bins to pothole-detecting drones, new technologies can help tackle some of the greatest challenges facing local communities across the UK. Further, as we discuss, these technologies can help address some of the financial constraints facing local government at present – offering potential efficiency gains and cost savings.

Greener and cleaner streets –smart bins and street lighting

Tackling climate change, air and light pollution, and increasing the rates at which households recycle waste, are likely to be key issues for local government in the future. The emergence of new monitoring tools, robotics and automation all offer possibilities to address these challenging issues. Below we discuss several examples of how 4IR can meet the environmental goals of local government.

Environmental monitoring

Smart sensors are likely to be increasingly rolled out in local communities as a way of monitoring the environment and intervening where appropriate. Connected sensors can be used to monitor a wide range of environmental issues, including water quality, air quality, solid waste levels, noise pollution, energy usage and light pollution. Critically, these issues can be monitored both remotely and in real-time, allowing rapid responses where appropriate. Two examples of this are the use of smart street lighting and smart bins – both of which are generating environmental and financial benefits in the communities in which they are being rolled out.

Smart street lighting

Smart street lighting is currently being explored as a way of reducing light pollution, generating financial savings and offering other benefits to local government. By being able to detect the presence of people and vehicles nearby, smart street lighting can activate itself only when it is needed – it can switch off or lighting levels can be dimmed accordingly when people or vehicles are not present.

The experience of smart street lighting in Oslo shows that this technology can pay for itself over a relatively short space of time, through electricity savings. Norway's capital saw smart street lighting pay for itself in less than three years[xi].

As well as reduced electricity costs, smart street lighting in Oslo delivered further financial savings through its ability to share data more effectively with local government. Smart, connected street lighting in Norway's capital is able to transmit maintenance data, such as bulb replacement information, to better enable city officials to provide systemwide maintenance and servicing. Previously, city officials had to drive to the specific light location in order to see if a light was on. This has vastly improved the maintenance capabilities of the city because it learns about outages and burnouts much quicker, in real time. It has also led to a reduction in maintenance costs, by enabling local government to focus maintenance efforts where they are needed the most – for example in areas where several streetlights have stopped functioning.

Oslo's smart street lighting uses a dimming feature to save electricity by changing the lighting levels depending on time of day and the amount of natural light. It can also increase or decrease light levels in certain areas based on a particular need, such as responding to a road accident or large-scale activity. The previous lighting system in Oslo operated on a purely on-or-off basis, resulting in significant energy waste as lights were turned on at full power during dawn and dusk periods, when lower levels of lighting were sufficient to meet the city's safety and security needs.

Beyond being able to better control lighting and maintenance, smart, connected streetlights could bring a range of other benefits to local communities. This includes:

- **Increased revenue opportunities for local government** with add-ons such as digital signage/advertising and wi-fi hotspots[xii].
- **Providing analytics for other uses.** Cameras, water sensors and sound detectors can provide local authorities with additional information about the weather, traffic flows and even crimes (such as fly-tipping) and parking violations.
- **Environmental monitoring** such as examining levels of air pollution.
- **More timely and efficient gritting of roads,** through the installation of cost-effective temperature sensors onto streetlights. Such sensors have been developed by meteorologists at the university of Birmingham and Amey plc, an Oxford-based engineering consultancy. Each of the hand-sized sensors costs only around £200, compared with the £10,000 or so needed to maintain a weather forecasting station like those currently relied on by local authorities to help them make decisions on when and where to grit. The sensors were successfully trialled in Birmingham, London and elsewhere in the UK[xiii].

In the UK, Glasgow City Council has also reported successful outcomes through the deployment of smart street lighting, as described in the case study box below.

Case study: smart street lighting in Glasgow

In 2013, Glasgow City Council won a Future City Demonstrator competition run by the UK government's Technology Strategy Board. The city received £24m to showcase a number of smart city projects that aimed to improve the local economy, increase quality of life and reduce the impact on the environment. This included funding to support a smart street lighting trial.

The Intelligent Street Lighting Project demonstrated how the city can use smart streetlights to improve lighting quality, reduce energy usage, improve public safety and make maintenance more efficient.

The lights were initially deployed in three locations. One was Riverside Walkway, where a dynamic lighting system was integrated with movement sensors that reacted to the presence of citizens. Lights would be set to 20% brightness, but this increased to 100% when movement was detected.

The trial of smart streetlighting was successful in demonstrating efficiency savings and other benefits. Subsequently, Glasgow City Council progressed a project to retrofit approximately 3,500 columns across the city centre's street lighting network with more efficient, controllable LED lighting. The smart street lighting also helped form a wifi network across the city centre[xiv].

A recycling revolution

As we discussed in the previous chapter of the report, there are currently substantial variations in recycling rates across the UK. Addressing this needs to form a key part of improving the environment in the future.

Already, emerging evidence suggests that 4IR has the potential to revolutionise waste collection in the UK through the use of smart, connected bins.

The use of bin-fill sensors can alert local authorities to when and where bins need to be emptied, helping to save time and money spent collecting waste. Indeed, evidence suggests the efficiency savings are potentially enormous. Rugby Borough Council, for example, replaced 56 traditional bins, each of which had traditionally received between two and three collections per day, with 23 "BigBelly" stations fitted with bin-fill sensors. In only 12 months it reduced manual waste collections from 51,100 per year to just 1,509 per year – a saving of 49,591 collectionsxv.

Figure 7: A "BigBelly" smart bin

Going forward, the use of internet-connected bin-fill sensors in *household* bins could generate savings for local government through reduced collections, as well as providing new financial incentives for homes to recycle more. For example, rather than funding household waste collection through Council Tax, bin-fill sensors could help pave the way for households paying on a *per-collection* basis. Households would be incentivised to produce less waste and recycle/reuse more frequently. Having said that, while such a charging model could bring environmental and efficiency benefits, public opposition could be sizeable. Even without new charging regimes or internet connectivity, concern has been expressed in recent years about the use of "spying" microchips in some local authority bins for the purpose of data collection[xvi].

Furthermore, savings might not be achievable in all instances. Economies of scale mean that, particularly in urban areas, it might make more sense to retain the current system of collecting bins regularly on a house-by-house basis. Savings might be more obvious in more rural areas, where distances between houses are greater.

Finally, the smart bins of the future are set to be increasingly able to *sort* waste as well as detect when bins are full – driving up recycling rates significantly. A bin, designed by start-up company Bin.E, recognizes different type of waste via a system positioned inside the bin which uses sensors, image recognition and artificial intelligence. Once waste is placed inside, the camera and sensors identify its type and place it in one of the smaller bins. Then it compresses the waste so it occupies less space[xvii].

Goodbye to gridlock – the impact of 4IR on cars and roads

Transport – both private and public – is set to transform over the coming decades. The rise of electric, autonomous vehicles provides opportunities to both reduce air pollution and congestion. Further, autonomous vehicles, "smart cities" and data analytics can improve experiences on public transport – encouraging more individuals to leave their cars at home.

Encouraging greener, more efficient use of cars

4IR will change the way individuals travel to and from where they live, with the rise of car clubs, telematics and autonomous vehicles.

The car industry is already evolving from one providing goods (vehicles) to households to one providing services. 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. Zipcar recently announced that more than 250,000 UK residents have now signed up to use its service, with one third of members having joined since January 2018[xviii].

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 as 4IR gains momentum, 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[xix] and there have been calls for this to be brought forward to an earlier date[xx]. A shift towards electric vehicles will help tackle the challenge of air pollution described in the previous chapter. In London, for example, road transport currently accounts for about half of all nitrous oxide and particulate matter emissions[xxi].

Autonomous vehicles could significantly increase the efficiency with which cars are used. 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[xxii]. 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 cut congestion by reducing the number of cars on the road. 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. Reduced levels of on-street parking could also contribute to reduced congestion and improved traffic flows in some areas.

New charging models for roads

As we discussed in our report on 4IR in the home, 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 usage. At present fuel duty revenues account for 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 local road networks. 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 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. The London Congestion Charge demonstrates the reductions in congestion that can be achieved through even a relatively basic form of road pricing; the number of private cars entering Central London's congestion charging zone has fallen by about two fifths since 2002[xxiii] (the Congestion Charge was introduced in 2003).

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" telematics 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.

As we discussed in our report on the benefits of 4IR for households[xxiv], telematics also offers the potential for cheaper vehicle insurance for motorists that drive in a safe manner, by collecting accurate information on driving patterns. In Italy, 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. Further, in Italy, provision of telematics insurance is required by law to be cheaper than non-telematics insurance[xxv], to encourage uptake.

Finding a parking space - at a fair price

In addition to dynamic road pricing, there is scope for local government to phase in increasingly smart forms of car parking charges, as well as technologies which make it easier for motorists to find vacant parking spaces in urban areas. The political challenges around road pricing – which we discuss in the next chapter of this report – mean that "smart parking" might be more viable than smart road pricing – at least in the short-term.

As mentioned in the previous chapter of the report, current car parking charges are often inefficient – leaving car parks either under or overutilized depending on the time of day. By monitoring levels of occupancy (and thus demand), "smart car parks" could vary parking charges accordingly to encourage a more even distribution of usage throughout the day.

By collecting data on occupancy, smart car parks, in conjunction with connected automobiles, can help ensure that motorists are guided towards car parks where spaces are available – helping to reduce congestion in urban areas causes by motorists searching in vain for parking spaces. In Barcelona, space-vacancy sensors in multistorey car parks have been a big success, helping drivers find spaces and increasing the city's parking revenues[xxvi].

In the future, the concept of smart car parks in towns and cities could go a step further – allowing individuals to increasingly reserve a space online (for example using their smartphone). At present, parking reservation facilities are very limited across the UK.

Smart signage

Increasingly, we are likely to see digital, smart signage on the road network, which utilises data on traffic flows, road incidents, weather and other factors to divert traffic and change speed limits. This can help reduce congestion and increase safety on the road network.

Already, smart motorways are being rolled out in the UK, and there is scope for similar smart signage to become an increasing feature of our urban areas.

Figure 8: Smart motorway signage

Improving road quality

As well as reducing congestion on the roads, there is scope for 4IR to improve the physical *quality* of the road network – with new tools for detecting and fixing the potholes which blight so much of the road network.

One way of dealing with potholes might be through the use of drones. Academics at the University of Leeds have developed a drone which not only spots cracks and potholes in roads, but is also able to address these. The drone has a built-in 3D printer which is able to spray asphalt into cracks and potholes. Leeds City Council is working closely with the university, looking to pioneer the use of drones in a concept described as "self-repairing cities"[xxvii].

Figure 9: Road-repairing drone developed by academics at the University of Leeds

Other technologies are also being explored as a means of identifying potholes and other road defects – including using data gathered from devices fitted to cars and other vehicles (known as "car as a sensor"). The latest Ford Focus has optional pothole-detecting technology that can smooth out a car's ride over broken roads[xxviii]. It uses 12 high-resolution sensors that can "see" potholes before the car drives over them. Once a pothole is identified, dampers are automatically adjusted to their hardest setting, so the wheels that run over the hole do not fall so deep into it – improving the ride and reducing the chances of damage.

Going forward, we expect such technologies to not only be utilised to improve ride quality and reduce damage to cars, but to share data on potholes and other road maintenance issues with government. This will facilitate much more rapid detection and repair of potholes than is feasible at present. It will also facilitate earlier detection of road defects, when repair costs are likely to be lower and involve less disruption to traffic flow.

A new software system developed by researchers at the University of Waterloo in Canada automatically analyses photographs taken by vehicle-mounted cameras to flag potholes, cracks and defects. The intention of the software is to ensure that governments have the information that they need to better plan when to repair a particular road and to do it at a lower cost[xxix] (for example by addressing faults early, when repair costs are lower). In addition to refining their road assessment technology, the researchers are exploring the use of the AI software on images

recorded by drones of bridges, buildings and other infrastructure – to detect other aspects of the urban environment in need of repair.

If vehicles are able to share data with local authorities on the presence of ice on the road, via temperature sensors, this can lead to more timely and efficient gritting of roads.

Increasing the attractiveness of public transport

Tackling the congestion issues of the 21st Century will require, at least in some parts of the country, a radical departure from our heavy reliance on private transportation – especially cars. Encouraging more widespread use of buses, trains, trams and other forms of public transport could go a long way towards reducing congestion.

To do this, public transport needs to become a much more appealing and cost-effective proposition from where it currently stands – and here 4IR technologies create some opportunities.

One way 4IR can improve public transport is through the rollout of "smart city" and "smart town" monitoring devices, such as internet-connected traffic lights. In Barcelona smart traffic lights are being used to ensure buses encounter as many green lights as possible when travelling – improving the quality of the public transport service. In addition, the use of smart traffic lights has allowed Barcelona to provide "green light routes" for emergency services responding to incidences, allowing them to provide assistance more rapidly[xxx].

Autonomous public transport, which does not require a driver, could also improve the reliability of the public transport network - for example by minimising downtime due to staff shortages or industrial action. Indeed, this is already a reality; the Docklands Light Railway in London operates driverless trains.

In Singapore, there are plans to introduce driverless buses on its public roads by 2022[xxxi]. Nanyang Technological University in the country already uses driverless shuttles at its campus.

Figure 10: Driverless shuttle bus at Nanyang Technological University in Singapore

Creating towns and cities fit for the future

The changing nature of the economy and increased uptake of new technologies are set to reshape our towns, villages and cities. Done right, local communities can unlock substantial benefits from these changes. Those that struggle to adapt to change, however, risk being left behind - widening existing economic divides.

One of the most controversial and debated changes has been the rise of online retail, and the subsequent "decline of the High Street" as households are increasingly won over by the convenience of buying goods and services from the comfort of their own home. It is now possible, with companies such as Amazon, to buy goods online and have them delivered on the same day. The company is also exploring the use of drones to deliver goods to consumers even more rapidly. Amazon Prime Air is a future delivery system designed to safely get packages to customers in 30 minutes or less using drones[xxxii].

A key debate for local government, and high street businesses serving communities, is how best to respond to changing consumer spending patterns. While one response is to try to preserve society in aspic – for example by pressuring households to buy from local stores – this is likely to prove ineffective unless stores can truly compete with the increasing efficiency of web-based businesses. Indeed, the challenge of competing is becoming greater as web-based firms increasingly take advantage of 4IR technologies such as big data analytics to hone their product offers, advertising and pricing strategies.

Rather than pushing against change and trying to preserve the traditional high street, arguably local planners need to radically rethink the structure of our urban spaces, seeing opportunities in the great economic changes taking place. Rather than seeing the decline of store-based retail as a negative which needs to be stopped, for example, planners could instead see this as an opportunity to address housing shortages in urban areas. Increasingly, land in urban centres could be made available for housing as retail migrates online – if planners allow it.

As a recent report from the House of Commons Housing, Communities and Local Government Committee noted[xxxiii], with online shopping set to grow in the future, high street retail needs to carve out a separate role, focusing on providing "experience" and "convenience". This might mean increasing the number of "click and collect" facilities in stores, where individuals order goods online and then collect them in a shop. The high street stores that remain might increasingly be "concept stores" or "showrooms", where individuals go to try out goods, rather than buying them in the store. Overall, though, the rise of online retail means the need for high street stores is set to diminish, requiring a rethink of urban design.

More broadly, town and city planners in the UK need to become a lot more forward-thinking. Beyond re-imagining the high street, there is a growing need to ensure that our roads, houses and commercial spaces are "future proof". This means ensuring that roads are autonomous vehicle-friendly. It also means ensuring that the houses being built today are able to take full advantage of the Fourth Industrial Revolution – for example, with better access to car sharing facilities, electric vehicle charging points and drop-off points for online deliveries, which allow goods to be safely deposited when an individual is not at home to collect orders.

To bolster economic growth in communities, local government needs to consider the role that 4IR can play in making areas attractive places for high valued-added, fast growing sectors of the

economy. High speed broadband and mobile connectivity are increasingly important to businesses. Local government needs to consider the steps that can be taken to improve broadband access and speeds, as well as start thinking about the role it can play in the roll-out of 5G mobile connectivity across the UK.

In addition, local authorities need to explore the role that data sharing – facilitated through connected devices – can play in bolstering the attractiveness of areas as places to do business. Sharing data on pedestrian and traffic flows with businesses, for example, can help them make better decisions – such as around appropriate opening hours and delivery routes. In its recent report, the Housing, Communities and Local Government Committee noted that many high street shops are open at hours that are not convenient for much of the population. Data sharing on pedestrian flows could help shops open at times when they are more likely to receive custom – for example, more shops might choose to remain open into the evening if owners are aware of the number of potential customers based on footfall figures.

In addition, smart town and city data can create new opportunities for businesses, such as through the development of phone apps providing individuals with travel advice (for example, on optimal journey routes and likely delays). A report from Transport for London (TfL) and Deloitte found that open transport data in London is creating commercial opportunities for third-party developers. Over 80 TfL data feeds are available for developers through the free unified application programming interface (API). These are accessed by over 13,000 developers and more than 600 apps are powered specifically using TfL's open data feeds[xxxiv]. A wide range of companies now use TfL's open data commercially to help generate revenue, many of whom are based in London.

CHAPTER 3: CHALLENGES IN REALISING THE BENEFITS OF 4IR

While 4IR brings with it a wide range of opportunities for local government, realising these benefits is not without its challenges. This includes the upfront costs of rolling out new technologies, the need to build an evidence basis on their benefits and public concerns. In addition, the implications of 4IR for the wider economy are likely to have an impact on local government – for example by affecting tax receipts such as business rates.

Financing the 4IR revolution and building an evidence base

4IR has the potential to offer significant improvements and cash savings for local government, but in some instances there may be large upfront costs and infrastructure requirements – for example in the rollout of smart street lighting, drones and autonomous public transport. In other instances, for example with the rollout of internet-connected temperature sensors, benefits can be achieved with much lower upfront costs.

Given the costs of some aspects of 4IR, and the funding challenges currently facing local government, it will be crucial that local authorities take a long-term view on 4IR technologies where upfront investment needs are relatively high. Rather than seeing such technologies as gimmicks, local government needs to appreciate the potential for providing vastly improved and more cost-effective services in the long-run.

Local government will also need to become much more willing to take risks and experiment with new technologies, if 4IR is to take off in the UK's towns, cities and villages. As we discussed in the previous chapter, there are clearly success stories around the use of technologies such as smart street lighting and bins, but inevitably not all forays into new technologies will be as successful.

Excessive risk aversion and "fear of failure" could lead to inertia in rolling out new technology within local government, particularly given the precarious state of finances at present. Fears of failure can be overcome by building an evidence base on the successes of 4IR within UK local authorities – highlighting the benefits realised by others (such as Rugby Borough Council's use of smart bins). At present, such an evidence base is very limited. As we discuss in the next chapter, there is scope for central government to provide stronger incentives for local authorities to start experimenting and innovating in their use of 4IR and to help establish an evidence base to encourage others to adopt the most successful technologies.

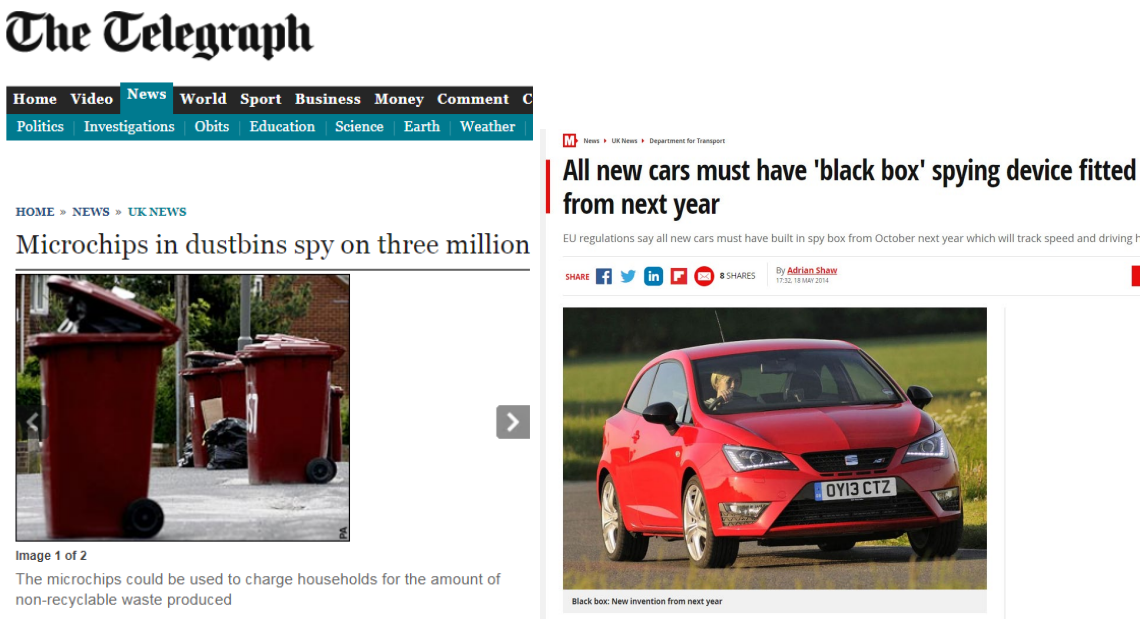
Public concerns

One major barrier to the rollout of 4IR in local communities is potential public opposition. For example, recent news stories have raised concerns about "spying bins and cars" with respect to smart, internet-connected technologies. Rather than focusing on the benefits of bin-fill sensors and data-gathering black boxes in cars, media coverage has often honed in on the negatives – with a likely bearing on public opinion.

Similarly, while the long-term need for smarter road pricing and parking charges is widely recognised by economists and transport experts, public opposition could be immense. Increased use of road tolls was much discussed by the New Labour government in the 1990s and early 2000s, yet implementation was curtailed by public concerns. In 2007, 1.8 million people signed an online petition opposed to toll roads on the Downing Street website. A BBC-commissioned survey in that year showed 74% of respondents opposed to road pricing, where motorists would be charged by the mile during busy periods[xxxv].

4IR could pave the way for new, more efficient charging models – for bins, roads, public transport and much more. But it is crucial that the public sees benefits in a shift towards these pricing structures. If they are seen as a "stealth tax", public opposition could limit the ability to roll out new technologies. The UK's past experiences in proposing and implementing road pricing highlight these risks all too well.

Figure 11: Unflattering media coverage of 4IR technologies



Has local government got what it takes? The digital skills gap

The rollout of data analytics, artificial intelligence, robotics and automation in local government will require greatly enhanced digital capabilities. This means bringing in new expertise with the capability of implementing and managing 4IR technologies – such as smart transport networks.

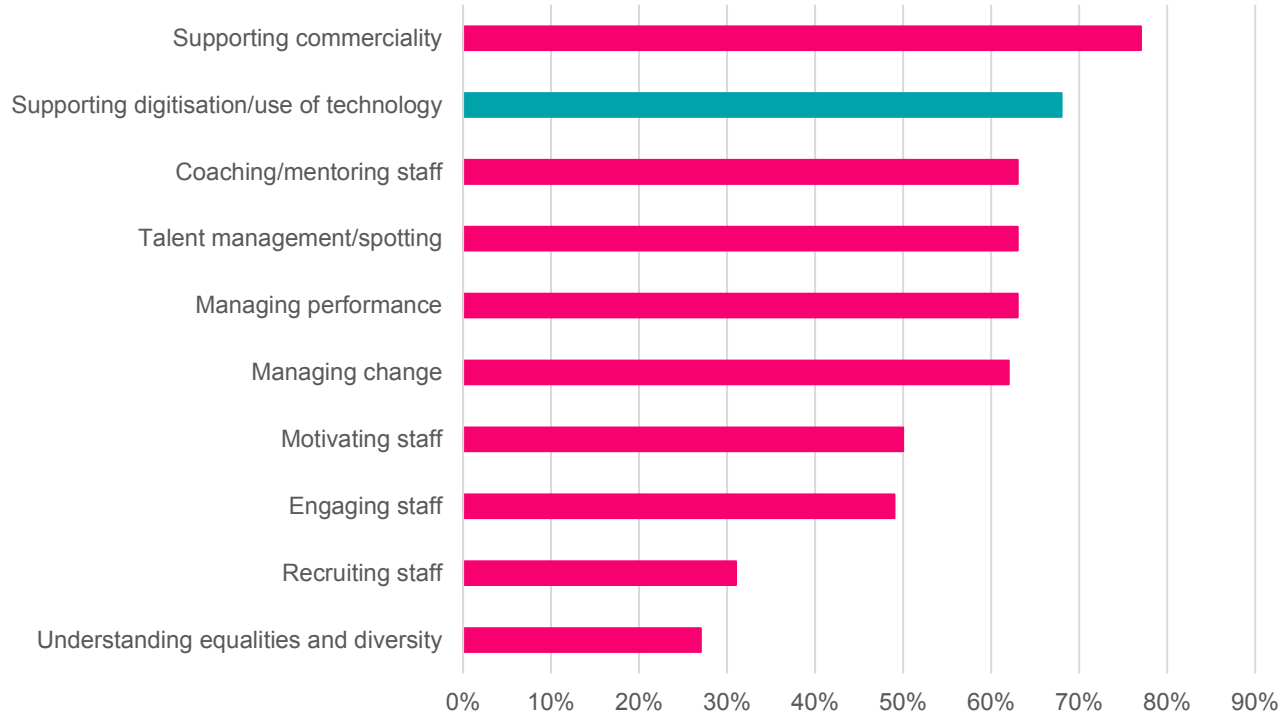
However, as things stand, many local authorities are likely to lack the skillsets needed to implement such technological solutions. In its 2014/15 workforce survey, the Local Government Association found that over two thirds (68%) of local authorities in England had a capability or capacity gap in terms of supporting digitisation and the use of technology[xxxvi]. This was the second greatest capability gap, after supporting commerciality. Commercial nous is also an important skill if local government is to take full advantage of the benefits of 4IR; it requires an

understanding of the ability of these technologies to create new revenue streams for government (for example from including digital advertising signage on smart street lighting).

Further, according to the Local Government Association survey, only two fifths of local authorities thought that supporting digitisation and use of technology was a skills priority for them. Not only are digital skills gaps present, but the desire to address these is lacklustre.

Silo working across government departments can also hinder the rollout of 4IR technologies, given that this can constrain data sharing and lead to local authorities failing to see how technologies such as smart street lighting can benefit a range of aspects of local government – such as community safety, financial savings and the environment.

Figure 12: % of local authorities in England reporting capability/capacity gaps, by skill area



Source: Local Government Association workforce survey 2014/15

Will 4IR make some things worse?

Finally, while 4IR brings with it a number of significant benefits to local government, it can also lead to more challenging circumstances – at least for some authorities.

As discussed, technological revolution is likely to bring about stark changes in the nature of our urban areas. The shift away from store-based businesses to online firms has implications for numerous local authority revenues, including those derived from parking charges and devolved business rates. The closure of high street stores could place further financial pressure on some local authorities given the loss of revenues from, for example, business rates – unless this is offset by revenue gains elsewhere (for example from online businesses based in an area, or from Council Tax as commercial space is converted into residential space).

Local authorities that fail to attract the businesses of the future risk falling behind economically, losing ground to authorities that more readily embrace 4IR and smart town/city technologies. If uptake of new technologies is uneven across the country, it could widen, rather than narrow, some of the already stark economic divisions in the country. Ensuring that this does not happen will need to be a crucial objective for policymakers.

At a national level, debate is currently underway over the case for reforming the tax system to "level the playing field" between online and store-based retailers, given the burden of business rates for stores. Amazon recently confirmed it pays business rates of £63.4m per year, almost £40m less than Next plc, despite the fact that Amazon has more than double the UK sales[xxxvii]. The Labour Party has recently suggested it is investigating the case for an "Amazon tax" on digital retailers to level the playing field with store-based retailers[xxxviii].

Beyond impacts on tax revenues, the decline of the high street poses other challenges for local government. Given its social care responsibilities, there will be a need for authorities to support the digitally excluded – those that cannot access goods and services (such as banking) online, and thus risk losing access as stores close. A recent ONS report showed that one in ten (10.0%) of adults were non-internet users in 2018, though this is half the 20.3% seen in 2011[xxxix].

Over half (55%) of non-internet users in 2018 were aged 75 and over. Older non-internet users might be particularly affected by the closure of nearby high street stores, as they are more likely to have mobility difficulties and be unable to travel further to access stores. Further, for these individuals (and indeed others), "going to the shops" might be a crucial source of interaction; the decline of stores might increase levels of loneliness in communities. Given increased concern among policymakers on the need to tackle loneliness in society, this might require intervention from local government, including ensuring that older households are in a position to take advantage of the internet and new technologies Done right, technology can *reduce* loneliness among older individuals, making it easier for them to live independently[xl] and to engage with services such as healthcare from their homes.

CHAPTER 4: WHAT NEXT FOR POLICYMARKETS?

The previous two chapters demonstrated the potential benefits of rolling out 4IR technologies such as smart bins, smart street lighting and road pricing solutions in our local communities – and the challenges associated with realising these benefits in reality.

Addressing the challenges identified in the previous chapter will require consideration from policymakers. Below we set out three practical policy recommendations that we believe could encourage more widespread use of 4IR technologies across local communities in the UK – supporting the creation of "smart cities" and even "smart towns".

Creating a local government 4IR innovation fund

As discussed in the previous chapter, funding constraints, skills gaps and risk aversion within local government risk undermining the development of smart towns and cities in the UK. The lack of a solid evidence base in the UK on the use of technologies such as smart street lighting is a further factor discouraging investment by local authorities in such technologies.

Given this, there is a need for central government to kick-start innovation among local authorities in their use of 4IR. One way of doing this is through the creation of a "4IR innovation fund" specifically for local authorities, which they could use to access financial support for initiatives such as smart bin collection and street lighting. By incentivising innovation, the fund would allow a 4IR evidence base to gradually build up, providing insights into the extent to which technologies such as smart street lighting and connected transport networks are likely to generate financial savings and other benefits in the long term. Establishing this evidence base will encourage other local authorities to also innovate and roll out 4IR solutions, even if they are unable to access additional funding – reducing risk aversion in the use of new technologies.

As well as creating a local authority innovation fund, there is a case to be made for opening up existing funding streams to local government – such as those provided by Innovate UK. Innovate UK funds business and research collaborations to accelerate innovation and drive business investment into research and development[xli]. However, at present local government is unable to access such funding without a private sector partner.

Recommendation 1: Create a local government 4IR innovation fund to incentivise the roll out of 4IR technologies such as smart street lighting and bins, and to help build an evidence base on the long-term financial benefits of such technologies. Proper economic evaluation and monitoring of projects should be a requirement for receiving funding, to ensure an evidence base is established.

In addition, ensure local authorities can access existing sources of innovation funding, such as that provided by Innovate UK.

Embedding innovation into outsourcing with outcome-based contracts

Where funding is unavailable, the onus may lie with private enterprise to provide technological innovation in local communities – for example, through rolling out the use of smart technology in waste collection and street lighting. If these services are outsourced, *outcome-based contracts* can provide strong incentives to innovate and roll out new technologies.

Under outcome-based contracts, service providers are paid according to the *outcomes* they deliver, rather than the *means* with which they reach such outcomes. In the case of waste collection, for example, service providers could be paid to ensure that bins are never overfull and that fly-tipping/litter does not increase. This contrasts with more traditional contracts, where providers are paid according to the *means* of reaching an objective – for example paid to empty bins a certain number of times per week.

Under outcomes-based contracts, service providers have a great deal of flexibility in how they reach a given outcome, which can incentivise innovation and efficiency savings. For example, waste collecting firms might be incentivised to roll out bin-fill sensors and only empty bins on an as-needed basis, as a way of saving money and boosting profits.

To encourage greater rates of recycling, councils could pay waste collection firms to meet a given recycling rate outcome within local communities. Going forward, this might incentivise investment in the rollout of emerging technologies, such as smart bins which are capable of sorting recyclable and unrecyclable rubbish.

Getting the details right with outcomes-based arrangements is critical. Poorly designed contracts can result in excessive cost cutting and end up undermining service quality. For example, this could happen if outcome-based payments are set at too low a level. Outcomes-based contracts need to take account of the measurability of outcomes, and the extent to which it is possible to directly attribute improving or deteriorating outcomes to, say, a company collecting waste and providing street lighting. Such matters are complex and will require high levels of expertise in local government procurement teams – including through hiring new staff with such expertise. Yet, amid funding constraints and risk aversion in local government, such contracts might be the most viable way of bringing some aspects of 4IR to the UK's local communities, with the private sector supporting initial capital investments.

Recommendation 2: Explore the role that outcome-based contracts could play in encouraging private sector providers of outsourced services to roll out new technologies such as bin-fill sensors and smart street lighting.

Carrots, not sticks. Getting public support for new pricing structures

As discussed in the previous chapter, getting public buy-in with respect to new technologies is crucial. This includes getting support for new pricing structures, such as dynamic road and parking charges, and bin collection charges which vary according to the amount of rubbish a household generates.

Local authorities need to be clear that such policies are about creating more efficient, fairer charging structures, rather than creating new forms of "stealth taxation". Public support might require authorities to pledge that dynamic pricing structures arising from 4IR will be rolled out in a largely revenue-neutral way, rather than a revenue-raising one, or at least assurances that any extra charges will translate into tangible benefits. For example, those paying more to use roads during peak hours should benefit from reduced congestion and travel delays.

Public support might be more readily available if new pricing models are rolled out on a "carrot" basis, rather than a "stick" basis, where possible. For example, in the case of waste collection, households that do not require bins to be emptied as regularly (as measured by connected bin fill-sensors) could receive some form of Council Tax rebate. This contrasts with a "stick-based" approach whereby households generating average/above average levels of rubbish are charged more.

Rather than sharply increasing car parking charges during the busiest times of day, councils might get more support by cutting parking charges at times when car parks tend to be underutilised – which should encourage a more even spread of traffic throughout the day as drivers seek to benefit from lower parking charges. Italy's legislation on telematics, requiring telematics-based insurance to be cheaper, is a further example of a carrot-based approach to encourage support for new technologies.

Recommendation 3: Dynamic road and parking charges, and new smart bin collection charges, should either operate on a largely revenue-neutral basis, or in a way that generates clear, tangible benefits to households and businesses. A carrot rather than a stick-based approach to dynamic pricing might be most acceptable to the public. For example, households that produce less waste or recycle more could be awarded some form of Council Tax rebate.

ENDNOTES

[i] SMF (2018), "4IR in the Home" and "4IR in the Workplace"

[ii] https://webarchive.nationalarchives.gov.uk/20160105231823/http://www.ons.gov.uk/ons/rel/wellbeing/measuring-national-well-being/commuting-and-personal-well-being--2014/art-commuting-and-personal-well-being.html#tab-2--Key-Points

[iv] http://www.asphaltuk.org/wp-content/uploads/alarm-survey-2019-digital.pdf

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[vi] https://www.telegraph.co.uk/science/2019/03/12/air-pollution-killing-nearly-many-people-smoking-britain/

[vii] http://www.nhm.ac.uk/discover/light-pollution.html

[viii] https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.117-a20

[ix] https://ec.europa.eu/info/news/commission-reviews-implementation-eu-waste-rules-proposes-actions-help-14-member-states-meet-recycling-targets-2018-sep-24_en

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