

Future of the UK Mobile and Wider Communications Value Chain Final Report

February 2022

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Executive Summary

The UK's mobile networks are essential foundation stones of the digitalisation of the UK economy. Continued investment in widely available high-quality resilient mobile connectivity will underpin the sustainable and equitable digitalisation of the UK economy and society, the benefits of which are clear and pervasive:

- Sustainable economic growth as a result of increased business potential and productivity;
- Enhanced opportunities and quality of living for citizens; and
- A more resilient and equitable society and economy.

Realisation of these benefits will require UK consumers and businesses to have access to mobile networks of the highest quality, reliability, and availability. In this context, the UK's Mobile Network Operators ("MNOs"), have invested more than £20 billion in mobile networks over the last decade and are currently undertaking investments in the initial rollout of 5G networks.¹ However, delivering full capability 5G, and the associated benefits, across the UK will require significant further investment. It is estimated that cumulative investment in 5G deployment in the UK had reached £2.3bn by 2020, but a report commissioned by DCMS estimated that capital investment in excess of £20bn may be required to provide nationwide 'seamless high performance connectivity'.^{2 3}

The context for Ofcom's and DCMS' strategic reviews

The need for the investment required to deliver the wider benefits of digitalisation coincides with a continued transformation of the mobile value chain. This transformation is reshaping the way in which returns on investment in mobile connectivity are generated. It is in this context that Ofcom's strategic review of its approach to the mobile sector is taking place; in its Terms of Reference, Ofcom recognised the importance of understanding how the value chain is evolving and the implications this has for the business case for investment in mobile connectivity.⁴ Similarly, the UK Government Department for Digital, Culture, Media and Sport ("DCMS") ongoing development of a Wireless Infrastructure Strategy is intended to provide a framework for the development, deployment and adoption of 5G and future networks in the UK over the next decade.⁵

The shape and structure of the mobile value chain, and competitive dynamics within it, have changed significantly over the last decade, and can be expected to continue to evolve. The value chain has expanded - with new dimensions to it enabled by the wide range of services and applications that are now delivered over mobile networks, many of which overlap with value chains in adjacent sectors.

There are an increasing number and diversity of participants competing across this expanded value chain, many of which are vertically integrated and able to leverage global scale. For example, in addition to intense competition between MNOs, mobile virtual network operators ("MVNOs"), and

¹ Capex for 2010 – 2018 from: National Infrastructure Commission, "[Strategic Investment and Public Confidence](#)", October 2019. The technical annex: [Performance data for water, energy and telecoms](#). 2019 value from: National Infrastructure Commission, "[ANNEX A: DIGITAL, The Second National Infrastructure Assessment: Baseline Report](#)", November 2021.

² Full capability 5G in this context refers to providing ultra-high capacity, low latency and high reliability network services (including indoors) through network cell densification and deployment of low, mid and potentially mmWave band spectrum frequencies (e.g., 700 MHz and 3.4 GHz).

³ Frontier Economics, "[UK Mobile Market Dynamics – A report for DCMS](#)", July 2018.

⁴ Ofcom, "[Mobile Strategy – Terms of Reference](#)", 11 May 2021.

⁵ Department for Digital, Culture, Media & Sport, "[Wireless Infrastructure Strategy: call for evidence](#)", 17 November 2021.

other re-sellers, MNOs are now transacting, and in some cases competing, with global network equipment vendors and independent tower companies upstream, and global integrated device vendors, content providers and other application providers downstream. This has changed the competitive dynamics and balance of power across the value chain.

Commercial and technical innovation has altered the way in which value is generated and shared across the value chain

Over the last ten years the transition to subscription-based pricing models for mobile services, with various forms of inclusive allowances, has continued. As Ofcom has noted, this has enabled most consumers to make use of more data and call minutes for less; in 2020, data usage increased by 33%, but average cost per consumer declined by 10% in real terms.⁶

Consumers are also benefitting from a range of zero-priced communication services (e.g., app-based instant messaging and voice-over-IP service) that rely on mobile connectivity but which generate value in different ways, for example through monetisation of data generated by mobile applications. Demand for these services has stimulated demand for data subscriptions. However, changes in the mobile value chain that have transformed the way in which value is generated and shared may be contributing to a weakening in the relationship between levels of mobile data consumption (a key driver of network costs), and the revenues generated by providing the services. This may in turn contribute to increased pressure on returns on investment in the underlying infrastructure that supports these services.

Over the next ten years, the continued digitalisation of the economy and society will make further demands on the underlying connectivity infrastructure

Digitalisation of the economy and society presents new value creation opportunities for all participants in the mobile value chain, including the MNOs. As Ofcom notes in its Terms of Reference, for 60% of the UK adult population smart phones are the most important device for connecting to the internet whether at home, at work or elsewhere.⁷ However, high levels of competition, changes in the balance of bargaining power across the value chain, uncertainty around the monetisation of 5G investments (e.g. uncertain demand), the adoption of new commercial models and constraints imposed by policy and regulation will all continue to impact the business case for investment in mobile network connectivity.

Empirical evidence is already emerging to suggest that comparatively lower levels of returns in the UK mobile sector could be insufficient to support the investment required to deliver the highest capability 5G networks to a substantial proportion of UK consumers and businesses. While estimates of Return on Capital Employed (“ROCE”) vary widely depending on assumptions made on the valuation of intangible assets, there is evidence that at least some UK MNOs earn an overall return below the cost of capital (i.e. below the costs of financing their operations).⁸ Further, estimates of other financial metrics, which reflect MNOs’ underlying capacity to invest and therefore impact overall levels of investment, suggest that telecoms operations in the UK are less profitable than in other European markets. UK MNOs’ EBITDA margins have generally been below European mobile operators, with some

⁶ Ofcom, [“Pricing trends for communications services in the UK”](#), July 2021.

⁷ QE9 (QE40) SHOWCARD Which is the most important device you use to connect to the internet at home or elsewhere? Total response for Smartphone. Ofcom, [“Technology Tracker 2020 UK data tables”](#), 30 April 2020.

⁸ A report by Enders Analysis estimated that the ROCE (using spectrum at current value) for two of the four UK MNOs was below Ofcom’s pre-tax nominal cost of capital (9%), and the ROCE (using spectrum at historic costs) was at or below the cost of capital for three of the four UK MNOs. See: Enders Analysis, “What’s to become of H3G”, 25 January 2022.

operations in other large European markets earning EBITDA margins that are nearly double those in the UK.

The lower returns in the UK today, coupled with uncertainty around future returns from 5G investment, may already be contributing to lower capital investment in the UK. For example, over the same period, levels of UK investment (i.e. capex/revenue ratios) have remained below those of MNOs' operations in other European markets.⁹ The impact of these effects may already be evident in the distribution of 5G network coverage; while more than 50% of the UK population now have 5G coverage from at least one MNO, by comparison UK 4G population coverage had reached 72% within the first two years of launch.^{10 11} Further, while UK MNOs have announced plans to rollout nationwide 5G coverage over the next 6-7 years, deployment of full capability 5G networks (e.g., in terms of high capacity and low latency) is expected to be more limited (e.g., primarily to urban areas)¹².

If further investment in underlying connectivity is to be unlocked, collaboration will be required between all participants in the value chain, including policymakers, to help ensure that the wider economic and social benefits of digitalisation are enjoyed equitably across the UK. Where innovative value generation models develop there are often affordability benefits to consumers, however if the value generated from infrastructure investment is not commensurate with investment risk, incentives to invest could be undermined to the detriment of consumers in the longer term.

Key trends influencing MNOs' returns on investment in connectivity

MNOs are seeking to generate new sources of commercial value through network innovation, commercial partnerships, and operating efficiencies (e.g., network sharing, deploying Software Defined Networks and Network Function Virtualisation technologies). However, they face a series of challenges that may constrain their ability to generate value from investment in connectivity:

Softening in MNOs' bargaining power: Increased concentration in the network infrastructure supply chain has the potential to weaken MNOs' upstream bargaining power in the procurement of critical network inputs, at least in the short to medium term, and therefore to put upward pressure on network costs. When combined with the softening in MNOs' ability to generate new sources of value, resulting from their relative lack of scale compared to global players with whom they both compete and partner in various parts of the value chain, further pressure will be placed on MNOs' ability to retain value generated from investment in connectivity.

Competition from global players in high growth areas of the mobile market: Whilst new sources of competition in the enterprise segment, in particular private mobile network operators, can be expected to deliver wider benefits in terms of innovation and investment, this may limit MNOs' ability to generate the scale required to support investment in deploying full capability 5G for the widest number of consumers and smaller businesses. The potential for the 'cherry picking' of higher growth opportunities by private mobile network operators without the same public policy obligations and expectations, for example in terms of service ubiquity and social tariffs, presents a risk to the marginal investment cases on which the widest possible deployment of infrastructure depends.

Regulatory and policy constraints on MNOs' commercial flexibility: There are opportunities for MNOs to generate the scale and value required to support more widescale deployment of full capability 5G networks (e.g., through more extensive network sharing and consolidation). However, broader

⁹ See Figure 10 below.

¹⁰ Ofcom, "[Connected Nations 2021](#)", December 2021.

¹¹ 4G: Ofcom, "[The Communications Market Report](#)", 7 August 2014. 5G: Ofcom, "[Connected Nations 2021](#)", December 2021.

¹² BT Press Release, "[EE to offer 5G solutions across the entire UK, as BT Group unveil new mobile and convergence ambitions](#)", 14 July 2021.

competition policies may restrict MNOs' ability to consolidate investments in this way, and other forms of regulatory intervention that constrain MNOs commercial flexibility, such as net neutrality rules, also act to constrain the generation of returns on investment in connectivity.

Implications for investment in full capability 5G networks

Constraints and uncertainty around MNOs' ability to generate revenue from new network investments, allied to increasing cost pressures, could weaken MNOs' incentives and capacity to invest.

The impact of constraints to a business case are most pronounced at the margins; in the case of mobile connectivity, this is where the deployment costs are relatively high and where revenues are expected to be lower than average. Where these constraints are felt, they can be expected to lead to slower and/or less extensive network rollouts in areas where the business case is most marginal.

In practice this could mean that the availability of full capability 5G services is limited to more densely populated areas due to the significant investment required to go beyond that. In this context, the Centre for Policy Studies has estimated that delays and geographic constraints on 5G deployment could mean that up to 11 million households and businesses do not get access to high-speed mobile connectivity by 2027.¹³

Policymakers, network and application providers, and society beyond share an interest in ensuring the widest possible availability of full capability 5G networks. Unlocking the investment required to deliver this can be transformative socially, environmentally, and economically; equitable distribution of these benefits will be essential if digital divides are to be bridged.

As Government and Ofcom develop their future strategies for the mobile sector, it will be critical for consideration to be given to the challenges faced in generating returns on investment in mobile infrastructure. The Ofcom and DCMS strategic reviews provide a platform for sector, regulator, and Government to discuss the mobile connectivity that the UK needs and to evaluate which combination of regulatory, policy, private and public/private initiatives can deliver this most effectively.

¹³ Centre for Policy Studies, "[Upwardly Mobile: How the UK can gain the full benefits of the 5G revolution](#)", 1 October 2020.

Introduction

UK policymakers are undertaking strategic reviews of the mobile sector. In this context, this report considers how the mobile communications value chain is evolving and the implications for investment in connectivity.

Ofcom is undertaking a strategic review of its approach to markets that deliver mobile services.¹⁴ The aim of this review is to ensure that these markets work well for consumers and businesses over the next five to ten years, as technologies develop, and markets change. The review is expected to consider a range of questions including:

- how are consumers' and businesses' use of mobile likely to evolve?
- how will the value chain change and what will be the impact of these changes?
- are there barriers to the market delivering good outcomes in the coming years?
- might any existing regulations need to be revised to help ensure the delivery of those outcomes?

The review will also take account of Ofcom's ongoing work across a range of areas such as spectrum policy, mobile coverage, supply chain diversification and net neutrality. As part of the review, Ofcom is gathering evidence and views from a wide range of stakeholders, so that it can develop a holistic view of the challenges and opportunities facing the industry, and how these could affect people and businesses.

In parallel to Ofcom's review, DCMS is developing a Wireless Infrastructure Strategy, which is intended to provide a framework for the development, deployment and adoption of 5G and future networks in the UK over the next decade.

It is in this context that this report has been commissioned by BT Group, Vodafone, and VMO2, in consultation with Three UK, to provide an independent perspective on the future of the UK mobile and wider communications value chain.¹⁵ The report considers how the UK mobile communications value chain has changed and could evolve further over the next five to ten years, the challenges this may present for investment in mobile connectivity, the implications of such constraints for the UK economy and society, and potential policy enablers to address these challenges.

The report has been informed by a review of existing literature, consultation with the four UK MNOs on the themes discussed in the report, and bilateral interviews with several industry stakeholders from across the communications value chain.¹⁶ This report was completed prior to the publication of

¹⁴ Ofcom, "[Mobile Strategy – Terms of Reference](#)", 11 May 2021.

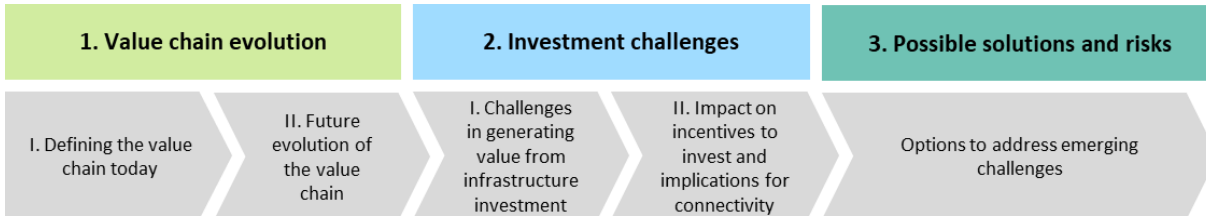
¹⁵ While Three UK were consulted on the scope and findings of the report, they were not a contracting party to the commissioning of the report.

¹⁶ Informal interviews were conducted with parties including a European MNO operating outside the UK, a content provider, device vendors, a mobile application provider, and network equipment vendors. These interviews were conducted by Deloitte and the findings in this report do not necessarily reflect the views expressed by the parties that were interviewed.

“Ofcom’s future approach to mobile markets” discussion paper and therefore does not reference or respond to findings in that paper.¹⁷

The report is set out across three sections, as summarised in Figure 1 below:

Figure 1: The approach to this study



- The first section outlines how the value chain has changed over the last decade, and key emerging trends that could impact MNOs’ ability to generate value from investment in connectivity infrastructure.
- The second section considers how value generated from investment in mobile connectivity is changing, the factors that may constrain the generation of value from these investments, the impact such factors could have on incentives to invest in UK mobile connectivity, and the potential implications for consumers, businesses, and the wider economy.
- The third section sets out potential policy enablers that could support investment in connectivity going forward.

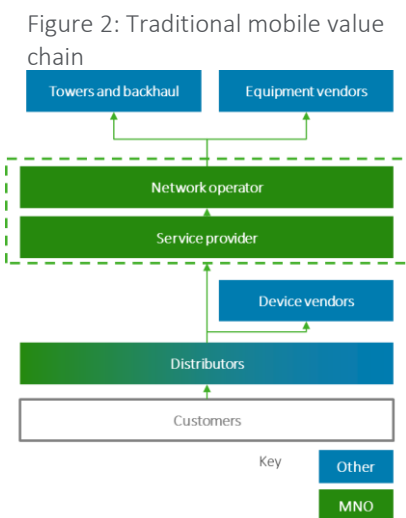
¹⁷ Ofcom, ‘Ofcom’s future approach to mobile markets: a discussion paper’, 9 February 2022.

1. Value Chain Evolution

The mobile communications value chain has grown, fragmented and become more complex; this will continue in the years to come as will the associated impacts on competitive dynamics.

1.1. The mobile communications value chain today

The last decade has seen fundamental changes in the mobile communications value chain



The traditional mobile value chain depicted in Figure 2 has been transformed; technological and commercial innovation have expanded its scope and complexity.

The introduction of smart devices and deployment of 4G networks have contributed to a transformation in the nature of services demanded – from a focus on voice and messaging, to a focus on mobile devices and applications, as well as on the data connectivity on which these rely.

New players are competing in mobile markets

The entrance of new players that compete across this expanded value chain, many of which leverage their global scale to capture high value growth opportunities, has stimulated innovation and competition in mobile markets and introduced new competitive dynamics. MNOs, MVNOs and resellers have continued to compete vigorously in mobile service markets. This has enabled consumers and businesses to benefit from sustained falls in mobile prices, as declining unit costs, driven for example by network innovation and network sharing, have been passed through to prices over time.

These traditional mobile service providers now also face competition from application-based ‘Over-the-top’ (“OTT”) voice and messaging platforms whose alternative value generation models have contributed to a significant erosion in traditional voice and messaging revenues (as shown in Figure 3 below¹⁸), whilst stimulating demand for data services.

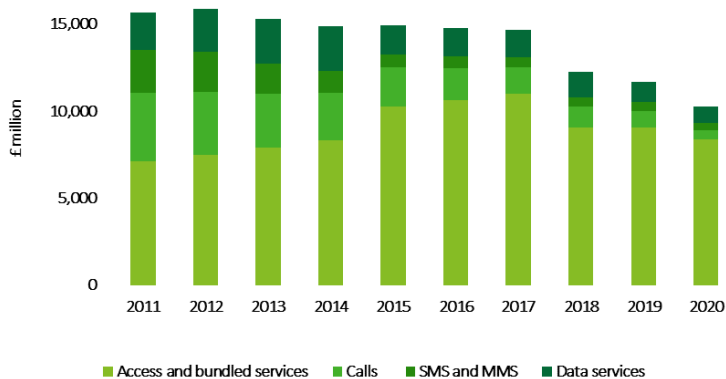
New value generation strategies challenge traditional monetisation models

MNOs’ investment in mobile networks has enabled and stimulated the growth of applications that rely on the wide availability of high-quality mobile connectivity to deliver innovative services to customers.

¹⁸ Sourced from Ofcom, "[Telecommunications Market Data Update Q2 2021](#)", 28 October 2021. Note: from 2018 device revenues are not included due to new IFRS15 accounting standard. The nominal series presented by Ofcom is converted to real series with base year of 2011 using GDP deflators.

Consumer demand for OTT services has helped drive demand for larger data packages, and thereby supported MNOs' transition to generating value from data services.¹⁹ However, MNOs have struggled to monetise this increased demand for mobile data connectivity and to rebalance revenue generation from voice services to data services. For example, UK MNOs have largely been unable to sustain pricing premia for value-add data services (e.g., enhanced 4G/5G data speeds). The popularity of subscription-based pricing models with inclusive data allowances has meant that the link between consumption and pricing is weaker than was the case with traffic-based pricing models. This may, in turn, have weakened efficient price signals to end users (e.g., the price of data may be less reflective of the incremental cost incurred from data consumption, which could in turn drive inefficient use of the network).

Figure 3: UK mobile telephony revenues



Source: Ofcom, *Telecommunications Market Data Update Q2 2021*

By deploying commercial models that create value by monetising the data generated by consumers' use of applications, OTT service providers have been able to expand beyond communications to compete across the value chain, including application, device, and content segments. These value generation strategies depend on business models that are hard for the MNOs to replicate and constrain their ability to generate value from traditional services as well as to expand into other parts of the value chain.

In some cases, OTT service providers have entered revenue sharing deals with MNOs, enabling MNOs to leverage their relationships with the end customer and their ability to support, for example, credit checks. However, the prospects for MNOs generating significant long-term value from such arrangements may reduce as consumers continue to build their direct relationships with a more diverse number of value chain players.

Consumers and businesses have formed relationships with a wider range of value chain participants

Previously, MNOs' unique direct relationships with end consumers provided a valuable commercial lever in partnership discussions with other value chain participants who often lacked the valuable direct billing relationships enjoyed by the MNOs.

While the MNOs still often benefit from a more tangible direct relationship with customers (e.g., through high street stores and call centres), ownership of end customer relationships has now diversified, with users forming a greater number of direct relationships with various players across the value chain. For example, a significant proportion of consumers now purchase connected devices (e.g., handsets, watches, tablets) directly from device manufacturers and opt for SIM-only mobile subscriptions from MVNOs and re-sellers. It is estimated that UK consumers purchased just 35% of

¹⁹ Ofcom, ["Pricing trends for communications services in the UK"](#), 22 July 2021.

handsets from MNOs and MVNOs in 2020 with the rest being acquired from other retailers, including directly from device vendors.²⁰ Looking ahead, the potential adoption of eSIMs could lead to further changes in customers’ relationships with, and dynamics between, MNOs, device vendors and mobile application providers.

Content and application providers have also grown significant subscriber bases through direct consumer channels that now compare in scale with those of the MNOs. For example, both Netflix and Amazon Prime have in excess 10 million UK subscribers, compared to Three UK’s 7.6 million contract subscribers.^{21,22} In the enterprise segment, the largest three specialist providers collectively have 61% market share in global cloud services²³ and often have direct relationships with business customers that MNOs may have owned exclusively in the past. This diversification of customer relationships may have reduced MNOs’ ability to generate value through partnerships with other value chain players.

Whilst new sources of value have emerged, these are not being captured by the MNOs

New sources of value have emerged, including content subscriptions (e.g., video, music, news etc), mobile applications, advertising, and monetisation of user data. While the generation of this value depends heavily on the underlying fixed and mobile connectivity infrastructure, the value generated has largely been captured by global players operating across wider segments of the value chain.

For example, UK digital ad spending generated £19.2 billion in revenue in 2021 (for all internet connected devices including mobile) and UK in-app purchases are forecast to generate approximately £3 billion in revenue in 2022, up 91.6% from 2019.^{24 25} By comparison, in 2020, UK mobile subscriptions generated around £10 billion, with a further £2.3 billion for out of bundle data, voice and messaging services.²⁶ Several factors have contributed to MNOs being unable to capture new sources of value including their lack of global scale and net neutrality policies that constrain their ability to innovate in the way that they generate value from network infrastructure .

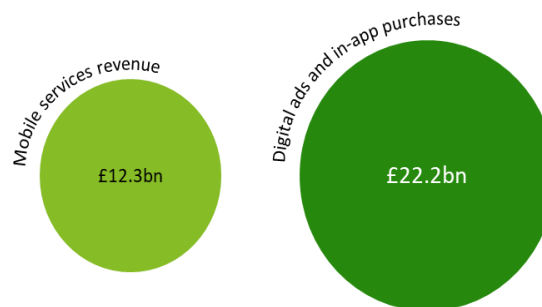


Figure 4: UK 2021 digital ads and in-app purchases revenue compared to mobile services revenue

Asset ownership across the value chain has become more complex and diverse

In addition to changes in services demanded by customers, there has also been an increase in the diversity of ownership of the infrastructure that MNOs use to provide services.

Whereas a decade ago MNOs were the principal owners of assets and competed primarily amongst themselves, they now face competition across the value chain. Faced with rising debt levels, a decade of revenue decline, and significant 5G investment requirements, many European telecoms operators have been exploring new strategies to commercialise their assets; this has included the carving out of mobile tower infrastructure to be acquired by independent tower companies (“towercos”). These changes in market structure, and their potential impacts, are currently being considered by the

²⁰ Deloitte, “Digital Consumer Trends 2020”, 11 November 2020.

²¹ Statista, “Number of Netflix subscribers in selected countries in Europe as of Q2 2021”, 29 October 2021; Statista, “Amazon Prime Video households in the United Kingdom (UK) quarterly 2014-2020”, Q3 2020.

²² Three, “Three UK reports Q1 2021 trading update”, 6th May 2021.

²³ Statista, “Cloud infrastructure services vendor market share worldwide from 4th quarter 2017 to 3rd quarter 2021”, October 2021.

²⁴ eMarketer, “UK Digital Ad Spending 2021”, 29 April 2021.

²⁵ Sensor Tower, “3-Year European Market Forecast”, 24 February 2020.

²⁶ Ofcom, “Telecommunications Market Data Update Q2 2021”, 28 October 2021.

Competition and Markets Authority (“CMA”) in context of the Cellnex and CK Hutchison UK towers merger.²⁷

Other changes in the ownership of assets are also continuing to play out. At the network infrastructure layer, transactions have resulted in backhaul infrastructure being owned within the same telecoms groups as mobile network assets, and there are now large independent infrastructure providers that own significant shares of other value chain assets such as fibre and data centres. Beyond tangible assets, content, mobile application and cloud service providers now own significant intangible assets, for example patented technologies, software, and content copyright.

Concentration in the mobile network supply chain has increased

Over the last ten years, UK MNOs have become increasingly dependent on the supply of network equipment from the three largest vendors – Nokia, Ericsson, and Huawei – which as of 2019 had a combined global market share of 80 percent in the supply of network equipment.²⁸ The UK MNOs procured the vast majority of the core and radio access network equipment from these three vendors, who also provide managed services on which the MNOs rely, to varying extents, for the day-to-day operation of the networks.²⁹

The UK government’s decision to ban the use of Huawei equipment in 5G deployments, and from 5G networks entirely from 2027, may further increase the level of concentration and weaken competition in the supply chain. This has the potential to reduce the competitive constraints that Nokia and Ericsson face in contesting new equipment contracts (e.g., 4G/5G upgrades), some of which have recently been awarded or will be awarded over the next 12-18 months. This has the potential to weaken MNOs’ bargaining power and to lead to an increase in MNOs’ network total cost of ownership (“TCO”) as network refresh contracts are negotiated in years to come. The increase in network costs could, in turn, reduce the value MNOs are able to retain from network investment and/or be passed through to consumers and businesses in the form of higher prices. DCMS has also identified concerns that a reduced choice of vendors in the short term could also impact the quality and resilience of mobile networks.

The evolved mobile value chain has transformed the ways in which value is generated and shared

The mobile value chain has become more disaggregated and complex, and competitive dynamics between the various participants have shifted in ways that have fundamentally changed the way in which value is generated and shared. An illustration of the continually evolving mobile value chain, characterised by the trends outlined above, is provided in Figure 5 below.

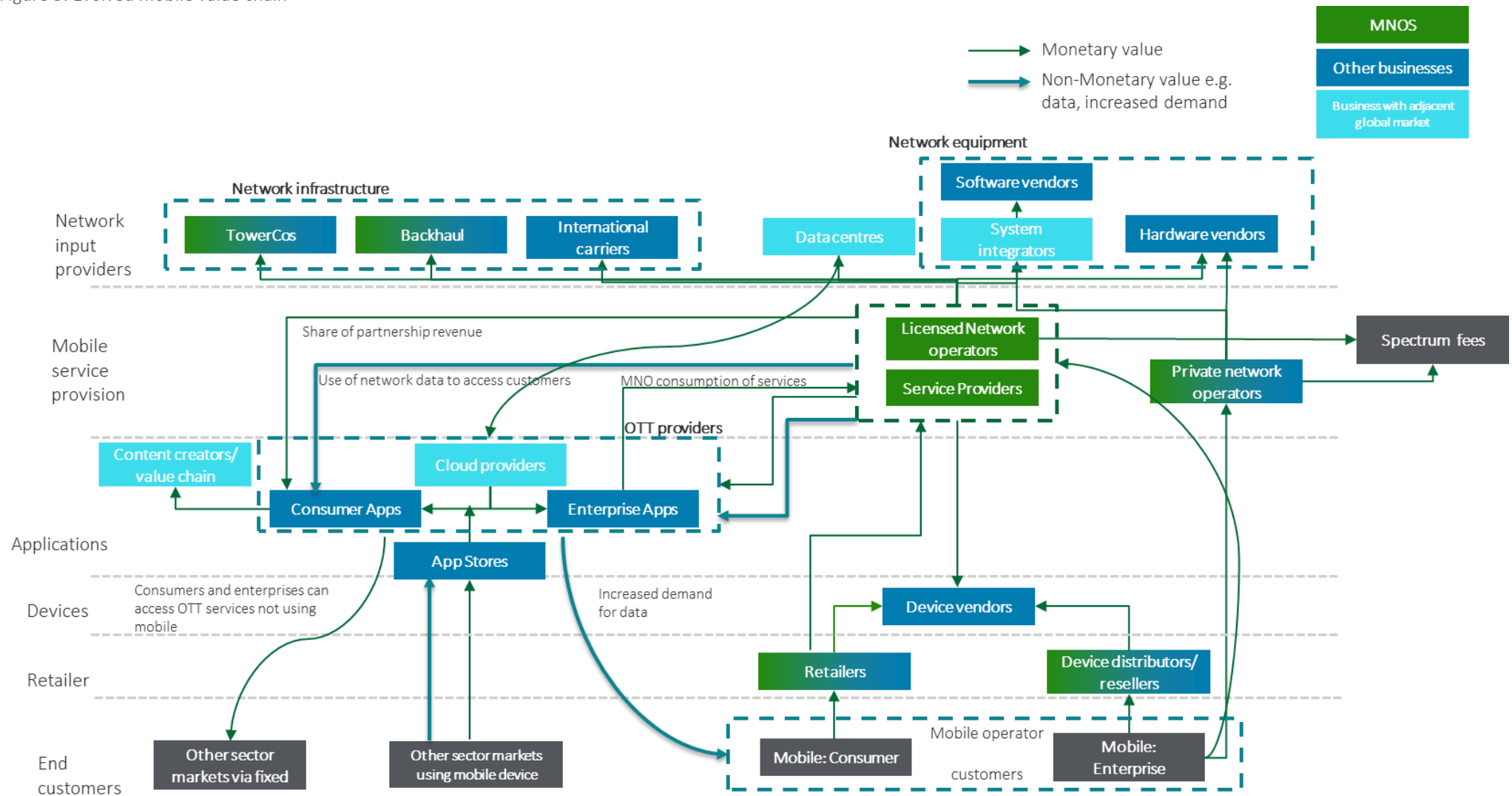
The next section of this report considers the key trends that can be expected to shape the way in which the value chain will evolve in the future, and then explores the potential implications for investment in the UK’s mobile connectivity infrastructure.

²⁷ UK government, "[Cellnex / CK Hutchison UK towers merger inquiry](#)", 16 December 2021.

²⁸ DNB markets, Telecom Equipment – 5G: on the threshold of a new cycle, published 8 October 2019.

²⁹ There are other equipment vendors that have supplied network equipment to UK MNOs including Samsung.

Figure 5: Evolved mobile value chain

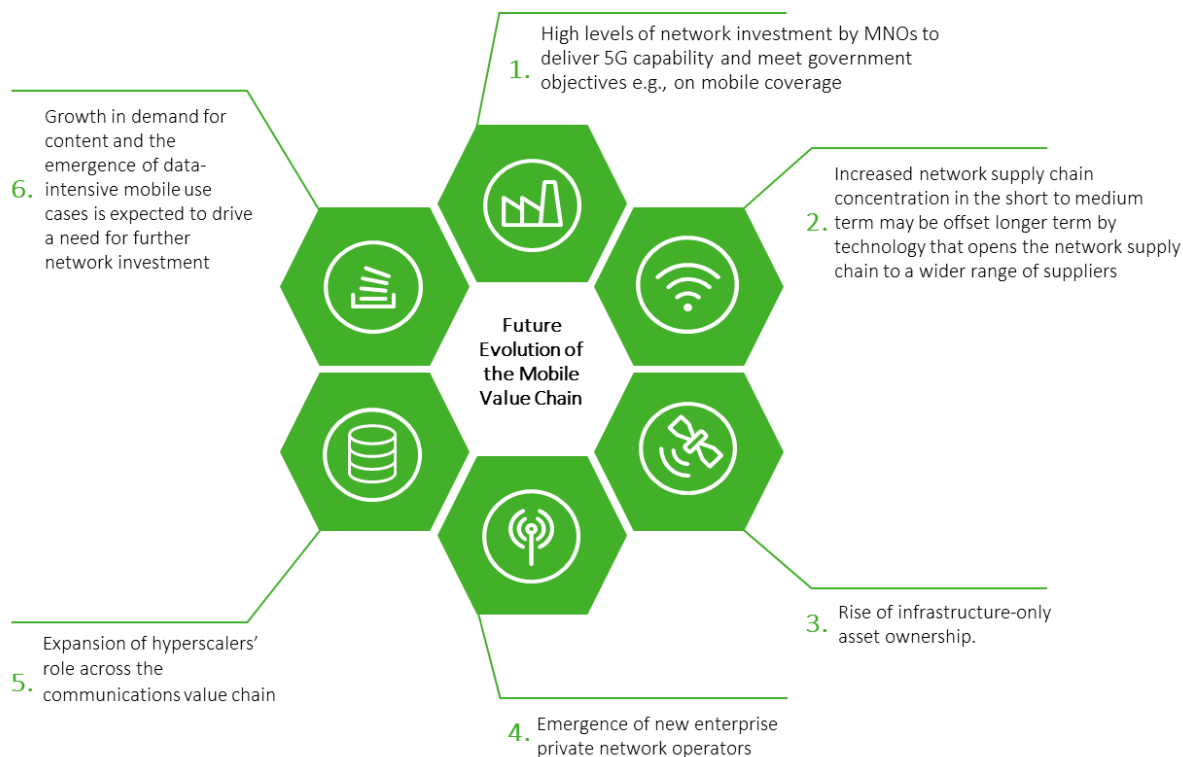


1.2. Future evolution of the value chain

The mobile value chain will continue to evolve; driven by commercial, technological, and regulatory trends that are reshaping the distribution of value and the proportion of that value that provides MNOs with a return on their investment in underlying connectivity infrastructure.

This study has identified six trends that have the potential to impact on the ability of mobile connectivity providers, principally MNOs, to generate and retain returns on investment. These are set out in Figure 6 and described below. These emerging trends are expected to evolve at a time when there is increased focus on, and need for, investment in sustainable, secure and resilient national infrastructure to support mobile connectivity.

Figure 6: Key trends in the future evolution of the mobile value chain



1. High levels of network investment by MNOs to deliver 5G capability and meet government objectives e.g., on mobile coverage

UK MNOs are already deploying 5G to densely populated areas in response to strong competitive pressures but will also be expected to provide 5G coverage more widely in support of UK government's broader digital connectivity ambitions.³⁰ However, there is likely to be significant variation in the capacity and quality of 5G coverage between urban areas in which there is a business case to support the network upgrades (e.g. cell densification, edge computing) and deployment of higher frequency spectrum required to deliver the highest levels of 5G capacity and capability ("full capability 5G") and those areas where basic 5G coverage is provided.³¹

³⁰ Department for Digital, Culture, Media & Sport, "5G Supply Chain Diversification Strategy", 7 December 2020.

³¹ 'Full capability 5G' in this context refers to ultra-high capacity, low latency and high reliability network services (including indoors) through network cell densification and deployment of low, mid and potentially mmWave band spectrum frequencies (e.g., 700 MHz and

Delivering full capability 5G for all will require levels of investment beyond that which has currently been committed. As with previous mobile generations, widescale 5G deployment requires MNOs to invest heavily in upgrading existing macrocell sites and the acquisition of spectrum. MNOs have already spent £2.5bn in obtaining spectrum identified for 5G deployment, and whilst 5G has been deployed on between five and ten percent of UK macro sites, it is estimated that a further £4.4bn will be required to upgrade existing macro cells.^{32 33} In addition to this, delivery of full capability 5G will also require MNOs to invest in densifying networks through the deployment of additional small and macro cells. A report commissioned by DCMS in 2018 estimated that approximately 303,000 small cell sites would be required to provide nationwide full 5G performance to most of the UK population with an associated capex estimate of £19.4 billion.³⁴

These 5G investments come at a time when MNOs are facing increased commercial and policy pressure to improve and extend mobile coverage, particularly in rural areas where it may not be economic to do so. In seeking to improve coverage and build next generation 5G networks, MNOs also face significant costs in operating legacy networks in parallel, the decommissioning of which will take time.

2. Increased network supply chain concentration in the short to medium term may be offset longer term by technology that opens the network supply chain to a wider range of suppliers

The UK government's ban on the use of Huawei equipment in UK 5G networks reduces the number of large-scale vendors able to supply UK MNOs. This may have the effect of weakening MNOs' upstream buyer power in negotiating contracts for supply of 5G equipment. This could, in turn, impact MNOs' ability to retain value from investment in connectivity as a greater share flows through to the equipment vendors. The extent of this impact on value share will in large part depend on the extent to which MNOs are able to pass-through any increased network equipment costs through to mobile prices for consumers and businesses.³⁵ As part of its UK Supply Chain Diversification Strategy, the UK government has announced its intention to support an increase in supplier diversity which, if effective, could help mitigate this impact.³⁶

Longer term, the development and adoption of open interface radio access network ("OpenRAN")³⁷ technologies could help counter this shift in the balance of power. OpenRAN is expected to lower barriers to entry into the network equipment market and potentially lead to the emergence of new software vendors across the radio network value chain. Whilst several UK MNOs have already started deploying OpenRAN in low complexity deployments (e.g., 4G rural deployments), in the short to medium term, there are a range of technological and commercial challenges that are likely to inhibit UK MNOs' ability to deploy OpenRAN at scale. If these challenges can be overcome, it could lead to the emergence of credible vendors that are able to compete with traditional global vendors in segments of the RAN equipment.

3.4 GHz). In this context '5G coverage' refers to providing enhanced network performance (e.g., faster data speeds and lower latency) compared to 4G networks (albeit lower performance compared to full capability 5G) as well as improved indoor coverage primarily through deployment of low frequency spectrum (e.g., 700 MHz).

³² This includes the fees MNOs paid to acquire 700 MHz, 3.4 GHz and 3.6 GHz spectrum licences in recent auctions.

³³ Frontier Economics, "[UK Mobile Market Dynamics – A report for DCMS](#)", July 2018.

³⁴ 98% of the cell sites are modelled for urban, dense urban and suburban areas with the other 2% for villages or less developed areas. Frontier Economics, "[UK Mobile Market Dynamics – A report for DCMS](#)", July 2018.

³⁵ If MNOs are able to pass-through some of the increased network costs to prices, this could reduce the impact on their value retained.

³⁶ Department for Digital, Culture, Media & Sport, "[5G Supply Chain Diversification Strategy](#)", 7 December 2020.

³⁷ OpenRAN opens the interface between individual hardware and software components in the RAN, enabling components from different vendors to be interoperable; this has the potential to enable multiple vendors to compete to supply each of these RAN components.

3. Rise of infrastructure-only asset ownership

The growth of independent towercos is expected to continue as MNOs remain under pressure to address debt levels and free cash flows for investment in 5G. Many of these towercos can be expected to expand into adjacent parts of the value chain; building on their capabilities to become, for example, a neutral host for small cells or providing fibre backhaul, distributed antenna systems, edge data systems and open radio access networks. Towercos could even emerge as wholesale network infrastructure providers (“netcos”), able to use their large tower portfolio to offer active network management for multiple operators, although their ability to do so could be constrained to an extent by MNOs’ continued ownership of spectrum licences.

4. Emergence of new enterprise private network operators

Over the next five to ten years, there is potential for growth in enterprises’ demand for private 5G networks, creating opportunities for MNOs to generate value by deploying and managing these networks for enterprises.³⁸ In a recent Deloitte survey, 98% of businesses indicated that they planned to use both 5G and Wi-Fi 6 together within the next three years.³⁹ These networks could supplement or even provide a credible alternative to solely Wi-Fi based solutions, particularly for connectivity in industrial environments such as manufacturing plants, logistics centres, and ports. For example, Vodafone Business is delivering a 5G mobile private network at Ford’s E:PrIME facility in Essex to support its electric vehicle manufacturing processes, while VMO2 is partnering with Nokia to provide a private 4G network (capable of being upgraded to 5G) for all of British Sugar’s manufacturing facilities.^{40 41}

However, there remains uncertainty around the size and value of the private network market and the timeframe for it to mature. Further, MNOs’ ability to generate value from this part of the value chain will be constrained by the emergence of other players who can obtain shared and/or localised access to spectrum and use this to operate dedicated private 5G networks. Nokia, for example, is the 5G technology provider at Nissan’s automotive test track in Sunderland.⁴² As of September 2021 only seven private networks were being operated by MNOs⁴³ whereas Ofcom has issued over 550 shared access spectrum licences, of which half may be supporting non-MNO private network solutions.⁴⁴ As rational commercial actors without the same licence obligations as the MNOs, these competing private network operators can be expected to ‘cherry pick’ high value enterprise customers, and thereby to extract a greater proportion of enterprise value than has been the case previously.

Whilst enterprise private networks present a genuine value generation opportunity for MNOs, the significant competitive pressure that they face in the enterprise sector means their ability to generate new sources of value from investment in 5G is far from certain.

5. Expansion of hyperscalers’ role across the communications value chain

Large global technology companies will continue to expand their role across multiple parts of the communications value chain, from selling devices, through providing OTT services, to providing data centre, cloud infrastructure, software, innovative solutions and - to varying extents - network infrastructure. These firms leverage their broad scope and global scale in generating returns on their

³⁸ Deloitte, [“Partnering for 5G opportunities”](#), 7 October 2021.

³⁹ Deloitte Insights, [“TMT Predictions 2022 | Wi-Fi 6”](#), 1 December 2021.

⁴⁰ GSMA, [“Ford and Vodafone Harness Private 5G Networks to Continually Optimise Vehicle Manufacturing”](#), 5 May 2021.

⁴¹ VMO2, [“British Sugar and Virgin Media O2 Business launch first multi-site private mobile network”](#), 25 January 2022.

⁴² North, [“Pioneering pilot to bring ground-breaking 5G technology to life for the first time”](#), 25 February 2021.

⁴³ Not all using 5G. Others are in the pipeline.

⁴⁴ Ofcom, [“Connected Nations 2021”](#), December 2021.

investments, increasing their competitiveness and bargaining power compared to investors in connectivity within more limited geographic markets.

Traditionally, hyperscalers have used their global grid of data centres to provide redundancy and resilience, with cloud-based data stored and flowing between multiple data centres. This has driven demand for, and investment in, data centres as well as in the connectivity infrastructure between them. The rapid increase in demand for cloud computing services has been striking, with more than 50 percent of UK based enterprises using cloud services in 2020. Connectivity providers have themselves used cloud providers to increase the efficiency of network and business operations, and to help improve decision-making and agility. Cloud providers could become more involved in network operations if cloud-based networking develops further.⁴⁵

More recently, the growth in demand for latency-dependent use cases has contributed to the need for data processing closer to where data is generated and used (“the edge”). Going forward, hyperscalers can be expected to respond to this by increasing their scale closer to where this demand is generated, expanding to capture value across both enterprise and consumer segments.

The expansion of resources closer to the edge will create new opportunities to generate value from connectivity infrastructure. Bringing computation resources to the edge of the network enables the development of applications that require high bandwidth and ultra-low latency. However, traditional connectivity providers may struggle to compete effectively with the scale, resources, and IP of global hyperscalers in providing cloud/Infrastructure-as-a-Service. Additionally, hyperscalers now offer an increasingly sophisticated suite of tools across verticals to enterprise clients that leans on their depth of IP in software. This is both in adjacencies with existing types of software that are innovated for cloud (e.g., productivity solutions such as Office 365 with Azure) and more cutting-edge solutions that can also enable enterprises to innovate further (e.g., AI solutions such as TensorFlow with GCP).⁴⁶

There will be opportunities for MNOs to partner with hyperscale cloud providers; many of the expected use cases, such as connected cars and wearables, will rely on mobile connectivity, especially 5G. The hyperscalers can bring the distributed cloud infrastructure, and the MNOs can bring the access to local physical locations as well as the radio connectivity. While the propositions are in their early stages, and returns are uncertain, commercial partnerships and revenue sharing deals can share value, spread risk, and reduce costs. In this regard UK mobile connectivity providers have already started to partner with hyperscalers.⁴⁷

The share of value that connectivity providers will be able to retain will be influenced by their relative scale and commercial position compared to the global players with which they compete and/or partner. However, it is expected that MNOs will seek diversity in their cloud edge suppliers, particularly amongst the three largest suppliers, to support supply chain diversity and to provide more choice for end customers.⁴⁸ Depending on how the market for cloud edge and associated services develops, there is a risk that supply chain diversity is not sufficient to avoid uneven partnerships.

Overall, the hyperscale cloud providers can be expected to increase their share of the value within the ecosystem through both supporting MNOs in providing connectivity services as well as generating value from new applications enabled by edge computing.

⁴⁵ For example, Microsoft acquired Affirmed Networks and Metaswitch in 2020 to support the advancement of cloud networking.

⁴⁶ TensorFlow is an end-to-end open-source platform for machine learning.

⁴⁷ Vodafone UK, [Press Release](#), 16 June 2021.

⁴⁸ The Edge, ["How Amazon, Microsoft and Google are courting - and challenging - telcos"](#), 6 April 2020.

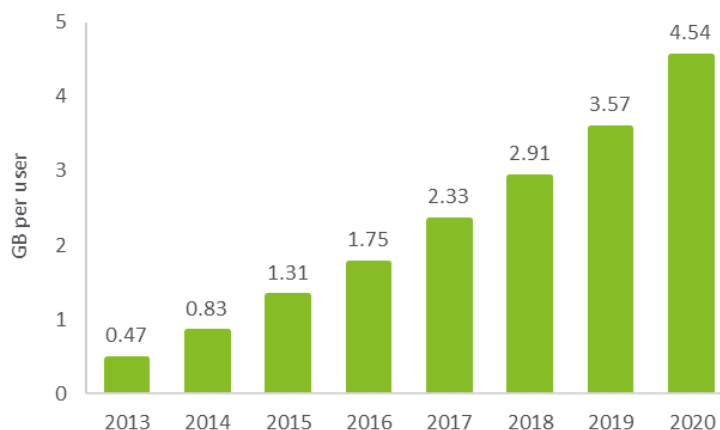
6. Growth in demand for content and the emergence of data-intensive mobile use cases is expected to drive a need for further network investment

Over the last decade, mobile data traffic has grown rapidly, as shown in Figure 7 below; this growth is expected to continue.^{49 50} Competition in the mobile market can also be expected to continue driving down the price of data as the unit cost of data continues to fall. This, alongside continued growth in demand for video streaming, mobile gaming and OTT services, and adoption of other emerging use cases for mobile connectivity (e.g., virtual and augmented reality) will drive increased data demand.

In response, UK MNOs will need to continue to increase network capacity through investments in network upgrades, network densification and spectrum deployment, driving significant further capex and opex. Network capacity investments are driven in particular by growth in busy hour data traffic, which increased by over 60% between 2019 and 2021.⁵¹ In this context, over the last four years, the UK MNOs have invested around £1.9bn in acquiring spectrum to provide additional network capacity.⁵² Developments in network technology are however expected to continue to reduce the unit cost of data (e.g., through increased spectrum efficiency and lower energy costs) and to help manage the incremental costs of adding capacity in response to rising data traffic.

The evidence to date suggests that, overall mobile network and service revenues have continued to decline. Whilst the demand for content and OTT services has undoubtedly stimulated demand for larger data bundles, market competition has driven down the price of data, resulting in mobile service revenues and average revenues per user (“ARPU”) declining steadily over time. For example, Ofcom’s recent Pricing Trends Report shows that while there has been a 388% increase in average mobile data use between 2015 and 2020, the average monthly household spend on mobile voice and data declined by 24% over the same period due to falling prices.^{53 54} UK MNOs have been able to generate additional revenues through bundling of content with mobile subscriptions, but this has been relatively modest in comparison to overall mobile service revenues.

Figure 7: UK average monthly mobile data per user



Source: Ofcom communications market report 2021

⁴⁹ Ericsson, "[Mobile data traffic outlook](#)", November 2021.

⁵⁰ Department for Digital, Culture, Media & Sport, "[Wireless Infrastructure Strategy: call for evidence](#)", 17 November 2021.

⁵¹ Ofcom, "[Connected Nations 2021](#)", December 2021.

⁵² This includes the fees MNOs paid to acquire 2.3 GHz, 3.4 GHz and 3.6 GHz spectrum licences in recent auctions.

⁵³ Ofcom, "[Pricing trends for communications services in the UK](#)", July 2021.

⁵⁴ Ofcom reports that average mobile data use per month increased from 0.8 GB in 2015 to 3.9 GB in 2020, while average monthly household spend on mobile voice and data fell from £50.28 to £38.22 between 2015 and 2020.

2. Investment Challenges

The evolution of the mobile value chain will continue to challenge the generation of value from infrastructure investment; this could constrain investment incentives such that wider economic and social benefits of digitalisation are not fully realised.

In an increasingly complex mobile communications value chain, MNOs' ability to generate and retain returns on investment is more constrained than in the past; value is increasingly being captured by other value chain players whose business models benefit from global scale, integration and network effects that MNOs are unable to replicate. While MNOs are continuing to invest in their UK networks low margins in could be placing limits on capex in UK operations and the extent to which competition can drive investment in areas in which returns are marginal.

In this section, we discuss the returns generated, and investments made, by UK MNOs compared to MNOs operating in other mobile markets. We also explore how value chain trends can be expected to affect UK MNOs' ability to generate value from investment in connectivity. Finally, we consider the implications of constraints on network investment and the wider impacts on the UK economy and society.

2.1. Challenges in generating value from infrastructure investment

Investment in new technologies capable of transporting data more efficiently has enabled consumers to enjoy more cost-efficient data services and access to OTT applications

MNOs have invested heavily in their networks as they compete on price and quality of service. Whilst the growth in peak traffic has driven network capacity investments, MNOs have invested in new technologies capable of transporting data more efficiently at a lower cost per gigabyte ("GB"); this has contributed to MNOs being able to maintain broadly stable or declining prices, whilst volume consumed has increased by 388% since 2015.⁵⁵ When quality of service is also factored in, prices for telecommunications services have fallen significantly with the output price falling by 3.3% per year on average between 1998 and 2018 but the price of inputs increasing by 0.2%.⁵⁶ This has enabled consumers, and service providers that use mobile data, to continue generating value without demand being impacted negatively by rising data prices.

However, investors in connectivity have struggled to generate additional revenue from these investments and debt levels have increased

The UK's MNOs have experienced broadly flat mobile revenues since 2010, in real terms, and a notable decline since 2018. This revenue decline is driven by falling ARPU; prices of an average mobile bundle subscription have fallen by 22% since 2015, with unit data prices falling even more sharply (in part reflecting declining unit costs).⁵⁷ At the same time as revenues have fallen, MNO group net debt has

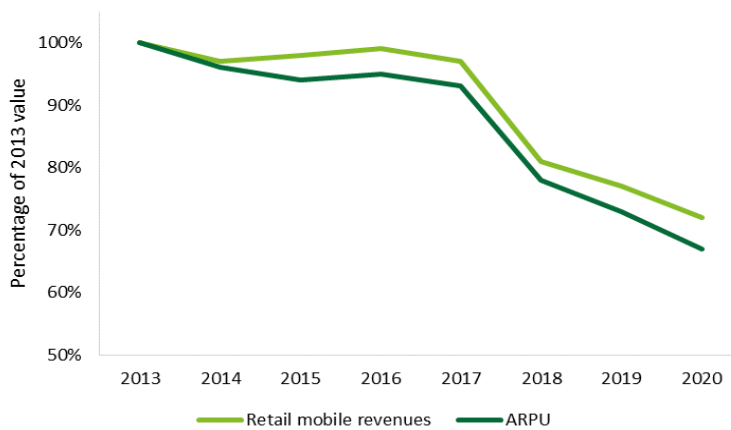
⁵⁵ Ofcom, "[Pricing trends for communications services in the UK](#)", 22 July 2021.

⁵⁶ Office for National Statistics, "[Indicative impact of a new framework including double deflation on industry volume estimates of GDP: Blue Book 2021](#)", 28 June 2021.

⁵⁷ Ofcom, "[Pricing trends for communications services in the UK](#)", 22 July 2021.

increased, with BT Group’s net debt doubling between 2015 and 2019⁵⁸ and Vodafone Group’s net debt to EBITDA ratio rising to 2.8 in 2021. As debt has increased and company valuations have fallen, both telecoms groups have a debt/equity ratio greater than one.

Figure 8: Retail mobile revenue and ARPUs compared to 2013



Source: Ofcom communications market report 2021.⁵⁹

MNOs have struggled to increase revenue per customer; this trend is set to continue with the average 5G price premium over 4G services falling from £21 per month in 2019 to just £3 per month in 2020.⁶⁰ This may have fallen further since, with three out of the four operators offering 5G SIM-only deals at no extra cost to the consumer compared to 4G.⁶¹ This may in part be driven by competition, but could also reflect consumers’ limited appreciation of, or willingness to pay a premium for, higher capacity mobile broadband services (e.g. they may not yet fully recognise or account for the full benefits that higher capacity mobile broadband services can deliver).

European telecoms Groups’ UK operations are less profitable than other divisions

In general, as illustrated in Figure 9 below, telecoms operations in the UK are less profitable than in other European markets; some operations in other large European markets earn EBITDA margins that are nearly double those in the UK. Of the three European telecoms Groups with operations in the UK, just one has UK operations whose profitability has been similar to other European operations (Telefonica in the UK compared to Germany).⁶²

⁵⁸ BT’s net debt increased by 63% from 2019 to 2020 however this was impacted by IFRS 16 accounting changes.

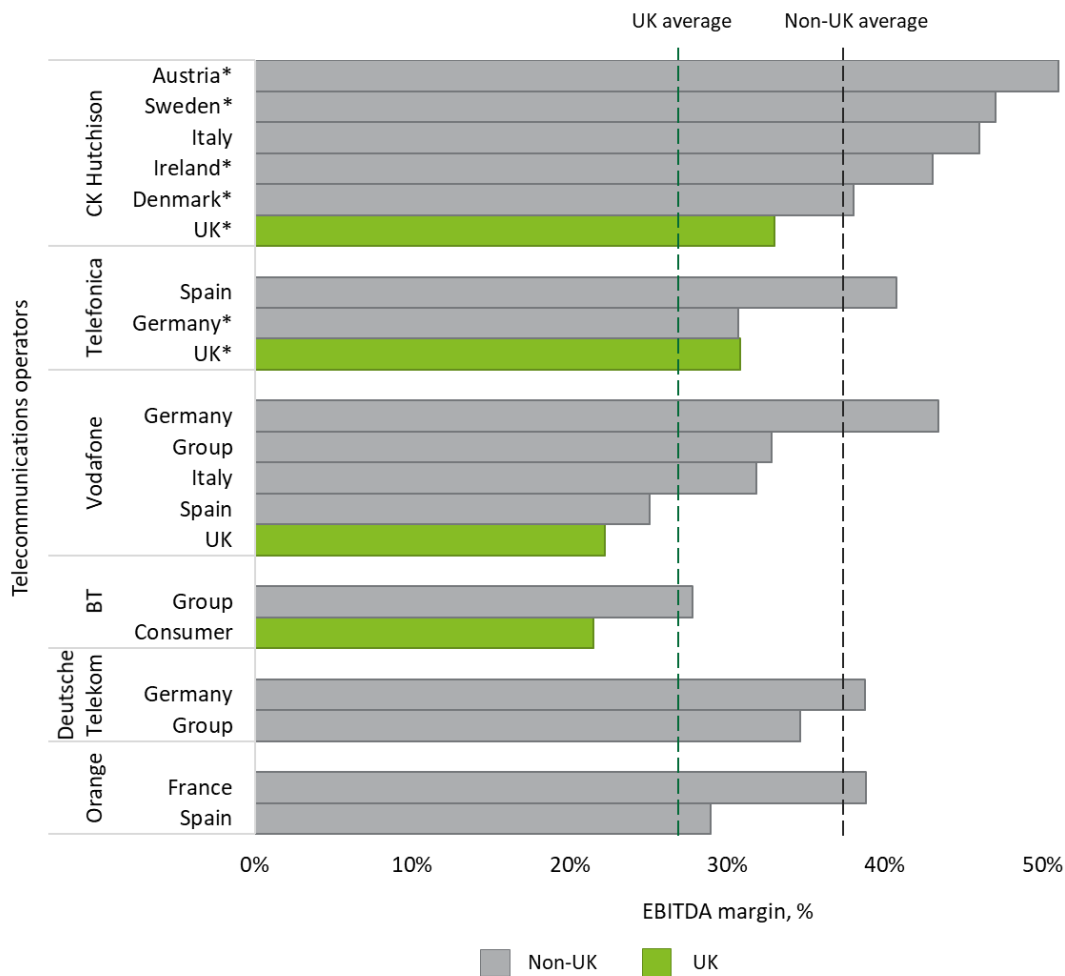
⁵⁹ Note that 2018 – 2020 values do not contain handset revenues due to an accounting change so are not directly comparable to prior years.

⁶⁰ Ofcom, “Pricing trends for communications services in the UK”, 22 July 2021. Note that in 2019 only EE and Vodafone offered 5G and only offered a bundle with large call, SMS and data allowances whereas by 2020 other operators were offering 5G with lower prices and different bundles.

⁶¹ TechRadar, “5G SIM only deals”, 1 December 2021.

⁶² Note that profits can be significantly lower than EBITDA due to MNOs’ capital investments in spectrum and assets resulting in significant depreciation.

Figure 9: Cross-country comparisons of EBITDA margins across UK and European operators⁶³



*Operations are primarily mobile at the time of reporting. Some of these operators have fixed revenues but at approximately 10% of total revenue or less.

Source: Company annual reports⁶⁴, Deloitte analysis

Each of the UK’s four MNOs are part of larger, multi-divisional businesses that make capital allocation decisions across a portfolio of operations and assets. In this context, the low profitability of the UK mobile market makes it a relatively less attractive destination for future investment than other markets, with the potential outcome that UK investments that are considered marginal may be delayed or not made at all. These more marginal investments may include those that support wider policy objectives such as rural and indoor coverage, and network availability on public transport or harder to reach areas.

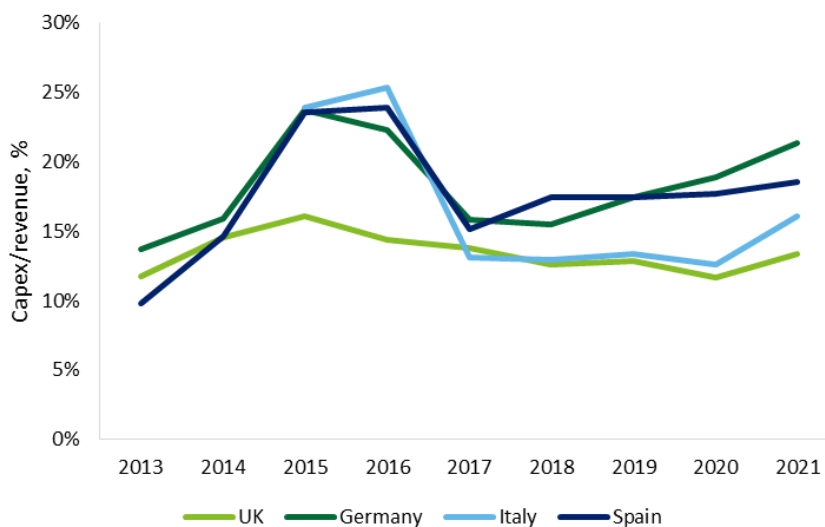
⁶³ Due to limitations of data available in annual reports, the values presented here cover all products offered in those markets, including fixed and mobile services. The countries and companies presented have been selected on the basis that UK operations are reported separately in annual reports. Deutsche Telekom and Orange are presented to provide additional comparison of large telecom providers that have overlap in non-UK geographic operations.

⁶⁴ EBITDA margins for the last complete financial year used. BT and Vodafone report for April 2020 – March 2021 and the other operators’ reports for January – December 2020.

Relatively lower margins could be impacting the amount of capex invested in UK operations

When comparing capital expenditure spending relative to revenues, there is emerging empirical evidence that lower profitability in the UK could be impacting the proportion of revenue that is spent on capex. For example, following the sale of Vodafone Group's share of US-based Verizon operations, Vodafone made investments in its networks and operations elsewhere. While some of this was invested in the UK, as a proportion of revenue the increase was less than in Germany, Italy and Spain.⁶⁵ Further, in all but one year since, the UK capex/revenue ratio has remained below those of operations in other mobile markets, suggesting that lower returns in the UK are resulting in lower capex (2021 is the only year in which capex increased in absolute terms since 2015). In comparison, EBITDA margins and capex have been increasing in Germany since 2017.

Figure 10: Capex/revenue shares of Vodafone's big four European operations



Source: Deloitte analysis of Vodafone Group annual reports

The level of capex relative to revenue shown for Vodafone UK in Figure 10 is broadly representative of the other UK connectivity providers. Over the past two financial years⁶⁶ BT Consumer (the BT Group division within which most of its mobile revenues and costs are reported) and Telefonica UK had capex/revenue ratios between 9.1% and 13.6%, in line with Vodafone UK.⁶⁷ There is a risk that lower returns in the UK could result in lower capex over the medium term than might otherwise be the case.

While investors in connectivity have struggled to generate growth in returns, other participants in the value chain have seen significant growth from their investments

Compared to the MNOs, the value that other participants in the value chain have been able to extract has grown significantly between 2010 and 2020.⁶⁸ In a 2021 report on the global telecoms value chain, Kearney estimated that while providers of connectivity have managed to increase their market size by just 3% globally the overall value chain has expanded by 119% with network infrastructure providers, including, towers, equipment and cloud, growing nearly fourfold, devices growing by 80% and digital services (including e-commerce, applications and media) growing fivefold. Within this, applications and

⁶⁵ Note that capex values include mobile, fixed network and general business operations.

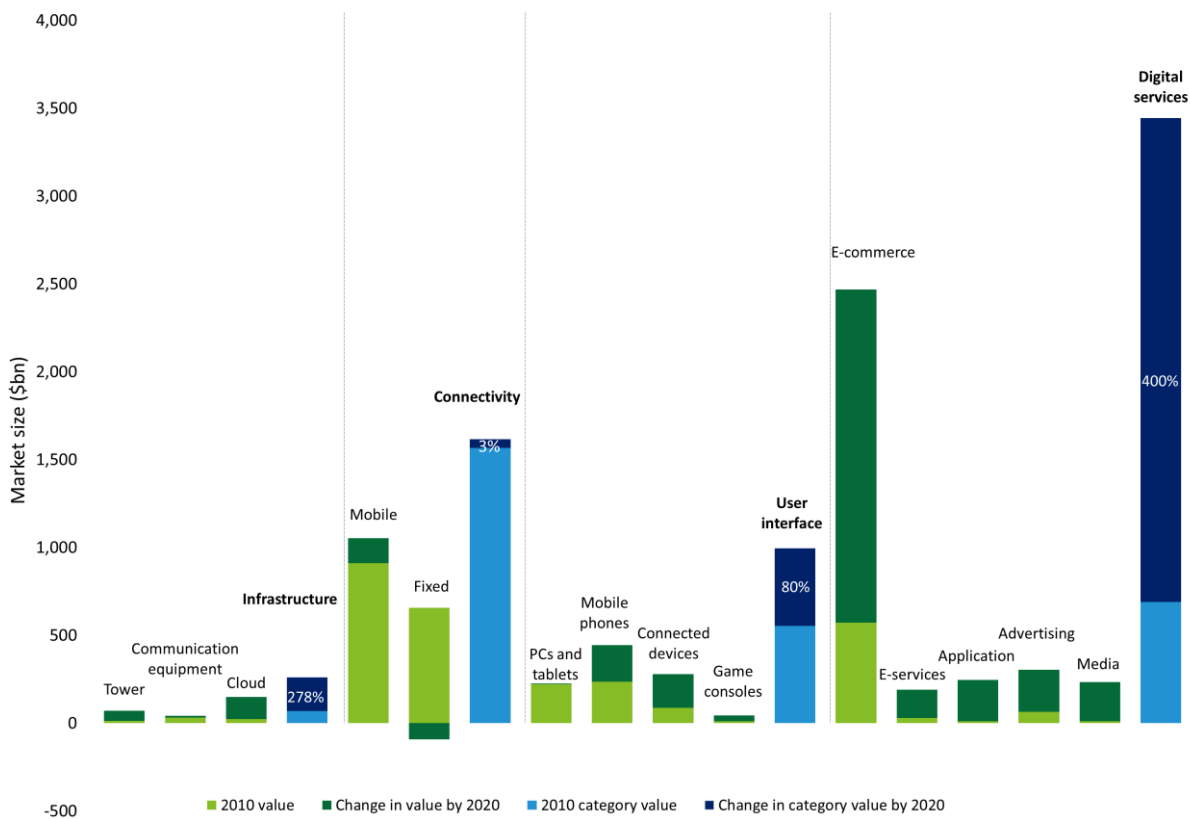
⁶⁶ Due to differences in financial reporting for Telefonica and Three this is 2019 and 2020, for BT and Vodafone this is March 2019 to March 2021.

⁶⁷ Telefonica 2020 and BT 2021 annual reports.

⁶⁸ Kearney, "[Transforming the telecom value chain – a platform business model](#)".

media have grown over 20-fold in a ten-year period.⁶⁹ This suggests that changes in the value chain outlined in section 1 of this report, combined with the impact of innovative business models, have enabled other participants in the value chain to extract more value from their investments in the communications ecosystem than the MNOs have made from their investments in connectivity.

Figure 11: Change in telecommunications market size from 2010 to 2020



Source: Deloitte analysis of Kearney data.⁷⁰

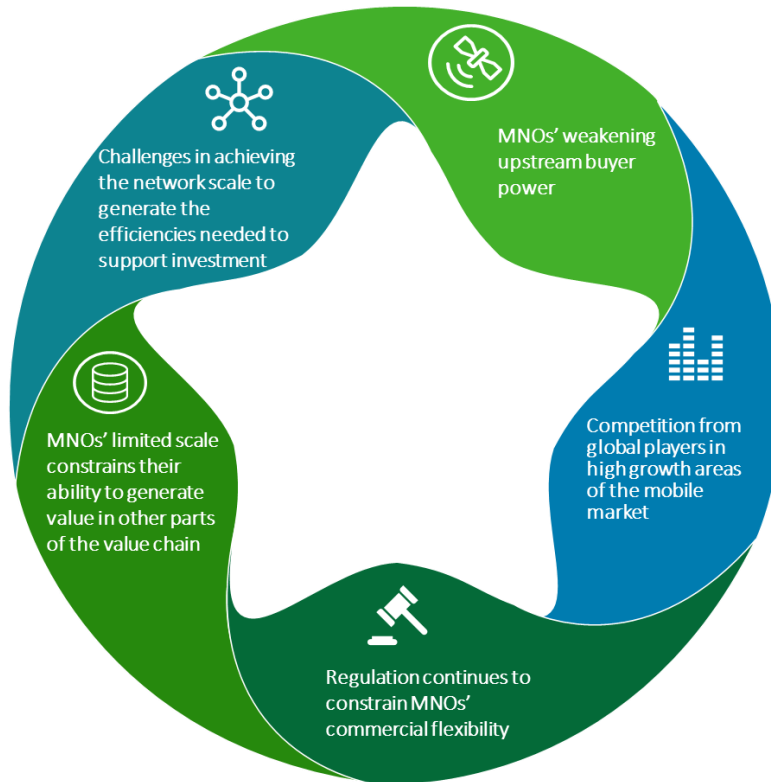
⁶⁹ The growth in network infrastructure value has been driven by a range of factors potentially including value generated through increased tower sharing ([The Rise of the TowerCo](#), Deloitte), increased global demand for network equipment (and the economies of scale arising from that) fuelled by significant investment in mobile network infrastructure globally ([GSMA Global Mobile Trends, December 2020, page 5](#)), and the rapid growth in cloud service adoption ([Gartner Press Release, August 2 2021](#)).

⁷⁰ Kearney, "[Transforming the telecom value chain – a platform business model](#)".

2.2. Factors constraining returns on investment in connectivity

This study has identified five factors that have the potential to constrain MNOs returns on network investment in the future; these are outlined below.

Figure 12: Key factors constraining future MNO value



MNOs' weakening upstream buyer power

Increased concentration in the network equipment supply chain, as outlined in section 1.2, has the potential to weaken MNOs' upstream bargaining power in the procurement of critical inputs to network deployment.

MNOs can be expected to continue to exert a measure of countervailing buyer power in commercial negotiations with network equipment vendors, leveraging their position as some of the largest buyers of RAN equipment across Europe. However, the increased concentration in the UK network equipment supply chain, following the government's ban on the use of Huawei equipment in UK 5G networks, has the potential to weaken MNOs' bargaining power in negotiations for future network equipment supply contracts, at least in the short to medium term. DCMS is currently undertaking a programme to support the diversification of the supply chain that could help mitigate this impact by increasing the number of options available to MNOs.⁷¹

The development and adoption of new technologies such as OpenRAN could help offset this by lowering the costs of switching between vendors, and by lowering barriers to entry for emerging vendors. However, these technologies will take time to mature, and require significant upfront investment, before they can be deployed across the UK's mobile networks; this is highlighted by the

⁷¹ Department for Digital, Culture, Media & Sport, "[5G Supply Chain Diversification Strategy](#)", 7 December 2020.

Government and MNOs' joint ambition for 35% of mobile traffic to use open and interoperable solutions by 2030.⁷²

If these trends do indeed have the effect of weakening MNOs' upstream bargaining power this could put upward pressure on the cost of procuring network equipment. This could, in turn, reduce the proportion of value that MNOs are able to retain in the future, and would place further pressure on MNOs' ability to retain value generated from investment in connectivity. The extent of this impact on value share will in large part depend on the extent to which MNOs are able to pass-through any increased network equipment costs through to mobile prices.

Competition from global players in high growth areas of the mobile market

Beyond continued competition between themselves, the MNOs can also expect to face new sources of competition in potential growth areas. Whilst competition stimulates innovation and investment, these new sources of competition can also constrain the value that MNOs are able to generate from investment in 5G and future generations of networks.

For example, private 5G enterprise networks present a significant value opportunity for MNOs, which could help support investment in the wider deployment of full capability 5G public networks. However, a range of more recent entrants to the mobile value chain, including hyperscalers, equipment vendors, infrastructure providers and public bodies are developing their own private network propositions and competing directly with the MNOs for high value enterprise and public sector contracts. For example, Cellnex UK was recently awarded a 10-year contract to deliver a 5G private network to support businesses in Basingstoke.⁷³ AWS has also launched an end-to-end 5G private network proposition which includes deployment, operation, and scaling of the network, with all required hardware and software provided by AWS.⁷⁴

Whilst these new sources of competition in the enterprise segment can be expected to deliver benefits in terms of innovation and investment in enterprise markets, they may also erode MNOs' ability to generate the scale that may otherwise support investment in deploying full capability 5G services for consumers and many businesses. The wider impacts of this could be felt most acutely if new private network operators seek to 'cherry pick' the highest value (i.e., most profitable) enterprise customers, capturing or competing away a significant portion of new value that MNOs may otherwise be able to generate from network investments to support public 5G networks.

To the extent that the investment case for wide scale full 5G capable networks is dependent on the value generated from both consumers and enterprises (i.e., deployment of full capability 5G networks in some areas may only be economic where value can be generated from enterprise as well as consumer segments), an erosion in the value that MNOs generate from private networks could weaken the investment case for wider deployment of full capability 5G public networks.

Regulation continues to constrain MNOs' commercial flexibility

Regulatory and policy decisions, from net neutrality and consumer regulation to merger controls and spectrum licensing, will continue to constrain MNOs' commercial flexibility and their generation of returns on investment in connectivity.

⁷² Department for Digital, Culture, Media & Sport, "[Ambition for the deployment of open and interoperable RAN architectures](#)", 8 December 2021.

⁷³ Cellnex, "[Cellnex UK awarded a 10-year contract to deliver 5G private network to support businesses in Basingstoke](#)", 15 November 2021.

⁷⁴ [AWS Private 5G](#).

Current UK net neutrality rules are expected to continue restricting MNOs' ability to generate additional sources of value through commercial arrangements with application, content, and OTT providers. The rules also limit MNOs' ability to manage network traffic efficiently, potentially driving higher network costs that will be borne ultimately by consumers and businesses, and/or which may in turn constrain MNOs' ability to invest. For example, the rules preventing MNOs from directing non-time critical traffic away from peak hours may drive increased network costs, while restricting MNOs' ability to send cost-reflective price signals that could support more efficient use of networks (i.e., enable the costs of increasing network capacity to be recovered from the applications that drive the need for greater capacity, in order to support efficient consumption of limited resources).

Further, whilst merger controls seek to prevent a significant lessening in competition, these measures can also restrict MNOs' ability to generate the scale, and the efficiencies arising, to support investment (e.g. eliminating inefficient duplicative investment, enabling networks and spectrum to be combined to increase network capacity more efficiently).

MNOs also face spectrum licencing fees (both to acquire and retain licenses) and are required to provide widescale national coverage, as set out within their spectrum licence coverage obligations. These obligations require the deployment of a large number of often underutilised sites in rural areas with low or negative returns.

MNOs' weakening limited scale relative to global players constrains their ability to generate value from other parts of the value chain

MNOs' relative lack of global scale, combined with the regulatory constraints considered above (e.g., net neutrality rules), weakens their relative position in commercial negotiations with global players in high growth segments of the value chain, limiting their potential share of new value generated.

MNOs in the UK and abroad are seeking to develop new value streams through revenue sharing partnerships with providers of content, applications and cloud and edge computing services. For example, UK MNOs currently have partnerships with global content providers, whereby content subscriptions are included within mobile subscriptions and a proportion of revenue is shared. While MNOs are able to leverage their market position in the mobile service market, including their domestic or even pan-European subscriber base, their commercial negotiations are with players in other parts of the value chain that are able to leverage global scale, and rapidly growing subscriber bases. In its recent review of the digital advertising market, the CMA highlighted the potential for vertically integrated digital platforms to leverage market position in digital advertising markets across parts of the value chain and/or adjacent markets (although mobile service markets were not identified specifically). The dynamics of participation in these global markets may constrain UK MNOs' ability to generate significant sources of value from new opportunities; as these global players continue to grow and expand, while seeking to maximise the value they generate from their products and services, the share of the value generated by domestic telecoms operators from these partnerships could be eroded further.⁷⁵

The relative lack of scale also restricts MNOs' ability to expand and compete in adjacent markets and high growth segments of the value chain. For example, where global content and applications providers can generate revenue and recover investments from a global subscriber base, MNOs' subscriber bases are generally limited to the UK and parts of Europe meaning MNOs have smaller addressable markets while having to rollout national networks in each country. This factor, alongside

⁷⁵ Where two parties are in commercial negotiations (e.g., for revenue sharing partnerships), both parties acting rationally can be expected to seek to maximise the value (e.g., revenue) they generate directly from that negotiation, and may not be incentivised to account for the impact on the other party or their incentives to invest.

significant pressure on MNOs' cash flows, regulatory obligations and significant investment requirements may limit MNOs' ability to expand into other markets or parts of the value chain to generate new sources of value that could support investment in connectivity.

Challenges in achieving the network scale to generate the efficiencies needed to support investment

MNOs' ability to deploy full capability 5G networks at scale will depend on the extent to which they are able to generate the economies of scale that make investments economic. This is particularly important given the significant investment needed to provide the capacity required to deliver full capability 5G (e.g., network densification through the deployment of small cells). Increased scale can enable MNOs to generate greater efficiency, reducing deployment costs and improve returns on investment.

In urban areas, where demand is concentrated, each of the UK MNOs may be able to generate the scale economies required to support deployment of full capability 5G networks. However outside of these areas, more dispersed demand and relatively higher deployment costs mean that it may not be possible for multiple MNOs to generate the scale required to sustain the business case for the deployment of full capability 5G networks.

Network consolidation and co-investment, as well as further network sharing can help MNOs generate scale economies by consolidating demand, pooling costs and risks, and reducing the incremental cost of adding network capacity. However, merger and broader competition policy may restrict their ability to gain scale through consolidation.⁷⁶

The cumulative effect of the five factors discussed above create potential to constrain MNOs' ability to generate value from investment in connectivity. The tightening of such constraints will, in turn, have significant implications for incentives to invest in connectivity as outlined below.

2.3. The impact on incentives to invest in UK mobile connectivity

Constraints on MNOs' ability to generate value from network investments could limit further investment in UK mobile networks being unlocked and limit rollout of full capability 5G networks

Constraints on MNOs' ability to generate revenue from new investments, allied to increasing cost pressures, risks weakening incentives to invest under a range of different assumptions. For example, even under classical investment theory, which suggests that companies will invest in projects where the net present value ("NPV") of future cash flows is positive, declining marginal revenues from network investment and upward pressure on network input costs have the effect of reducing the NPV of network deployments for a given discount rate.⁷⁷ This would result in a greater number of investments at the margin being rejected (i.e., those projects that would no longer have a positive NPV or where the internal rate of return ("IRR") is below the cost of capital).⁷⁸ For example, Vodafone Group has stated in its capital allocation strategy that, in order to deliver shareholder value, it will only make investments where ROCE exceeds the cost of capital over the medium term.⁷⁹ This could lead, for example, to investments in full 5G capability outside of urban areas, where the direct return from upgrading existing mobile sites and building new sites is lowest, being rejected.

⁷⁶ The MNOs already have arrangements in place that are permitted under relevant network sharing rules.

⁷⁷ Tobin, "A General Equilibrium Approach to Monetary Theory", 1969.

⁷⁸ If a reduction in cashflows leads to the Internal Rate of Return of an investment falling below the cost of capital, this could lead to the investment being rejected.

⁷⁹ Vodafone, "FY21 Results", May 2021.

The impact on levels of investment could be even more significant; if MNOs' ability to generate value (e.g., in the form of cashflows) declines further, this could also reduce total capital budgets (i.e., the total amount MNOs can invest). A reduction in retained earnings would reduce the available cash to be re-invested.⁸⁰ Further, whilst capex may be funded through equity or debt, investors in telecoms groups are typically focussed on financial ratios such as net debt and EBITDA margins that are not directly related to NPV, but which reflect the groups' underlying capacity to pay dividends. This can drive management to set a capital budget (i.e., a capex envelope) for the group as a whole as well as for individual operations in different country markets (e.g., between the UK and another European market) and business units within them (e.g., between fixed and mobile), based on their respective capacity to generate sufficient future cashflows.

Each UK MNO may therefore need to justify its annual capital budget within its respective parent group, and then keep within budget, by prioritising investments that have the highest IRR (as opposed to investing in any project with a positive NPV or IRR above the cost of capital). If UK MNOs' ability to generate cashflows is constrained, and below that of operators in other markets (as indicated in Figure 9), this could lead to less investment in UK mobile networks than could be realised in different circumstances. This will most likely have the greatest impact on areas where the IRR of investment is lowest (e.g., network densification outside of urban areas).

Uncertainty about the proportion of value generated by 5G investments that can be retained by the MNOs risks delays and constraints to full capability 5G deployment

There remains uncertainty around the level of value that MNOs will be able to generate from 5G network investments. Enterprise 5G private networks are still at a pilot stage, and the value generated by the UK MNOs could be constrained by the availability of alternative technologies (e.g. WiFi 6) and the emergence of new private mobile network operators. In the consumer segment, as noted previously, UK MNOs have largely been unable to sustain pricing premia for 5G consumer subscriptions, potentially reflecting both the impact of competition and, as yet, limited consumer willingness to pay.

This uncertainty, allied to the high sunk costs associated with network investments, could lead to constraints on widescale rollout of full capability 5G networks. While all four UK MNOs have launched 5G in some areas, the 5G population coverage in the UK (c.50%) lags behind other large advanced economies including the USA (76%) and South Korea (93%), where ARPU, a key determinant of returns, is considerably higher.⁸¹ Further, while some UK MNOs have announced plans to rollout nationwide 5G coverage over the next 6-7 years, deployment of full capability 5G networks (e.g. in terms of high-capacity) is expected to be much more limited.

'Real options' theory suggests that when there is uncertainty around future cashflows (e.g., demand uncertainty), and/or significant sunk costs, investors may delay or carry out investment incrementally to preserve flexibility.⁸² This is particularly relevant to 5G network investments, where there is significant uncertainty around the ability of investors in 5G networks to generate and retain value from the investment in full capability 5G networks (e.g., due to uncertain consumer demand, regulatory constraints on network monetisation, new sources of competition etc.) as well as high sunk costs (e.g.,

⁸⁰ Vodafone stated in its FY21 Annual Report presentation that incremental 5G investments will have to be funded through successful delivery of efficiency savings rather than significant group wide increases in capex. Given the low marginal costs in the communications sector, a reduction in retained earnings would result in a reduction in the cash made available by efficiency savings.

⁸¹ A report by ETNO estimated that 5G population coverage in the USA and South Korea was at 76% and 93% respectively by Q3 2020 (ETNO, The state of digital communications, 2021). The ETNO report also estimates that mobile ARPU in the USA and South Korea was €37 and €24 respectively, compared to the UK's average ARPU of around €20 for post-pay only (Statista) in 2019.

⁸² A. Dixit and R. Pindyck, "Investment under uncertainty", Princeton University Press, 1994.

investment in network densification). In the face of uncertainty around returns and high sunk costs, rational investors may defer and/or constrain marginal investments in full 5G connectivity.

UK MNOs' 5G networks rollouts have focussed primarily on urban areas

MNOs are acting rationally by prioritising deployments where there is the greatest demand for network capacity and therefore greatest potential returns on investment. This is reflected in the fact that, more than two years into the commercial rollout of 5G, half of the UK's 3,000 busiest cell sites now have 5G capabilities compared to just 5% of cell sites in suburban areas.⁸³ This is having an observable effect on the distribution of 5G coverage. While more than 50% of the UK population has 5G coverage from at least one MNO UK, by comparison UK 4G population coverage had reached 72% within the first two years of launch.⁸⁴ Further, only 6-10% of the UK landmass has 5G coverage from at least one MNO.⁸⁵

There are signs that the uncertainty around monetising 5G networks is constraining investment

It is estimated that cumulative investment in 5G deployment in the UK had reached £2.3bn by 2020.⁸⁶ This investment has focussed primarily on deploying 5G in high traffic areas to provide extra capacity rather than wider 5G coverage.⁸⁷ This is further highlighted by the proportion of capex MNOs are spending on 5G access investments. Typically, MNOs spend approximately 20% of their total capex on expanding mobile network coverage and capacity, potentially higher during a period of new technology deployment.⁸⁸ ⁸⁹ However, in 2020, capex on 5G access accounted for approximately 18% of MNO mobile network capex⁹⁰, compared to 55% on other mobile access such as 4G so, while 5G capex is growing, it is currently less than the 20% of total capex benchmark.⁹¹ ⁹²

Current estimates suggest that the investment incentives may not be sufficient to deliver widescale full capability 5G services across the UK

Estimates of 5G network investments to deliver high 5G coverage and full capability 5G in more urban areas are forecast to reach £10.9bn by 2030 and £14.4bn by 2040.⁹³ This is significantly lower than the £23.8bn that has been estimated as necessary to provide 'seamless high performance connectivity'.⁹⁴ This suggests that there is potentially an investment funding gap of up to £9.4bn that will need to be filled to ensure that all consumers and businesses have access to full or at least close to full 5G capability networks. In the face of weakened incentives to invest in the widest possible availability of full 5G infrastructure that will be critical to the continued digitalisation of the UK economy and society, policy makers will need to consider whether alternative forms of funding or investment and deployment models, may be required as they have been with previous network rollouts.

⁸³ Ofcom, "[Connected Nations 2021](#)", December 2021.

⁸⁴ 4G: Ofcom, "[The Communications Market Report](#)", 7 August 2014. 5G: Ofcom, "[Connected Nations 2021](#)", December 2021.

⁸⁵ Ofcom, "[Connected Nations 2021](#)", December 2021.

⁸⁶ Analysys Mason, "[Analysis of the costs and benefits of 5G geographical roll-out in Europe: final report, page 17](#)", 29 March 2021.

⁸⁷ This is in part due to the fact that 700 MHz spectrum, which is being deployed to provide 5G coverage, wasn't awarded by Ofcom in April 2021.

⁸⁸ Vodafone, "[Vodafone Group Results: for the year ended 31 March 2018](#)", 15 May 2018.

⁸⁹ Frontier Economics, "[UK Mobile Market Dynamics – A report for DCMS](#)", July 2018.

⁹⁰ Note that this is only of mobile network capex whereas total capex will include capex on other services as well as retail and business operations.

⁹¹ Ofcom, "[Connected Nations 2021](#)", December 2021.

⁹² This may in part reflect large investments being undertaken by UK telecoms operators in fixed broadband networks.

⁹³ Analysys Mason, "[Analysis of the costs and benefits of 5G geographical roll-out in Europe: final report, page 17](#)", 29 March 2021.

⁹⁴ Frontier Economics, "[UK Mobile Market Dynamics – A report for DCMS](#)", July 2018.

2.4. Implications for connectivity and society

The implications for the UK of constrained incentives to invest in mobile connectivity infrastructure are significant and wide-ranging.

The impact of constraints to a business case are most pronounced at the margins; in the case of mobile connectivity, this is where the deployment costs are relatively high and where revenues are expected to be lower than average. Where these constraints are felt, they can be expected to lead to slower and less extensive network rollouts in areas where the business case is most marginal, such as rural areas and travel corridors.

For policymakers, the MNOs and society alike, the concern arising will be that it is in precisely these areas where the availability of current and next generation mobile technologies can be socially, environmentally, and economically transformative. Any degradation in investment incentives will have impacts beyond the provision of mobile communications services, with wider economic and social impacts including on the equitable distribution of the benefits of digitalisation. Three categories of implications – economic impact, sustainability impact and digital divide impact – are explored further below.

Economic impact

Digitalisation impacts economic output and growth in various ways:

- **Directly**, by expanding production possibilities and creating demand for new products and services which leads to creation of new jobs (e.g., the ONS estimates that an increase in unit output in the telecoms sector creates around seven new jobs in the economy (i.e., a type 1 employment effect of seven)).⁹⁵
- **Indirectly**, by improving the production efficiency of existing workforce and capital through improved information access and exchange, coordination of activities, reduced communication costs and improved market conditions.⁹⁶

Several studies have investigated the positive impacts of connectivity on GDP and economic growth. In our recent report 'Digitalisation: An opportunity for Europe', a 10% increase in the EU's Digital Economy and Society Index ("DESI")⁹⁷ score, which has connectivity as one of its measures, was associated with 0.65% higher GDP per capita.⁹⁸ Similarly, an increase of 1% in mobile cellular subscription uptake, as an ICT infrastructure measure, has been estimated to contribute 0.396% increase in GDP per capita growth.⁹⁹

The impact of mobile on the UK economy has been estimated at £112 billion for 2020, approximately 4% of GDP, with potential to increase in the years to follow.¹⁰⁰ This estimate formed part of the economic case for the UK government's funding of the 5G Testbed and Trials¹⁰¹ programmes, led by DCMS, which is exploring innovative use cases many of which will be reliant on the widest availability

⁹⁵ Office for National Statistics, [FTE multipliers and effects, reference year 2017](#), 23 June 2021.

⁹⁶ Ofcom, [The economic impact of broadband: evidence from OECD countries](#), April 2018.

⁹⁷ The Digital Economy and Society Index ("DESI") measures five important aspects of digitalisation: connectivity, human capital (digital skills), use of internet services, integration of digital technology (focusing on businesses) and digital public services. It is an index developed by the EU to measure digital progress.

⁹⁸ Deloitte, ["Digitalisation: An Opportunity for Europe"](#), February 2021.

⁹⁹ MDPI, ["Impact of Information and Communication Technology Infrastructure on Economic Growth: An Empirical Assessment for the EU Countries"](#), 17 October 2018.

¹⁰⁰ Department for Digital, Culture, Media & Sport, [UK 5G Testbed & Trials](#), 16 October 2017.

¹⁰¹ Department for Digital, Culture, Media & Sport, [5G Testbeds and Trials Programme](#), 26 March 2021. The Phase 1 trial projects began receiving funding in early 2018 and cut across sectors like healthcare and transport with different UK cities and regions of focus.

of full capability 5G to deliver high capacity and low latency use cases across a range of industrial sectors.¹⁰²

Examining the indirect effect of digitalisation on GDP through its impact on productivity, our ‘Digitalisation: An opportunity for Europe’ report found that a 5-point increase in the DESI score is associated with a 2.5% increase in total factor productivity (“TFP”) on average. TFP measures long-term technological dynamism driven by factors like change, research and development and collaboration, so the estimated increase represents an improvement in efficiency and economic output not associated with input growth.

Sustainability and environmental impact

Beyond providing economic stimulation, digital applications enabled by mobile connectivity are also essential to enabling more efficient use of resources, both on the supply side (i.e., resource extraction) and the demand side (i.e., product consumption). The wide availability of mobile connectivity enables the continued transition towards an economy in which growth in output can be decoupled from growth in environmental impact.¹⁰³ To achieve the UK government’s sustainability targets and to help arrest global warming, significant changes are required across industrial value chains, from the point of resource extraction and input production, through to the behaviour of consumers.¹⁰⁴

Digital technologies enabled by mobile connectivity can underpin this change by helping deliver smart ecosystems that will connect previously fragmented value chains, to provide better quality information about environmental impact to citizens, businesses, and governments. For example, Vodafone Group has trialled smart logistics use cases that deploy IoT technologies to optimise route management, maintenance cycles and driver behaviour with a view to realising reductions in fuel consumption, emissions and supply chain waste, whilst increasing supply chain traceability. Innovations of this type have the potential to empower stakeholders across society, including consumers, businesses, and governments, to embed sustainable thinking in their decision making. Beyond this, emerging technology solutions built on, for example, IoT applications and machine learning, will support the development of new sustainability use cases, from smart cities through to smart agriculture¹⁰⁵ and energy meters.¹⁰⁶

Innovative technologies and applications can also, in themselves, deliver greater energy efficiency and reduced emissions. Not only can 5G be expected to enable many of the sustainability use cases expected of it (e.g., smart meters, connected agricultural monitoring, emissions-reducing smart logistics) but it is also inherently more energy efficient than legacy network technologies. In this context, a recent study by Nokia and Telefonica found that 5G networks are up to 90 percent more energy efficient per traffic unit than legacy 4G networks, which if this proves to be the case in practice will help reduce the overall impact on energy consumption arising from continued growth in data traffic.¹⁰⁷ Investment in the transition from legacy generation mobile networks technologies to 5G will help secure these energy efficiency outcomes.

¹⁰² Department for Digital, Culture, Media & Sport, [5G by Sector \(uk5g.org\)](https://www.uk5g.org/)

¹⁰³ Decoupling occurs when the growth rate of an environmental pressure (for example, CO2 emissions) is less than that of its economic driving force (for example, GDP per head) over a given period. See: Office for National Statistics, [The decoupling of economic growth from carbon emissions: UK evidence](https://www.ons.gov.uk/articles/economy/gdp/growth/decoupling-of-economic-growth-from-carbon-emissions-uk-evidence), 21 October 2019.

¹⁰⁴ Department for Business, Energy & Industrial Strategy, ["Net Zero Strategy: Build Back Greener"](https://www.gov.uk/government/consultations/net-zero-strategy-build-back-greener), 19 October 2021.

¹⁰⁵ For example, through the use of connected monitoring devices and farming equipment that enables farmers to manage their crops and livestock more efficiently

¹⁰⁶ Vodafone Group, ["Digital for Green"](https://www.vodafone.com/press-releases/digital-for-green), January 2021.

¹⁰⁷ Nokia, [Press Release](https://www.nokia.com/press-releases/5g-networks-are-90-percent-more-energy-efficient), 2 December 2020.

Digital divide impact

Constraints on full capability 5G deployment also risks widening the digital divide between consumers and businesses with access to services and applications enabled by full capability 5G connectivity and those for whom access is limited to more basic coverage. This divide is particularly acute in rural areas in which the business case for full capability 5G network deployment is most marginal but is also felt in urban areas in which service affordability can impact consumers' access to mobile connectivity. The timely rollout of 5G can contribute significantly to UK government's levelling up agenda; In this context, the Centre for Policy Studies has estimated that delays and geographic constraints on 5G deployment could mean that up to 11 million households and businesses do not get access to high-speed mobile connectivity by 2027.¹⁰⁸

Expansion and enhancement of access to full 5G capability networks are critical to the digitalisation of rural economies and will bring a broad range of benefits that might otherwise be limited to urban and sub-urban areas. Two key categories of benefits that will mitigate the risk of digital divides widening rather than narrowing are discussed below – first, those relating to income and employment, and second, those relating to infrastructure and services.

Income and employment

Rural incomes and employment rates typically lag those experienced in urban areas; wider availability of full 5G mobile connectivity in rural communities can help address this by supporting small businesses and rural entrepreneurship which can in turn drive employment opportunities and income growth. Reliable mobile connectivity is regarded as an essential business need as reported by 81% of firms surveyed by the Confederation of British Industry.¹⁰⁹ In our June 2021 report 'Enhancing rural connectivity', we identified three transmission mechanisms through which connectivity promotes the health and growth of rural economies:¹¹⁰

- By enabling **teleworking**, digital connectivity can increase labour market participation, enable employees to live and work in different communities thus helping to address 'brain drain' effects, and can enable labour market re-entry by those who might otherwise have exited the labour market.
- By providing scope for **business efficiency gains and operating model innovation**, for example through access to cloud services, the availability of digital connectivity can enable small- and medium-sized business to innovate and to compete in markets beyond their immediate locations.
- By enabling a wider range of businesses to locate outside of urban areas, the availability of digital connectivity can enable **rural communities to attract and retain new businesses**, which in turn creates employment and skills development opportunities for people living in those communities.

Infrastructure and services

As an ever-increasing proportion of public and private services transition to online models, the long-term sustainability of many communities depends on the availability of access to robust fixed and mobile connectivity infrastructure. Absent wide availability of digital connectivity, the ability of these communities to access essential health, education and financial services will be degraded; the benefits

¹⁰⁸ Centre for Policy Studies, "[Upwardly Mobile: How the UK can gain the full benefits of the 5G revolution](#)", 1 October 2020.

¹⁰⁹ Local Government Association, "[Why digital connectivity matters](#)".

¹¹⁰ Deloitte, "[Enhancing Rural Connectivity](#)", June 2021.

of the digital transformation of the economy and society will not be distributed equitably, and existing digital divides will be reinforced rather than eliminated. Telemedicine, smart transportation, precision agriculture and immersive virtual reality education are amongst the emerging 5G use cases that will require the URLLC¹¹¹-connectivity enabled by full capability 5G networks in order for the potential benefits to be realised.

In this context, Deloitte’s recent ‘Enhancing rural connectivity’ study identified a series of transmission mechanisms that provide benefits to rural communities under three headings – health, education, and government services, each of which are discussed further below:

- **Digital healthcare services** can lead to improved health outcomes for people in rural communities by providing improved prevention, diagnosis, treatment, and monitoring of health-related issues. For those living in rural areas in which the nearest doctors’ surgery may involve long journeys and/or dependence on others, digital health care can be particularly important. In this context, a European Commission study on telemedicine found that a 5 percentage points increase in technology adoption could increase citizens’ healthy life years by 1.7% and reduce mortality rates by 3.6%.¹¹²
- The wide availability of high-quality mobile connectivity can support improved access to, and quality of, **education services to children and adults** in rural communities. Over and above the effects for children, the availability of digital connectivity can also support the development of digital skills in adults. These skills are becoming essential to employability and have been observed to be reflected in an ICT wage premium.¹¹³
- **Digitalisation of public services** helps drive cost efficiencies to the benefit of the public purse but can also help reduce frictions for people and businesses when they interact with national and local government. These frictions can be particularly pronounced in rural areas, which tend – by definition – to be the most remote from central administrative functions. The wide availability of digital infrastructure across rural communities can help enable equal access to essential local and national government services, without which the risk of digital exclusion for the most vulnerable in those communities will be most pronounced.

¹¹¹ Ultra-Reliable Low-Latency Communication

¹¹² European Commission, "[Market study on telemedicine](#)", October 2018.

¹¹³ European Commission, "[Facing the Digital Transformation: are Digital Skills Enough?](#)", July 2020.

3. Policy Enablers

Policy and regulation have a vital role to play in unlocking investment in the next generation of the UK’s mobile networks.

Policy and regulation have a vital role to play in providing the conditions and stimulus that can help strengthen and reinforce incentives to invest in UK mobile connectivity. This final section of our report sets out some key regulatory principles that can support investment in connectivity, and identifies some specific areas where regulation and policy interventions can help support investment in the sector.

3.1. Regulatory principles to support investment

Ofcom already has a set of high-level regulatory principles that guide its approach to regulation in the communications sector.¹¹⁴ This includes having a bias against intervention and only intervening where it has a specific statutory duty to fulfil that markets alone cannot deliver. However, to further support investment in the sector, one of Ofcom’s statutory duties, there are specific principles that - if applied - could help incentives to invest in the sector:

Taking a holistic view of the changing competitive dynamics across the value chain to ensure regulation continues to reflect competitive conditions. Regulation of the mobile sector was originally set in the context of a mobile value chain in which MNOs were competing as the only vertically integrated players, controlling assets across much of the value chain and having primary ownership of relationships with the end customer. Going forward, the future regulatory and competition framework will need to take account of the changes in structure of the broader value chain, the competitive dynamics within it, and the way in which value is generated. This will help ensure that the decisions on whether to intervene, and the form of regulatory intervention, reflect broader competitive conditions and thereby mitigate the risk of distorting competition and investment.

A renewed emphasis on promoting investment. Where competitive dynamics in a market are such that the focus of competition is on providing ever more bandwidth whilst limiting corresponding increases in prices, the potential rewards for investment and innovation can be squeezed. The DCMS Fixed Telecoms Infrastructure Review (“FTIR”) and subsequent Statement of Strategic Priorities for Ofcom recognised the need to incentivise significant additional commercial investment to deliver the Government’s full fibre ambition. The policy and regulatory changes that have since been made have contributed to an acceleration in fibre rollout. As set out above, a gap is opening up between planned 5G investments and the amount that would be required to realise the full capabilities of 5G and beyond for the whole of the UK. DCMS and Ofcom may need to place a similar emphasis on promoting dynamic efficiency and investment incentives to deliver the long-term consumer and national benefits of the widest possible availability of full capability 5G networks.

Assessing the cumulative impact of regulation on investment in the sector. In assessing the case for regulatory and public policy interventions, it is critical to consider the cumulative and marginal impact that these interventions could have on both the incentives and capacity for investment in mobile connectivity, rather than a narrow assessment of the impact each intervention might have on a standalone basis. This will help ensure that decisions on whether to intervene take proper account of

¹¹⁴ Ofcom, [Policies and guidelines - Ofcom](#).

the aggregate impact of regulation and policy on investment, and therefore appropriately balance the range of regulatory and public policy objectives.

Regulatory stability and certainty, to improve conditions for investment. Network investments have long-term payback periods and the risk of unanticipated regulatory interventions that impact on long term returns on investment creates uncertainty for investors and weakens incentives to invest. Providing regulatory stability and certainty can help mitigate this and support investment. In practice this could involve providing transparent, prescriptive, and objective criteria for regulatory interventions to be deemed necessary and making commitments to not intervene in parts of the market where there is already effective competition, or the market is still emerging, for a set period and reviewing this on a defined period basis. Further, in assessing regulatory interventions to support market entry (e.g., shared spectrum licences), consideration should be given to the risks this might pose to incentives to invest in wide-scale national mobile networks. This could help reduce regulatory risks associated with network investment by enabling investors to anticipate, assess and mitigate the impact that regulation has on returns. Early clarity around future spectrum release roadmaps would be another example of a positive regulatory measure.

3.2. Regulatory and policy solutions to support investment

There are a range of regulatory and policy interventions that could help support investment by reducing costs of mobile network rollout, stimulating demand for connectivity and allowing MNOs greater commercial flexibility in the way that they generate and retain value.

Reducing costs to network rollout

MNOs face significant costs in deploying networks, particularly in rural areas. Policy and regulatory measures that help to reduce the cost of network rollout could unlock investment where the commercial case for network investment is most challenging. Potential measures could include:

- **Facilitating the decommissioning of legacy 2G and 3G mobile networks** for example by abstaining from regulatory obligations to operate these networks and seeking to accelerate the timeframe over which they can be decommissioned. This could reduce the costs associated with operating multiple networks. It could also release spectrum for 5G deployment and enable a broader set of network equipment vendors to compete in the supply of network equipment (e.g., by lowering barriers to adoption of open interface network technologies such as OpenRAN), both of which could lower the costs associated with network rollout. The UK government has recently announced that it is working with industry to facilitate the switch-off of these legacy networks by 2033.¹¹⁵
- **Lowering the barriers and costs of vendor switching and integration:** The requirement for MNOs to remove high risk vendors from their networks by 2027 along with the introduction of new security requirements have the potential to significantly increase MNOs' costs of deploying and operating networks, as outlined in Section 2. There are a range of policy and regulatory measures that could help reduce these costs. The provision of funding to support the development of emerging open interface radio access network technologies, such as OpenRAN, could help reduce vendor switching costs and stimulate competition in the supply chain (as described in Section 2). Further, whilst the upfront costs and risks of transitioning to OpenRAN architecture may be significant today, OpenRAN deployment could also potentially generate long term capex and opex

¹¹⁵ Department for Digital, Culture, Media & Sport, "[New measures to boost UK telecoms security](#)", 8 December 2021.

savings that could reduce the cost of rural network deployment. In this context, the UK government has set out measures to reduce barriers to vendor switching and integration.¹¹⁶

- **Lowering barriers to network deployment:** UK government is already seeking to address the barriers to network deployment, for example through the shared rural network (“SRN”) programme and establishing a Barrier Busting Task Force that is leading several initiatives in this area.¹¹⁷ Continued efforts to reduce barriers to deployment (e.g. through simplifying and standardising planning approvals processes, further collaboration between public and private sector, and by making it easier for MNOs to access street furniture to deploy small cells) could help to reduce deployment costs. This could include reviewing international approaches adopted by other governments to lower barriers to deployment. Longer term making more spectrum available for mobile use could help reduce barriers to deployment, in particular network costs while potentially supporting new innovative use cases. These initiatives could support deployment of full capability 5G beyond urban areas including, for example, along road and rail travel corridors.
- **Competition policy that places greater weight on the efficiencies arising from mergers.** Further consolidation could enable MNOs to generate the scale required to support investment in full capability 5G networks. Whilst transactions should continue to be assessed on their merits and on a case-by-case basis, competition policy could in future place greater weight on the efficiencies arising from mergers and the extent to which these could stimulate both investment and competition. For example, a recent report by Compass Lexecon highlighted the ‘rivalry-enhancing;’ efficiencies arising from mergers that can support greater competition and further quality enhancing investments to the benefit of end customers.¹¹⁸

Unlocking demand for connectivity

Policy and regulation can also help provide demand stimulus to create new opportunities to generate value from investment in networks. Existing policy initiatives to stimulate innovation and demand include, for example, Digital Catapult and the regional 5G application accelerators.¹¹⁹ Further measures to help unlock and drive new value generating opportunities could include:

- **Investing in digital transformation:** UK government investment in digital transformation and leveraging of digital capabilities across public services and administration could help strengthen new mobile connectivity use cases. This could unlock value creation opportunities supporting investment in connectivity, from which UK citizens and businesses can benefit. This is particularly the case for the digital use cases that require national or supra-national scale, for the fullest extent of potential benefits to be realised, for example eHealth and the realisation of sustainability objectives.
- **Data sharing to unlock value:** To unlock value from the opportunities presented by new mobile use cases such as smart cities technologies, non-personal public data needs to be shared between a wide variety of systems and platforms to enable a wider set of use cases to be developed. Integration and interoperability at the scale required demands close collaboration between national governments, regional authorities, municipalities, infrastructure owners, and data generators.
- **Investing in digital skills:** Investment in digital skills can help stimulate adoption of emerging mobile technologies, a potential key driver of value generation, while closing the digital divide that might

¹¹⁶ Department for Digital, Culture, Media & Sport, [“5G Supply Chain Diversification Strategy”](#), 7 December 2020.

¹¹⁷ Department for Digital, Culture, Media & Sport, [“Barrier Busting Task Force: next steps”](#), 19 March 2021.

¹¹⁸ Compass Lexecon, [“Mobile market structure: Policy and investment a report commissioned by Vodafone”](#), November 2021.

¹¹⁹ [The UK authority on advanced digital technology - Digital Catapult | Digicatapult.org.uk](#)

otherwise develop between rural and urban communities, and vulnerable consumers within them, as well as between small and medium sized enterprises and larger businesses. The expansion of connectivity in rural areas will need to be complemented by programmes to improve digital skills in these areas, to help generate the return on investment required to sustain the deployment business case.

Providing MNOs with greater commercial flexibility to generate value

Policy and regulations help protect consumers from suboptimal outcomes, however in some cases they can constrain investment incentives in ways that could limit the speed and extent of network rollout. As Ofcom considers its approach to the mobile sector going forward, it will need to consider how best to provide the necessary consumer protections whilst unlocking incentives to invest in network investments. In this context consideration could be given to:

- Reviewing whether existing regulatory obligations that collectively constrain MNOs’ commercial flexibility remain appropriate considering changes in the value chain:** MNOs currently face a wide range of regulatory requirements that potentially constrain their commercial flexibility, from net neutrality rules to General Conditions of Entitlement (GCEs) and mobile coverage obligations. While each of these obligations were introduced to address concerns identified by Ofcom around whether the market could deliver optimal outcomes, most were introduced at a time when the value chain was very different. For example, whereas MNOs were once the sole or at least primary providers of mobile services, the value chain today is such that there are now a broader range of mobile service providers (e.g., OTT providers, private network operators). Reviewing whether existing regulatory obligations individually and collectively remain appropriate and providing a level playing field in light of changes in the value chain, could support competition and incentives to invest in the sector. For example, reviewing whether net neutrality rules in their current form remain proportionate given the changes in competitive dynamics being observed across the value chain.
- Clarity on regulations for monetisation of 5G network use cases:** The emergence of new network technologies and functionality such as network slicing could create opportunities for MNOs to generate new sources of value, which in turn support the underlying case for investment in mobile connectivity. However, it is possible that existing regulations such as net neutrality might constrain MNOs ability to generate value from investment in these new technologies. Providing greater clarity and certainty on the rules around monetisation of these networks could help mitigate this. Ofcom is already taking steps to do this through its ongoing review of network neutrality regulations.¹²⁰
- Ensuring that future regulation of emerging technologies and use cases supports a level playing field, while enabling a fair return on investment:** Policymakers will need to consider the case for regulation of emerging technologies that support new use cases, including Artificial Intelligence (“AI”), big data and the Internet of Things (“IoT”). Providing the MNOs with flexibility to commercialise these opportunities, and a level of certainty around that (e.g., for a defined period), before assessing the case for regulatory intervention could support the case for investment in these areas. Where regulation is deemed necessary this will need to be developed to create sustainable and fair competition between participants in the value chain, while enabling a fair return on investment.

¹²⁰ Ofcom, ["Call for evidence: Net neutrality review"](#), 7 September 2021.



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