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A COMMENTARY ON THE ROLLOUT OF 5G MOBILE IN THE UK

Peter Jones and Daphne Comfort

Abstract

The first waves of the fifth generation of mobile phone technology, 5G, are breaking on the telecommunication shores of the UK. The Government's ambition is for the UK to be a global leader in 5G mobile technology, but its widespread commercial deployment faces a number of barriers and challenges. The aims of this commentary paper are to outline the main characteristics and rollout of 5G mobile technology, to explore the forces driving and shaping the 5G market, to examine the perceived barriers to the deployment of 5G networks and to offer some wider reflections on the rollout of 5G.

Keywords 5G; mobile phone technology; telecommunications industry; digital divide; sustainability

Introduction

Mobile phones have become a necessity for many people throughout the world enabling them to keep in touch with family, business associates, and to have access to e-mail and social media. In a House of Commons Briefing Paper on mobile coverage in the UK published in February 2019, Hutton and Baker (2019) argued '*mobile services are now at the heart of how most people stay in touch and go online.*' The mobile phone market, which exceeds the ownership and use of landline phones in most countries of the world, has experienced rapid development in the last three decades. The first waves of the next generation of commercial mobile technology, 5G, began breaking on the telecommunication shores of the UK in 2019. EE launched its 5G service in London, Cardiff, Edinburgh, Belfast, Birmingham and Manchester in May 2019 and in the same month 2019 Vodafone announced that it would launch 5G in Birmingham, Bristol, Cardiff, Glasgow, Manchester, Liverpool and London in July 2019 for both consumers and businesses. 5G '*is expected to deliver faster and better mobile broadband, and to enable more revolutionary uses in sectors such as manufacturing, transport and healthcare. This may create benefits for people and businesses and expand the role of wireless connectivity within the economy and society'* (Ofcom 2018). While '*this Government has a clear ambition for the UK to be a global leader in the next generation of mobile technology*' (Department for Culture, Media and Sport and UK Treasury 2018), there are concerns about the speed and the extent of 5G rollout. Analysys Mason Limited (2018), for example, identified a range of barriers, relating to legislation, deployment and communication, to the commercial development of 5G. With these thoughts in mind, the aims of this commentary paper are to outline the main characteristics and rollout of 5G mobile technology, to explore the forces driving and shaping the 5G market, to examine the barriers to the deployment of 5G networks and to offer some wider reflections on the rollout of 5G.

5G

5G is widely used as shorthand for the fifth generation of mobile communication technologies. In this context, the term 'generation' usually refers to a change in the fundamental nature of the service. The early mobile phones (retrospectively described as 1G), which were launched first in Japan in 1979 and then in Europe from the early 1980s

onwards, used analogue radio signals and were simply used to make calls. 2G, which used digital networks, and which first appeared in 1991, enabled users to send and receive text messages and pictures. The introduction of 3G enabled Internet connections to be made from mobile phones and 4G introduced improved download and up load speeds, faster response times and clearer voice calls. The mobile communications industry claims that the main advantages 5G has over its predecessor are much faster data download and upload speeds, wider coverage, more stable connections, making better use of the radio spectrum and enabling far more devices to access the mobile Internet at the same time. The physical hardware for 5G uses large numbers of small antennae and operates on different radio spectrum frequencies to 4G and operators have argued that 5G will also demand enhanced fibre networks for backhaul, which in simple terms connects mobile users to the Internet.

More specifically, Ofcom (2018) identified '*three broad categories of use for 5G*', namely, '*improved quality of experience for wireless broadband*'; '*capacity for the Internet of Things*'; and '*revolutionary new services*.' In addressing the second of these categories, Ofcom (2018) lists a number of potential benefits. These include benefits in health and social care in that the Internet of Things will enable remote health monitoring and in creating more timely alerts for nurses and carers and in utilities in the form of smart meters and thermostats that will enable more accurate billing and greater control of energy consumption. At the same time, possible applications in the optimisation of street lighting, the monitoring of car parking and the timing of rubbish collection may contribute to the development of smart cities. Within the manufacturing sector of the economy, 5G may enable companies to make greater use of robotics and the remote control of industrial processes. Ofcom (2018) also suggested that 5G has the potential to produce a series of revolutionary new services. Harnessing the '*tactile Internet*', could, for example, enable medical students to practice surgery in a virtual reality environment and thus to '*feel the procedures as they developed their skills in a safe setting*.' More widely, 5G may also have a role to play in facilitating driverless cars.

Geographically, the rollout of 5G mobile services is likely to be concentrated in a relatively small number of countries, principally in Japan, China, US, South Korea, Singapore, Taiwan, Australia and a number of European countries including the UK. The first 5G rollout was at the winter Olympics at Pyeongchang in South Korea in 2018 and in Japan 5G deployment is underway and there are plans to showcase the range of 5G services at the Tokyo Olympics in 2020. The four major mobile network operators in the US, namely AT&T, Verizon, Sprint and T-Mobile, are all pursuing 5G rollout programmes. In 2018, AT&T became the first US operator to launch a commercial network in a number of cities including Dallas, Houston, Atlanta, Louisville and Oklahoma City. Sprint, the smallest of the major operators launched a 5G service in limited areas of four cities, namely Atlanta, Chicago, Dallas and Kansas City in May 2019. Trials are planned in a large number of European cities and the first commercial 5G service was launched in Switzerland by Swisscom in May 2019.

Within the UK all four of the national mobile network operators, namely EE, O2, Vodafone and Three have ambitious plans to roll out their 5G networks. EE, for example, is to launch 5G across 16 cities, including, London, Edinburgh, Cardiff, Belfast, Glasgow,

Birmingham, Manchester, Leeds, Bristol and Sheffield during 2019. Within some of these cities initial installations are targeted on the busiest areas including Hyde Park in London, Birmingham's Bull Ring and the Edinburgh's Waverley railway station. In a similar vein, Vodafone will begin its rollout of 5G in Manchester, Bristol, Cardiff and Liverpool in 2019 announced plans to launch 5G in a number of towns and cities, including Bournemouth, Blackpool. Portsmouth, Reading, Guildford and Stoke on Trent, across the UK, in 2019. In February 2019, O2 announced it would kick start its 5G rollout in London, Edinburgh, Cardiff and Belfast in 2019 and that it would begin to be available in other areas of the UK from 2020 onwards. Three, the smallest, of the national network operators seems likely to launch its network before late 2019, with launches in London, Birmingham, Manchester and possibly Swindon.

Driving and Shaping 5G in the UK

A number of forces can be seen to be driving and shaping the 5G mobile market. The UK Government (Department for Culture Media and Sport and HM Treasury 2017) announced its '*5G Strategy for the UK*' in 2017 and Oughton and Frias (2018) argued that this strategy is an important market driver. Underlying this strategy is the ambition that '*the UK should be a global leader in 5G so that we can take early advantage of its potential and help to create a world-leading digital economy that works for everyone.*' The strategy claims '*being at the forefront of the development and deployment of 5G networks will help the UK digital sector compete in global markets for a range of products and services; enhance UK capabilities at home and overseas; and help to attract inward investment*' (Department for Culture Media and Sport and HM Treasury 2017).

The strategy outlined the steps the Government would take to build the economic case for investment in 5G and to create an appropriate regulatory framework, and outlined the actions it is taking to improve mobile network access, its belief that local authorities have a vital role to play in supporting the rollout of 5G networks and the actions and plans to ensure the safe and secure deployment of 5G. In '*building the economic case*' for investment in 5G, for example, the Department for Culture, Media and Sport and HM Treasury (2017) emphasised the potential economic benefits of 5G in that enabling business to be done on the move will provide '*access to information and services anywhere*' thus '*enabling new markets to develop and reshaping others.*' The Future Communications Challenge Group (2017) commissioned by the UK Government to review its commitment to be a world leader in 5G, reported that, '*UK GDP impact of Mobile would be £112bn in 2020, growing to £198bn per annum by 2030*' namely '*5.7% of UK GDP*' and that '*not acting to ensure UK leadership in 5G would result in losing opportunity to create £173bn of incremental GDP over 10 years, 2020 to 2030.*' While the political controversy in 2018-2019 surrounding the potential role of the Chinese company Huawei in the supply of 5G equipment illustrated security concerns, a full treatment of the issues involved in this controversy is beyond the scope of this paper,

However, Blackman and Forge (2019), writing under the banner of the European Parliament, argued that '*5G is driven by the telecoms supply industry*' and that a '*major*

campaign is underway to convince governments that the economy and jobs will be strongly stimulated by 5G deployment.' More specifically, Blackman and Forge (2019) claimed '*since 5G endeavour is being primarily driven by the equipment suppliers, it is not surprising that there is a significant marketing campaign underway*' and '*this industry effort is reinforced by its long tail supply chain-semiconductor components, software managed operations and equipment suppliers- that together serve the major operators.*' At the same time, Blackman and Forge (2019) suggested that the aim of the major players in the supply industry is to encourage the mobile network operators to invest in the network infrastructure required for the rollout of 5G. Here the supply industry might supply the capital in instalments to allow the operators to develop their networks and then use future revenues to repay the equipment suppliers.

For their part, while all four national network operators in the UK have ambitious plans for their 5G networks and for the wide range of applications and services they will support and facilitate, they too are running major marketing campaigns to drive sales. However, Blackman and Forge (2019) have suggested that network operators currently '*have limited capacity to invest in the new technology and infrastructure as their returns from investment in 3G and 4G are still being recouped.*' More generally, Oughton and Frias (2018) claimed '*many operators are facing challenging times with static or declining revenues.* At the same time, the scale of consumers' enthusiasm for 5G and their willingness to pay for the enhanced range of services and applications it will offer, remains to be seen.'

Perhaps not surprisingly, the operators have emphasised the need for greater Government support, including financial support, for example, to help rollout networks in rural areas, to enable 5G to harness its full potential. While the UK Government has promised to invest £1.2 billion in 5G and full fibre connectivity, the industry has claimed that this is dwarfed by Germany's £100 billion investment in these developments (DIGIT 2019). For their part, the Department for Culture, Media and Sport and HM Treasury (2017) emphasised that '*the vast majority of the capital investment required for both full-fibre and 5G rollout will need to come from the private sector.*'

Barriers

The Broadband Stakeholder Group, the UK Government's advisory forum for telecommunications policy, commissioned Analysys Mason to explore barriers to the deployment of 5G mobile networks and to make recommendations as to how these barriers might be overcome. The ability to raise the required investment for 5G deployment, estimated at between £3 and 4 billion (Department for Digital, Culture, Media and Sport 2018) currently seems to be a major challenge. Analysys Mason (2018), for example, argued '*it is undeniable that the overarching barrier to the UK being a 5G leader is one of investment uncertainty*' (Analysys Mason 2018). Further, Analysys Mason (2018) argued '*the biggest barrier to rollout is currently economic, with the business case being balanced against the risk of investing.*'

In unpacking the overarching barrier to the rollout of 5G, Analysys Mason (2018) reported that both industry stakeholders and local authorities expressed two concerns.

Firstly, that '*there is need for greater clarity and wider promotion of the value of 5G rollout, and clearer definition of the UK's 5G strategy, to reduce uncertainty for industry*' and secondly, '*a lack of awareness of nationwide 5G priorities within local authorities, which risks delaying 5G rollout.*' Further, Analysys Mason (2018) claimed that '*without widespread promotion of relevant roll-out benefits, expected use-cases, deployment models and their benefits, there is a risk of fragmentation in approaches to 5G, creating additional investment uncertainty for the telecoms industry.*'

Economic and investment concerns aside, Analysys Mason (2018) also identified 13 specific barriers to the successful deployment of 5G, and grouped these barriers under three headings namely, '*legislation, deployment and communication*' but argued that as '*the overall investment case remains uncertain*' then '*this makes the importance of removing the other barriers that exist in the UK all the greater.*' A number of the specific barriers are linked in one way or another, to town and country planning issues and more generally to local authorities, and an exploration of some of these issues illustrates a number of the ways in which the perceived barriers are seen to be operating.

The Department for Culture, Media and Sport and HM Treasury (2017) explicitly recognised that '*planning regulations are a key factor influencing a network infrastructure provider's ability to expand its network*' because '*they govern where sites can be built and the physical appearance of the equipment that can be installed on such sites.*' The National Planning Policy Framework stressed that '*planning policies and decisions should support the expansion of electronic communications networks, including next generation mobile technology (such as 5G) and full fibre broadband connections*' (Ministry of Housing, Communities and Local Government 2019).

At the same time, the National Planning Policy Framework also emphasised that new electronic communications infrastructure must not interfere with other electrical equipment or air traffic services and that new buildings must not interfere with existing electronic communication services. Further, local planning authorities were advised that they '*must determine applications on planning grounds only*' and that '*they should not seek to prevent competition between different operators, question the need for an electronic communications system or set health safeguards different from the International Commissions guidelines for public exposure*' (Ministry of Housing, Communities and Local Government 2019).

However (Mason Analysys 2018) expressed concerns that the '*current planning processes do not support efficient planning of mobile infrastructure deployments*' and about '*fragmented application of planning regulations for mobile equipment, and a lack of best practice guidance.*' Further Mason Analysys (2018) claimed that '*some local authorities have not linked their approach to managing local planning issues to the strategic goals of central government policy on the provision of digital infrastructure*' and expressed concerns about '*the lack of clear guidance from central government to local authorities on the application of planning regulations for mobile telecoms equipment.*'

There are planning issues concerning the installation of both taller masts, and here operators either look to increase the height of existing masts or to construct new ones, and

of small antennae cells within new networks. The new masts also require the installation of larger equipment cabinets, which can require more land and new fencing. Plans for taller phone masts often face opposition from some people living in the surrounding area who feel the installations damage the appearance and amenity of local landscapes and who have cited health concerns about public health risks associated with wireless radiation. However, the operators have argued that these masts are becoming just as important as other utilities installations and that they should be given high priority and that planning process should be streamlined and permission application determination times should be reduced.

Permitted development rights, which allow operators to deploy the necessary equipment, principally masts, antennae, cabinets and telegraph poles, without submitting full planning application, vary across England and the devolved Governments of the UK. The permitted development rights were reformed in England in 2018 and in Scotland in 2017. In England, for example, permitted development rights cover new masts less than 25 metres in height (excluding antennae) but only up to 20 metres in height (excluding antennae) on Article 2(3) land which includes designated conservation areas, areas of outstanding natural beauty, national parks, the Norfolk Broads and world heritage sites. Small antennae are permitted development in England providing the visual impact is minimised but the precise conditions are detailed and vary depending on whether the antennae will be on a dwelling house or not and on whether, or not, they will be on Article 2(3) land.

In Wales, the legislation was last updated in 2014 but in 2017 the Welsh Government (2017) commissioned a study to investigate permitted development rights applying to '*mobile telecommunications infrastructure are fit for purpose.*' Two of the guidelines underpinning this investigation were the need to reflect '*the topography and population distribution of Wales*' and balance '*the local economic and societal benefits of having broad mobile signal coverage (and capacity) with the need to safeguard sensitive landscapes and protect residential amenity.*' The study recommended bringing existing permitted development rights into line with those in England and Scotland but at the time of writing, no changes have been announced. Indeed, in January 2019 Economy, Infrastructure and Skills Committee of the National Assembly for Wales (2019) argued that '*changes to permitted development should either be implemented, or an explanation given as to why they have been rejected.*'

Concluding Reflections

The UK Government and the four national network operators have ambitious plans for the deployment of 5G mobile technology, but a range of barriers may hamper the rapid national rollout of 5G networks. More generally, a number of wider issues merit attention. Firstly, there is the issue of the impact of 5G on the digital divide, namely the gap between those who have access to information and communications technology and those who do not, which is seen to give rise to inequalities in access to opportunities, knowledge, services and goods. Here the most marked differences may be at the international scale. Collins (2017), for example, argued that '*for all the hypes and benefits that stem from 5G, there are few parts of the world that will actually see deployments in the next few years*' and claimed that '*5G could widen the gaps between the have's and the have nots.*' However, the digital divide also exists at the national level within many advanced economies.

In the UK, for example, the Office for National Statistics (2019) estimated that in 2018, 5.3 million adults (10% of the adult population) were internet non-users (defined as those who had never used the Internet or who had last used it more than three months ago). In its '*UK Consumer Digital Index 2018*' Lloyds Banking Group (2018) estimated that in the UK, 4.3 million adults (8% of the adult population) had no basic digital skills and that 11.3 million adults (21% of the adult population) did not have '*all five basic digital skills*', which centre on '*managing information*', '*communicating*', '*transacting*', '*problem solving*' and '*creating*.' More specifically, Lloyds Banking Group (2018) estimated that 43% of the UK's adult population '*are not able to create something new from existing online images, music or video*' and that 16% of the adult population '*are not able fill out an online application form*'. Statista (2019) estimated that some 94% use a mobile phone and the Office for National Statistics (2018) estimated that 78% of adults within Great Britain used mobile phones to access the Internet.

Two dimensions of the current mobile digital divide are relevant here, namely the social and demographic gap and geographical variations in access. Put simply, socially and demographically, the less well-off sections of the UK population and the aged make less use of mobile technology than the more affluent and the younger sections of that population. Geographically the gap is manifest in two ways. Firstly, the proportions of the adult population with no basic digital skills were estimated (Lloyds Banking Group 2018) to be highest in Wales (19%), the North East of England (12%) and the North West of England (10%). Secondly, Ofcom (2018) suggested that '*too many rural areas are left with patchy or unreliable mobile reception*.' The increased cost of 5G mobile phones to consumers and the logistical problems and financial costs of establishing 5G networks in sparsely populated rural areas both make it unlikely that the advent of 5G will address the current digital divide. More generally, Bloom (2019) argued that '*5G is poorly suited to close the digital divide*' and perhaps more worryingly that it '*may widen it*.'

Secondly, there are issues about sustainability and more specifically if, and how, the development of 5G might contribute to sustainable development. On the one hand, West (2016), writing under the banner of the Brookings Institution, argued that '*with the emergence of the 5G network and the internet of things, it is possible to deploy technology in ways that protect the environment and promote long-term sustainability*.' In a similar vein, Earth 911 (2017), a privately owned not for profit company which focuses upon recycling, claimed that in '*simple terms, 5G technology can help facilitate a cleaner, greener, more environmentally conscious future by making things more efficient*.' By way of an illustration Earth 911 (2017), suggested '*imagine a world in which self-driving cars, leveraging electric power for their journey, travel with millimeter precision to their destination — the effect would be fewer road blocks, traffic delays and accidents, plus more-efficient driving manners*'.

Belo (2019) emphasised the role that the Internet of Things may be able to play in connecting up different types of infrastructure so that they can be used much more efficiently. Further Belo (2019) argued that via 5G, systems equipped with IoT technology will be able '*to sense and respond intelligently to changes in their environment*', that '*these*

will only use the power and other resources that they need' and that as such the Internet of Things will 'significantly reduce the resources required in everything from manufacturing industries, to public transport systems, through to collecting, cleaning and distributing potable water.' At the same time, Beloe (2019) suggested that the '*as people increasingly purchase the service of road transport rather than owning their own car*' this will, in turn, '*herald the emergence of super-efficient electric vehicles as operating costs and energy use become the sector's defining metric.*'

On the other hand, the dominant messages surrounding the rollout of mobile 5G focus on continuing growth. In general terms the World Economic Forum (2018), claimed that '*the telecom industry reaches into every corner of our economies, societies and private lives, and it is one of the greatest drivers of economic growth*'..... '*the world has ever seen.*' More generally, Barclays (2019), claimed that '*the introduction of a 5G mobile telecommunications network could increase annual UK business revenues by up to £15. 7 billion by 2025*' and that manufacturing, distribution, professional services and business services are the sectors likely to see the highest growth. As such, the development of 5G mobile technology is justified by its potential, and in many ways its much needed, contribution to economic growth, despite some commentators' more general concerns that continuing economic growth is compatible with sustainability. Daly (2017) for example, suggested that '*there is an obvious physical conflict between the growth of the economy and the preservation of the physical environment*' while Higgins (2013) argued '*the economic growth we know today is diametrically opposed to the sustainability of our planet*' and Demaria (2018) argued that '*economic growth is environmentally unsustainable.*'

Thirdly there are conceptual issue about the role of the state in facilitating the rollout of 5G within the UK. Traditionally within the telecommunications industry, the state was the owner and operator of telecommunications networks and services, but from the 1980's onwards this '*regime was undermined by new technologies and globalization*' (Humphreys and Simpson 2008). Within this new operating environment, Humphreys and Simpson (2018) highlighted the importance the linked role of the '*competition state*' and the '*regulatory state.*' Here the main focus of the competition state is seen to be the promotion of economic activity and development and the enhancement of the competitiveness of the sector in international markets. At the same time the regulatory state '*might be deployed in the spirit of the neo-liberal competition state to stimulate new economic activity and attract new investment through diligent market opening and pro-competitive regulation*' (Humphreys and Simpson 2008).

More specifically, both concepts might be seen to strike a chord with the rollout of 5G. The is reflected in Governments ambition that '*the UK should be a global leader in 5G*' and that the '*development and deployment of 5G networks will help the UK digital sector compete in global markets for a range of products and services; enhance UK capabilities at home and overseas; and help to attract inward investment*' (Department for Culture Media and Sport and HM Treasury 2017). The latter is reflected in Ofcom's (2018) case for '*enabling 5G in the UK*', namely that '*we would expect competition to lead to a diverse range of services in the market*' but '*where competition does not provide the necessary services, we will need to consider regulation to ensure such services are available.*'

At the same time neoliberal models, in which the free market is seen to be extended from all parts of society and in which the state is seen to have become transformed from a provider of public services to a promoter of markets and competition, would also seem to help in offering a general explanation of the forces at work in the current debate about the rollout of 5G mobile networks. Neoliberalism is seen, for example, to '*favour the operations of transnational corporations over social imperatives*', while '*deepening neoliberal entrenchment in global communication policy making and its often oppositional relationship to civil society articulations of communication rights*' (Pickard 2007). More starkly, the Centre for Labour and Social Studies (2017) argued that '*under neoliberalism there is no role for the state in promoting*

More general debates in the social sciences about the role of the state in capitalist society might also be seen to help interpret government approaches to the rollout of 5G mobile networks. On the one hand, for example, a liberal pluralist perspective which provides opportunities for all stakeholders to influence state policy and sees the state as working for the benefit of society as a whole. Such an approach strikes a chord with the UK Government's belief that 5G will meet '*future demands of consumers and businesses*' (Department for Digital, Culture, Media and Sport (2018) and '*create benefits for people and businesses*' (Department for Digital, Culture, Media and Sport 2017) and with national mobile network operators' position on the roll out of 5G. This, in turn is reflected in the claim by Analysys Mason (2018) that '*as all stakeholders are working towards developing and preparing for a 5G future is on how to ensure the right foundations are in place to support the delivery of maximum benefits and realise the potential of this innovation.*'

By way of contrast, political economy perspectives on the role of the state are broadly based on the belief that within capitalist societies, the state will always act in such a way as to ensure that the long-term interests of capital are always dominant. Such a reading of the role of the state might resonate, for example, with the arguments from the national mobile network operators and the telecommunications supply industry for greater public funding to help rollout networks, particularly in rural areas, to enable 5G to harness its full potential, and with calls for a simpler and more coordinated approach to planning regulations.

At the same time neoliberal models, in which the free market is seen to be extended from all parts of society and in which the state is seen to have become transformed from a provider of public services to a promoter of markets and competition, would also seem to help in offering a general explanation of the forces at work in the current debate about the rollout of 5G mobile networks. Neoliberalism is seen, for example, to '*favour the operations of transnational corporations over social imperatives*', while '*deepening neoliberal entrenchment in global communication policy making and its often oppositional relationship to civil society articulations of communication rights*' (Pickard 2007). More starkly, the Centre for Labour and Social Studies (2017) argued that '*under neoliberalism there is no role for the state in promoting sustainability, social justice or' surprisingly 'technological progress.'*

Fourthly, the rollout of 5G networks in the UK would seem to provide fertile territory for public relations companies. Commetric (2018), for example, observed that the '*telecommunications companies aiming to leverage 5G are currently in the process of positioning themselves as top players in the new field*' and '*their public relations priority is to be perceived as first-movers, innovators, critical for digital transformation and fundamental for Internet of Things projects*'. Commetric (2018) also claimed that '*this can be achieved by data driven communications strategy*', which could best be developed through quantitative *high-level media measurement with human-led in-depth qualitative analysis.*' Further, Commetric (2018) suggested that the main national operators '*should accompany their research and development initiatives with effective communication campaigns which would highlight that they're in the front rows of the tech revolution.*' A more qualitative approach, which adopted a targeted public relations and communications campaign amongst all the main stakeholders involved in the rollout of 5G networks, and which focussed on the perceived benefits claimed for 5g, might also pay dividends. At a more basic level, Neesham PR, the business to business technology agency, advertised a '*Demystifying 5G*' seminar run by Rhode and Schwarz in Reading in May 2019, and such events may also have an important role to play in what is a rapidly evolving technological and business environment of 5G.

Finally, and by way of a concluding thought, in arguing that '*government needs to start treating mobile networks like a critical piece of national infrastructure*', Mark Evans (2019), the Chief Executive Officer of Telefonica UK, who trade as O2, claimed '*as we prepare to roll out 5G technology, we stand on the cusp of a new technological revolution. Developments such as artificial intelligence, machine learning, the internet of things, smart cities and virtual reality are set to completely challenge the way we live our lives.*' Rather cynically, and in the wake of the result of the Brexit Referendum in 2016, the current authors are left wondering how many people within the UK want to face up to having the way they live their lives fundamentally challenged.

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