making communications work
for everyone

Ofcom's future approach to mobile markets

A discussion paper

DISCUSSION PAPER:

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Contents

Section

1. Overview

1.1 Over the past ten years there has been a huge shift towards the use of mobile devices in our everyday lives, at home and at work. Most calls are now made from mobile phones rather than landlines and UK adults now spend on average two hours a day online on their smartphones.

1.2 This trend is set to continue, with more demand for data-hungry services like streaming, video calling and newer technologies such as virtual and augmented reality, as well as connected vehicles. New technologies will also create new uses for industry and the public sector. For example – robotics, smart cities and in healthcare with remote monitoring and diagnosis.

1.3 The mobile market has served the UK well over the past ten years, driven by competition among four mobile network operators (MNOs). But increasingly, mobile networks are just part of the range of different wireless technologies people use to meet their needs at different times, whether that is using Wi-Fi at home or work, or mobile networks when we are on the go.

1.4 In the future, we expect to see an increased role for other companies in providing networks, selling mobile internet access and providing online services.

1.5 Given the changes taking place, it is a good time for us to take stock, assess how well the market might work for people and businesses, and consider whether and how we might adapt our regulatory approach, while recognising that there is uncertainty about the future.

Our initial views

We are not proposing new regulatory interventions in mobile markets at this stage. Instead, we will **continue to monitor how competition evolves and assess any key risks that might affect the delivery of good outcomes**. But we are ready to engage and take action where necessary. We also:

- plan to **develop better information for customers so they can make more informed choices about their provider**. We will continue our work through our Mobile Reporting Project to provide customers with further information on network quality**;** and
- **invite further input on the potential wider benefits to society** that might warrant intervention to support a quicker, more widespread rollout of high-quality networks than that which the market is likely to deliver.

We will take steps to clarify our future regulatory approach, to create as much certainty as we can to support investment. Specifically:

- ***We propose to set out more explicitly how we have considered investment when making policy decisions.*** This will help to underline the importance we place on investment.
- ***We are confirming that we do not expect to introduce new consumer pricing rules.*** We have a strong set of consumer protection rules in place, which providers must comply with. We also want to see them delivering against the Fairness for Customers commitments without the need

for further regulatory intervention. We will continue to monitor the performance of mobile providers against the commitments, as well as other developments impacting consumers, such as affordability. Although we have no plans to intervene further, we will be ready to act if new problems emerge.

- ***We are clarifying our position on mobile consolidation*.** The question of whether a particular merger is likely to result in a substantial lessening of competition depends on the effectiveness of competition that can be expected in the market after the merger, rather than just the number of competitors. Our stance on a potential merger would therefore be informed by the specific circumstances of that particular merger, taking into account how markets are evolving.

In addition, we are currently carrying out a review of the UK's net neutrality framework, which impacts the way operators manage their networks and the services they can offer**.** We expect to publish our initial findings in Summer 2022.

We recognise there is considerable uncertainty about the way mobile markets will develop over the next five to ten years, and we welcome further evidence and views in response to this discussion document. We then plan to set out our conclusions by the end of 2022.

We want people and businesses to be able to use mobile services when and where they want to use them

1.6 One of Ofcom's priorities is for people and businesses across the UK to have internet they can rely on. We prioritise promoting competitive markets to support investment in strong, secure networks, getting everyone connected, and delivering fairness for customers. These are reflected in the range of outcomes that we want mobile markets to deliver:

a) Investment in new technologies and strong, secure networks to meet the future needs of customers and the country.

b) Widespread availability of reliable mobile services to keep people and businesses connected wherever they live, work and travel.

c) Quality, value for money and choice for customers to meet a variety of needs.

d) Customers who are empowered to shop around with confidence, and can make well-informed decisions, and switch easily.

e) Support for customers who may be vulnerable, including those in financial difficulty.

1.7 In the years ahead, we expect network quality[1] to become more important as dependence on mobile internet access grows, and people expect faster, more reliable connections on the move, not just at home.

[1] Put simply, a mobile internet access service offers a good quality of experience if it meets the customer's connectivity needs. This includes in relation to factors such as coverage, reliability and performance.

The mobile sector has delivered good outcomes to date

Competition among MNOs has driven investment, and led to customers getting more for less

1.8 Competition among MNOs has driven ongoing investment of around £2.5bn each year since 2012. This has enabled the rollout of 4G technology, providing faster, more reliable data to support online services, and increased network capacity to carry increasing volumes of data. Competition is now driving investment in 5G, which is initially focused on improving network capacity to meet demand in congested urban areas. So far, 5G coverage is only available to a small part of the UK, but we estimate 5G to be available from at least one MNO outdoors at 42% - 57% of UK premises.[2]

1.9 Competition among MNOs and mobile virtual network operators (MVNOs)[3] has delivered a wide choice of services and helped many customers to use more data while spending less. On average, between 2015 and 2020, the amount of data people used increased over three and a half times (369%), while prices fell by around one fifth (22%).

Competition has driven improvements in quality, though it can be difficult for customers to compare network quality across providers

1.10 Mobile providers compete to offer a good network quality to retain customers. Whilst we have good information about national coverage, it is more difficult to measure quality at a very local level. This makes it challenging for customers to judge the likely performance of their network where they want to use it. Competition based on quality is therefore likely to be less strong than on price.

Regulation and policy have also helped to deliver good outcomes

1.11 Regulation and policy interventions by Ofcom and Government have also played an important role in helping to deliver good outcomes. Key measures have been designed to:

- **Ensure the availability and efficient use of spectrum, a critical part of providing mobile services**. Ofcom has released significant amounts of spectrum to enable improved mobile services, generally using auctions to help promote its efficient use.
- **Promote widespread mobile coverage to help get everyone connected.** The Government reached an agreement with the four MNOs to provide coverage to many of the remaining outdoor not spots in the UK (the Shared Rural Network). This is due to be completed in January 2027.
- **Empower and protect consumers and help make sure they are treated fairly**. We have taken significant steps with the introduction of rules on end-of-contract notifications and the new simplified 'text-to-switch' process. The success is reflected in an increase in engagement among mobile customers and switching between providers which play an

[2] See page 3, Ofcom, Connected Nations 2021: UK report, December 2021.
[3] A Mobile Virtual Network Operator (MVNO) is a mobile provider that does not own the wireless network infrastructure over which it provides mobile services to its customers.

important role in making competition work effectively.[4] In 2019, we launched the Fairness for Customers commitments to promote the fair treatment of customers.

- **Strengthen network security.** To help protect customers, businesses and the UK economy from major network failures or security breaches, the Government recently introduced new measures under the Telecommunications (Security) Act 2021. This includes new powers for the Government to control industry's use of suppliers that are considered to pose a high security risk – also known as high risk vendors (HRV). It has decided that all Huawei equipment should be removed from 5G networks by 2027.

Looking ahead, we could see significant changes in how customers buy mobile services and how services are delivered

Customers might change how they buy mobile services

1.12 Over the next five to ten years, we might be more likely to buy mobile services together with other services, for example as part of a bundle with home broadband, with smart home devices and wearables, or with apps and online services in which mobile services are an add-on.

1.13 New eSIM technology (in which the SIM is embedded into the device and is not tied to one mobile network) could change the relationship between the customer and the mobile network providers. eSIMs enable customers to select and set up a new mobile provider directly on their device, and to have more than one virtual SIM on their device at a time. Without the need to replace a physical SIM card, this allows the customer to easily switch between mobile providers to use the network they want[5]: This is a marked change from the current model, where devices typically remain on a single network for the duration of the airtime contract.

1.14 Given their already important role in mobile ecosystems (providing mobile operating systems, devices and apps),[6] Apple and Google could start to take a direct role in selling mobile internet access, potentially as part of a wider bundle of services, to further strengthen their relationship with customers.

We expect to see changes in how mobile networks are provided

1.15 National mobile networks have historically been at the centre of the model that provides mobile services. They build, own and operate networks and offer retail services, often bundling airtime with mobile devices. However, technological developments such as 5G might bring changes to the role of existing players:

- **MNOs may continue to separate out their infrastructure, resulting in more infrastructure-sharing or new network-sharing and ownership models.** There is a trend

[4] For example, engagement among bundled customers whose contracts ended in September 2020 was higher than in the comparable period in 2019 (76% in 2020, up from 70% in 2019), while for SIM-only customers, engagement increased from 27% in 2019 to 32% in 2020.
[5] The customer could either switch provider themselves or choose to use a service (algorithm) to do so on their behalf.
[6] CMA, Mobile ecosystems market study interim report, December 2021.

– both in the UK and overseas – towards greater separation of network assets as MNOs seek to monetise their assets. Examples include sharing tower infrastructure, restructuring to increase transparency of the value of network assets, or structural separation (of services and infrastructure) and sale of network assets. We have also seen the emergence of different models for providing network infrastructure. As the trends of commercialisation and divestment continue, in the future we could see greater sharing of infrastructure, or new network sharing and ownership models.

- **Amazon, Google and Microsoft will play a greater role in the provision of mobile networks.** We expect MNOs to make greater use of cloud infrastructure to perform network functions, enabling them to deliver more flexible, scalable and cost-efficient networks. In many cases, this will be provided by Amazon, Google or Microsoft, (known as hyperscalers) who are the three largest cloud providers globally, and benefit from significant economies of scale and scope.
- **We expect to see strong competition to provide private networks.** Private mobile networks are accessible by a closed group of people and devices and use mobile technologies. They are often used in business premises or in a campus environment. These networks are already in use, but improvements in 5G and other technologies will enable them to provide much more responsive, reliable, and faster internet access that can be tailored to specific business needs. This could open up a wide range of new uses, such as fully automated construction robots, and safer remote operation of heavy machinery in industrial units. We expect to see a wide range of players deploying and operating these networks. These include MNOs, equipment vendors (such as Nokia), managed service providers and system integrators (such as Accenture) and hyperscalers (such as Amazon).

We expect competition to continue to deliver good outcomes over the next few years

Significant ongoing investment will be key to meeting customers' future needs

1.16 While there is considerable uncertainty around future growth in demand for mobile data, our medium-growth scenario suggests that total monthly data used on mobile networks could increase by a multiple of 20 by 2030.[7] Meeting this demand will require a significant expansion in network capacity.

1.17 We already plan to make some additional spectrum available, and will consult on our proposed approach to making millimetre wave (mmWave) spectrum available shortly. In addition, we anticipate that mobile networks will need to evolve to meet future demand, deploying a number of strategies which include technology upgrades, making full use of current spectrum holdings, and increasing the number of sites in their networks. We are

[7] This is based on a medium growth scenario, in which the recent trend of 40% growth year on year in mobile data continues. This is set out in the accompanying Mobile networks and spectrum discussion paper which we are publishing alongside this paper.

publishing a separate discussion paper on mobile networks and spectrum alongside this paper.

1.18 MNOs are currently deploying 5G networks on a non-standalone (NSA) basis, which involves deploying 5G radio equipment alongside the existing 4G. This delivers an increase in capacity and allows MNOs to support demand as it continues to grow, without the congestion and degradation of service quality that would otherwise result.

1.19 In the near future we expect MNOs to upgrade to 5G Standalone (SA), which involves the deployment of a new 5G core network. This could enable new use cases such as AR/VR and robotics, supported by the broader capabilities of 5G including ultra-low latency, advanced virtual network (slicing) functions,[8] and potentially improved coverage.

1.20 MNOs also need to complete the Shared Rural Network and to remove high risk vendors from their networks; and may need to increase their investment in the resilience of mobile networks.

We expect competition to continue to drive investment over the next few years

1.21 MNOs have said they face an uncertain and challenging investment climate and have raised concerns about their ability to invest in mobile networks

1.22 Our own analysis suggests that, at an industry level, financial performance appears to support investment: on an economic basis, the average industry return on capital employed (ROCE)[9] has been above the cost of capital. Nevertheless, there is variation between operators' ROCE, and our analysis suggests that not all MNOs have covered their cost of capital on a continuous basis.

1.23 MNOs continue to have commercial incentives to invest in improving their networks. Investment in 5G is likely to result in more cost-efficient networks and will improve the customer experience by reducing congestion. Without investment, MNOs could lose customers and scale to those who do invest and could therefore see their profitability fall.

1.24 Evidence from their business plans shows that the MNOs are all planning to continue to invest significantly, driven by competition among them. As a result, they should deliver the Government's ambition to see the majority of the population covered by 5G by 2027. However, there may be some geographical variation, with those in low-demand areas potentially not experiencing the same very high speed and responsiveness as in high demand areas.

[8] Network slicing is a feature of 5G SA networks. It allows an MNO to create multiple virtual networks (slices) on top of its common shared physical infrastructure. The virtual networks are then customised to operate with specific quality of service and meet the specific needs of applications, services, devices, customers or operators.

[9] ROCE is a measure of profitability that explains how well a company's capital base is at generating returns. When ROCE is above the cost of capital it means that the returns outstrip the costs to finance the business.

Our proposed approach

1.25 Although competition among MNOs is driving investment, the competitive dynamics are changing and there is uncertainty over what the longer-term impact will be. We will need to be agile in response to future changes and will continue to monitor market developments, ready to engage where necessary.

1.26 As it is likely that quality will become increasingly important to support new services, we will also focus on developing better information on network quality to help customers make more informed choices of provider.

1.27 Whilst we are not proposing any new regulatory interventions in this document, we recognise that it is important that our approach is clear to support investment going forward. So we are proposing to take a number of steps to clarify our future regulatory approach as set out above.

Next steps

1.28 We are publishing this document alongside a discussion paper on our proposed future approach to mobile spectrum.[10] The Mobile Networks and Spectrum discussion paper sets out our initial thoughts on how mobile networks might evolve to meet future demand for mobile data. We are inviting comments on both documents by 8 April 2022. We plan to set out our conclusions by the end of 2022.

[10] Ofcom, Mobile networks and spectrum discussion paper, February 2022.

2. Introduction and background

2.1 We launched this review in May 2021,[11] in recognition of the importance of mobile internet access, and the need for innovation and ongoing investment in new technologies to keep pace with the growing demands of people and businesses.

2.2 The overall aim is to help ensure that people and businesses get the mobile internet access they need over the next five to ten years, as technologies develop and the sector changes. In light of this, we are assessing what our future approach to mobile markets should be.

2.3 Our analytical framework includes consideration of the following elements:

a) the outcomes we want to see in mobile markets, and how well those outcomes have been delivered to date;

b) the changes we could see take place across mobile markets over the next five to ten years, both in terms of how customers' use of mobile services might evolve, and how the provision of mobile services might change;

c) how well mobile markets are likely to deliver good outcomes for people and businesses, including any risks that might arise; and

d) what our future approach should be.

2.4 We set out our initial thinking on these areas in this document. This is informed by a range of evidence, including trends in consumer behaviour, information from statutory information requests to the MNOs, stakeholder meetings with a range of industry players, as well as publicly available resources, such as financial statements, analysts' reports and industry publications. We also commissioned external consultants to carry out some international case studies.[12]

2.5 We have not directly considered issues relating to network security and resilience[13] or environmental issues,[14] which fall outside the scope of this review and are being considered separately as part of other Ofcom work.

2.6 With this discussion paper, we would like to start an open discussion with stakeholders on the future of mobile markets. We invite any comments and evidence in response to the questions set out in this discussion paper (Section 8) by 8 April 2022. We also set out in

[11] Ofcom, Mobile strategy – Terms of reference, May 2021.
[12] Plum, Mobile Strategy Review - International Case Studies, January 2022 (Plum Report (2022)).
[13] We are working with the UK Government to implement our responsibilities under the new Telecommunications (Security) Act 2021 ("Telecoms Security Act"), which received royal assent on 17 November 2021. The provisions within the Telecoms Security Act that impose new strengthened security duties and Ofcom's new powers to monitor and enforce compliance with them are expected to come into force in October 2022. We have set out our proposed work in this area in Ofcom's proposed plan of work 2022/23
[14] Fixed and wireless services can be instrumental in the move to environmental sustainability such as enabling a reduction in travel, increasing network durability, enabling decarbonisation through the use of monitoring devices. In a separate piece of work, we are engaging with our industry stakeholders to understand their approach to running their businesses sustainably, including how they affect the environment, and are affected by wider pressures to become more sustainable. We will consider what role Ofcom could have in addressing sustainability issues within communications sectors.

Section 8 further work we propose to undertake on the issues raised in this paper. We propose to set out our conclusions and any next steps by end 2022.

Links with other work

2.7 The Mobile Strategy review takes a high-level view of the mobile markets to consider what our future approach should be, and to inform future work.

2.8 We are publishing this discussion paper alongside an accompanying paper on mobile networks and spectrum (Mobile Networks and Spectrum discussion paper).[15] This outlines our initial thinking on how public mobile networks in the UK may need to evolve to meet future demand and the best use of spectrum for mobile, in light of expected growth and demand for spectrum from other sectors. The deadline for providing comments on the Mobile networks and spectrum discussion paper is also 8 April 2022.

2.9 Other ongoing work that relates to the Mobile Strategy includes Ofcom's work to improve consumer information on mobile coverage and performance, supporting Government's 5G Supply Chain Diversification Strategy, reviews of spectrum Annual Licence Fees (ALFs) where they become due, and our ongoing review of the net neutrality framework.[16]

2.10 In addition, we are working closely with the Government as it develops its Wireless Infrastructure Strategy to help ensure we provide a coordinated approach to the mobile sector.[17] More generally, in carrying out our work, we take account of the Government's Statement of Strategic Priorities,[18] which includes the following priorities: world-class digital infrastructure, secure and resilient telecoms infrastructure and furthering the interests of telecoms consumers.

Overview of Ofcom's duties

2.11 Ofcom has a wide range of statutory functions in relation to the regulation of mobile networks and services, including its functions in respect of electronic communications networks and services under the Communications Act 2003 (the Act) and those in respect of the management of spectrum under the Wireless Telegraphy Act 2006. We also have powers under competition and consumer law. In carrying out our functions, section 3(1) of the Act states that it shall be our principal duty:

- to further the interests of citizens in relation to communication matters; and
- to further the interests of consumers in relevant markets, where appropriate by promoting competition.[19]

[15] Ofcom, Mobile networks and spectrum discussion paper, February 2022.
[16] See Ofcom, Ofcom's plan of work 2021/22, March 2021. For net neutrality see Ofcom, Call for evidence: Net neutrality review, September 2021.
[17] See DCMS, Wireless Infrastructure Strategy: call for evidence, November 2021; Letter from Rt Hon Oliver Dowden CBE MP to Dame Melanie Dawes, July 2021; and Letter from Lindsey Fussell to Rt Hon Oliver Dowden CBE MP, August 2021.
[18] DCMS, Statement of Strategic Priorities, 2019.
[19] Consumer is defined in section 405(5) of the Act and includes people acting in their personal capacity or for the purposes of, or in connection with, a business.

2.12 In performing our duties under section 3(1) of the Act, we are required to have regard to the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed, as well as any other principles appearing to us to represent best regulatory practice (section 3(3) of the Act).

2.13 Section 3(4) provides that we must have regard, in performing our duties, to a number of matters, as they appear to us to be relevant in the circumstances, including:

- the desirability of promoting competition in relevant markets;
- the desirability of encouraging investment and innovation in relevant markets;
- the desirability of encouraging the availability and use of high speed data transfer services throughout the United Kingdom;
- the different needs and interests, so far as the use of the electro-magnetic spectrum for wireless telegraphy is concerned, of all persons who may wish to make use of it;
- the needs of persons with disabilities, of the elderly and of those on low incomes; and
- the extent to which, in the circumstances of the case, the furthering or securing of the matters mentioned in section 3(1) is reasonably practicable.

2.14 In addition, section 3(5) of the Act requires that, when performing our duty to further the interests of consumers, we must have regard, in particular, to the interests of those consumers in respect of choice, price, quality of service and value for money.

2.15 Ofcom also has a duty to act in accordance with the six requirements set out in section 4 of the Act when carrying out certain functions relevant to the regulation of mobile networks and services.

Structure of this document

2.16 The following sets out the structure of this discussion paper:

a) Section 3 outlines the importance of mobile services and the outcomes we want to see in mobile markets.

b) Section 4 describes the mobile markets today, including current outcomes, the central importance of competition, and the role of regulation and public policy.

c) Section 5 sets out key future developments in the mobile markets, including changes in the use and provision of mobile services.

d) Section 6 sets out how well we expect mobile markets to deliver good outcomes, and our initial thinking on what this means for our approach.

e) Section 7 sets out our initial thinking on our future regulatory approach to encourage investment.

f) Section 8 sets out the questions we would particularly welcome stakeholders' responses too, as well as the steps we propose to take before publishing our conclusions.

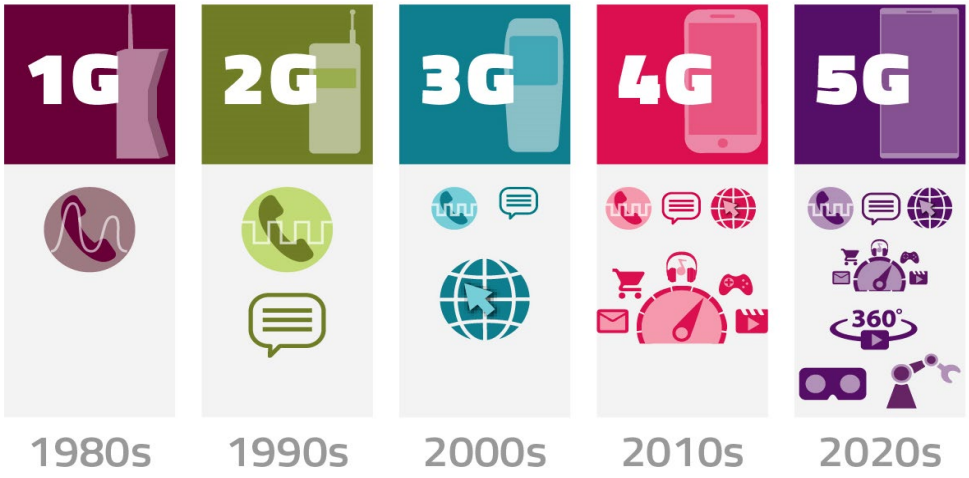
3. The importance of mobile services and the outcomes we want to see

3.1 This section outlines the importance of mobile services and the range of outcomes we would like to see mobile markets deliver.

Importance of mobile services

3.2 Mobile services have developed significantly, moving from voice and then SMS through to data services, which have offered higher download speeds and lower latency over time, as illustrated in Figure 3.1.

Figure 3.1: Evolution of mobile services[20]

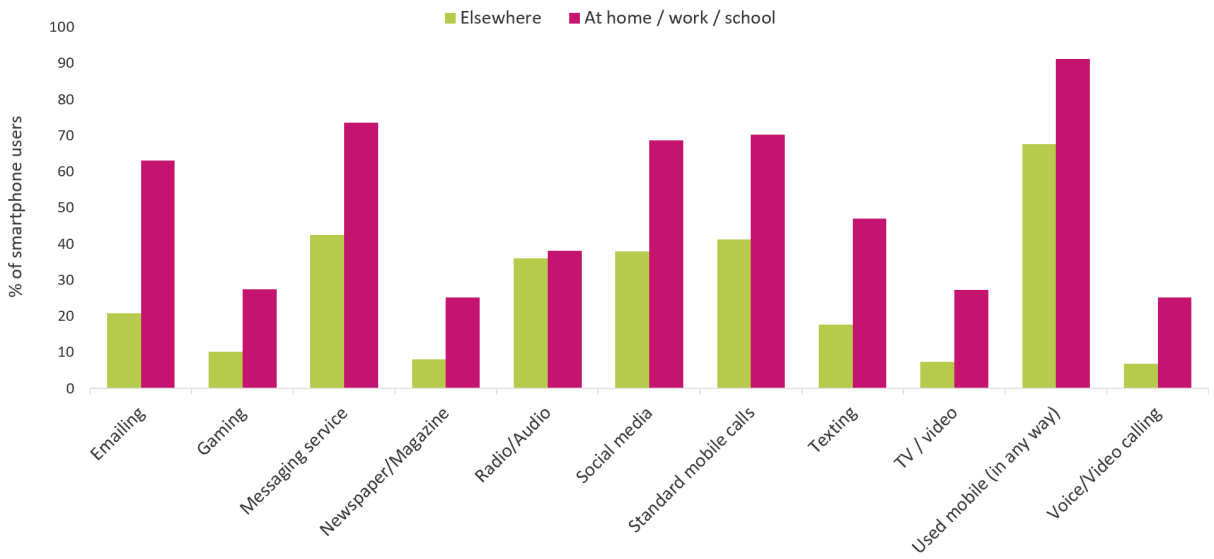


Source: Ofcom

3.3 Improved mobile services, together with the take-up of smartphones,[21] have enabled the use of online services that touch many aspects of people's lives, from keeping in contact with friends and family, engaging with public services, to accessing financial services and entertainment. We now see mobile devices being used for a wide range of purposes at home, work or school, as well as on the go (Figure 3.2), the majority of which rely on internet access. In 2020, six in ten internet users cited smartphone as their most important device for accessing the internet[22] In addition, UK adult internet users now spend more than two hours a day online on their smartphones.[23]

[20] The terms 1G, 2G, 3G, 4G and 5G refer to different generations of mobile standards. Since 1998 (i.e. from 3G onwards) The 3rd Generation Partnership Project (3GPP) has produced specifications to define these technologies.
[21] 92% of adults who personally use a phone use a smartphone. See Ofcom, Technology Tracker 2021, Table 37, 'Do you personally use a smartphone?'.
[22] Ofcom, Technology Tracker 2020, Table 56 'Which is the most important device you use to connect to the internet, at home or elsewhere?'.
[23] UK adult internet users spent an average of 2 hours 19 minutes online using Smartphones in September 2020. Comscore MMX Multi-Platform, Total Internet, Age: 18+, September 2020, UK

Figure 3.2: Consumers (aged 15+) used their mobile devices for a rich variety of services both on the move and in regular indoor locations in 2020 (pre-lockdown)



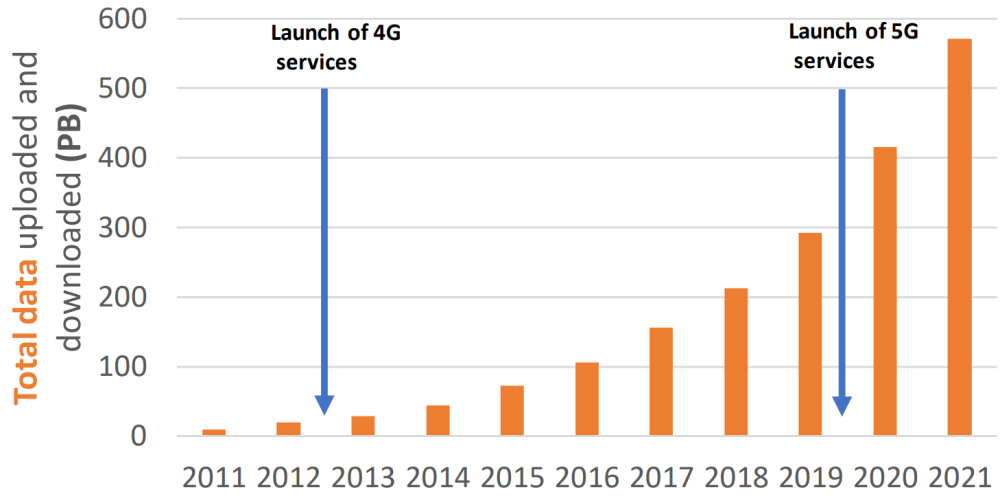
Source: IPA TouchPoints 2020

Note: 'Elsewhere' figures are an indication of locations where use is less likely to use Wi-Fi, by excluding use at home, work and school.

3.4 Some business customers also use mobile devices widely, such as for making or receiving calls, checking emails, and managing documents or social media accounts.[24] For these businesses, mobile services are particularly important when staff are on the move (such as while commuting or visiting clients, or if the work itself is mobile by nature), as well as when working from home or an office. Some businesses have made greater use of mobile services to support staff working from home since the start of the Covid-19 pandemic and, for some smaller SMEs, mobile phones have offered back up if Wi-Fi fails. [25] The growing importance of mobile services is demonstrated by the significant rise in mobile data consumption in the UK in recent years. Total aggregate monthly mobile data traffic rose by a multiple of 20 between 2011 and 2021 (from 9 PB (million GB) to 571 PB, see Figure 3.3) as both more customers used mobile data and as customers' average data use increased.[26]

[24] Further examples of uses are provided in Ofcom, SME Communications research: qualitative summary report, 2022 and Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes 5-18 – supporting information, 2020, pp. 149-150.
[25] Ofcom, SME Communications research: qualitative summary report, 2022.
[26] For 2011 see Ofcom, Infrastructure Report 2012 update, Figure 21 and for 2021 data see Ofcom, Connected Nations 2021, p. 49.

Figure 3.3: UK mobile data consumption over time



Source: Total data uploaded and downloaded (PB) over mobile networks sourced from Ofcom's annual Connected Nations reports; availability of mobile services sourced from web research.

3.5 Most of the time, mobile devices are connected to Wi-Fi, which in large part reflects the availability of Wi-Fi at indoor locations such as home, work and school.[27] However, mobile services remain important indoors as well as on the go, for data[28] as well as for voice[29] and SMS services.[30]

3.6 Mobile services are particularly important for people who do not have access to Wi-Fi, especially the 1.5 million households that currently rely on mobile data as their only source of internet access at home.[31] Mobile data can also provide back-up for those who have Wi-Fi but face a temporary loss of service. Recently some fixed broadband providers have started to offer routers that include mobile SIMs to offer more seamless backup.[32]

3.7 In addition to mobile phones, many consumers own other connected devices such as smart speakers (50%), smart watches or wearable technology (44%), and smart home technology including heating, lighting and security services (29%).[33] Many of these operate on technology such as Wi-Fi or Bluetooth. However, some may rely on mobile services when they are controlled remotely by smartphones connected to mobile networks (such as

[27] Crowdsourced data collected from around 280,000 Android devices between 1 January and 31 March 2021 showed that 73% of connections were made on Wi-Fi and 27% were made on mobile networks. These figures are rounded to the nearest whole percentage and refer to the proportion of connection tests run every 15 minutes; not data traffic. For more information see Ofcom, Mobile Matters, 2021.

[28] For example, mobile data use in the home continues to play an important part in traffic generated across mobile networks, with the busy hour for mobile data traffic occurring around 9pm. Ofcom, Connected Nations 2021.

[29] This is relevant when Wi-Fi calling services are not available or enabled, and particularly where households do not have landlines and rely on mobile for voice services (this accounts for 34% of UK households - Ofcom Technology Tracker, 2021, page 126).

[30] This is particularly the case when Wi-Fi SMS services are not available or enabled.

[31] This is defined as those whose only method of accessing the internet is through a mobile phone or other mobile device (for example a dongle or USB device). The 1.5 million figure is based on 5% of households being mobile-internet only. See Ofcom, Affordability of communications services, July 2021.

[32] Such offers include BT's Halo 3+ and Vodafone's Pro and Pro Xtra.

[33] Ofcom, Technology Tracker, 2021. This question was not asked to those answering the survey via a paper questionnaire.

controlling central heating while on the move), or when the smart devices themselves are used on the move (such as for some uses of wearable technology).

3.8 In 2021, the number of active Internet of Things (IoT) connections on MNO networks increased by 63% (more than double the year-on-year growth from the previous year) to 10.3 million.[34]

There is a range of outcomes we want to see mobile markets deliver

3.9 One of Ofcom's priorities is for people and businesses across the UK to have internet we can rely on. We prioritise promoting competitive markets to support investment in strong, secure networks, getting everyone connected, and delivering fairness for customers. These are reflected in the range of outcomes we want to see:

a) Investment in new technologies and strong, secure networks to meet the future needs of customers and the country.

b) Widespread availability of reliable mobile services to keep people and businesses connected on the move wherever they live, work and travel.

c) Quality, value for money and choice for customers to meet a variety of needs.

d) Customers who are empowered to shop around with confidence, and can make well-informed decisions, and switch easily.

e) Support for customers who may be vulnerable, including those in financial difficulty.

3.10 We outline in Section 4 how well these outcomes have been delivered and then in Section 6 we discuss our initial views on the extent to which the markets are likely to deliver them over the next five to ten years.

[34] See Ofcom, Connected Nations 2021.

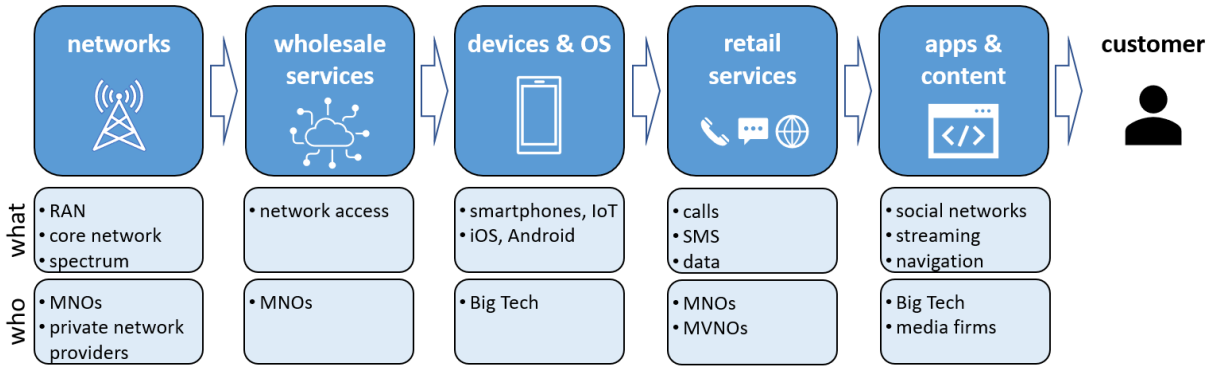
4. Mobile markets today

4.1 This section describes how mobile services are currently provided in the UK, discusses the outcomes that the markets have delivered over the last five to ten years, sets out the current competitive dynamics at the wholesale and retail level, and provides an overview of key regulation and policy initiatives.

MNOs play a central role in delivering services

4.2 The role of MNOs can be represented as a simple value chain, as set out in Figure 4.1 below.

Figure 4.1: Mobile internet access value chain[35]



Source: Ofcom

4.3 At the network level, there are four national MNOs – EE, Three, Virgin Media O2 and Vodafone.

4.4 Each MNO has its own spectrum, mobile core network[36] and Radio Access Network (RAN).[37] The RAN is made up of equipment on a collection of cell sites. To connect the mobile core network to the RAN, each MNO either self-supplies or buys backhaul and midhaul connectivity (typically fixed connections, such as leased lines).

4.5 The MNOs deploy and operate a proportion of their RAN through network sharing arrangements:

- **Mobile Broadband Network Limited (MBNL) is a 50/50 joint venture between EE and Three**. It provides a shared site portfolio (i.e. passive network) which supports both shared (3G) and non-shared (2G/3G/4G/5G) technologies (i.e. active network) used by Three and EE. MBNL manages the design and operation of the shared network. In high traffic areas, EE and Three have deployed their own separate 3G networks.
- **Cornerstone Telecommunications Infrastructure Limited (CTIL) is a 50/50 joint venture between Virgin Media O2 and Vodafone** that owns and operates the MNOs' network

[35] Big Tech includes Amazon, Apple, Facebook, Google, Microsoft, and potentially other large tech companies like Samsung.
[36] The core is typically a network of interconnected nodes which form the backbone of a communications network. It manages functions such as authentication, authorisation, connectivity and call routing.
[37] The RAN connects customer devices (e.g. handsets) and mobile phone masts using radio spectrum.

sites. Virgin Media O2 and Vodafone separately have a contractual arrangement to mutually share their (2G/3G/4G/5G) technologies in much of the country outside of the larger cities. Virgin Media O2 operates the active network in much of the East of the United Kingdom, Northern Ireland and most of Scotland, while Vodafone operates the active network in much of the West of the United Kingdom including Wales.

4.6 The MNOs also deploy and operate a proportion of their RAN independently of the network sharing arrangements. For both their shared network and unilateral sites, MNOs use the infrastructure of independent providers in some cases.

4.7 The four MNOs use their mobile networks to provide both their own retail services (under their own brand and sub-brands) and to offer wholesale mobile services to a number of MVNOs who use this input to provide their own retail mobile services.[38] The MNOs are therefore vertically integrated.

4.8 However, MNOs have only a limited role in the supply of operating systems, devices, apps and content. Apple and Google play a central role here, as outlined later on in this section.

4.9 We discuss potential future changes in provision of mobile services in Section 5 and the implications of this in Section 6.

The market has delivered good outcomes over the last ten years

There has been innovation across the value chain

4.10 Over the last ten years, innovations across the value chain have profoundly affected how mobile services are used in our everyday lives. The key innovations can be broadly categorised into three areas:

- **Networks** – 4G and 5G technologies, driven by global standards bodies and network equipment vendors. These have allowed MNOs to deploy new generations of mobile networks unlocking new types of online services such as video and bringing improvements to the quality of experience from faster download speeds and lower latency.
- **Mobile devices** – improvements in the functionality of smartphones and new types of mobile devices including wearable devices such as smartwatches.[39] These devices extend the functions of mobile devices into new areas, for example, smartwatches are now able to monitor some metrics relating to the health of the user.[40]
- **Online services** – new ways to perform traditional tasks (e.g. sending messages via messaging applications such as WhatsApp, paying for goods through applications such

[38] Sky Mobile is an example of an MVNO.
[39] The use of such devices is now relatively commonplace. 44% of respondents to Ofcom's technology tracker indicated that someone in their household had a smartwatch or wearable tech. See Ofcom Technology Tracker 2021 (QV10: Do you or does anyone in your household have a smart watch or wearable tech such as a fitness tracker – a wearable computer that may be compatible with a smartphone? Popular brands include Apple Watch, Fitbit and Garmin.)
[40] The extended functionality of mobile devices has been supported by innovations in both sensors and data analytics platforms that allow for more data to be captured, analysed and made available to the user.

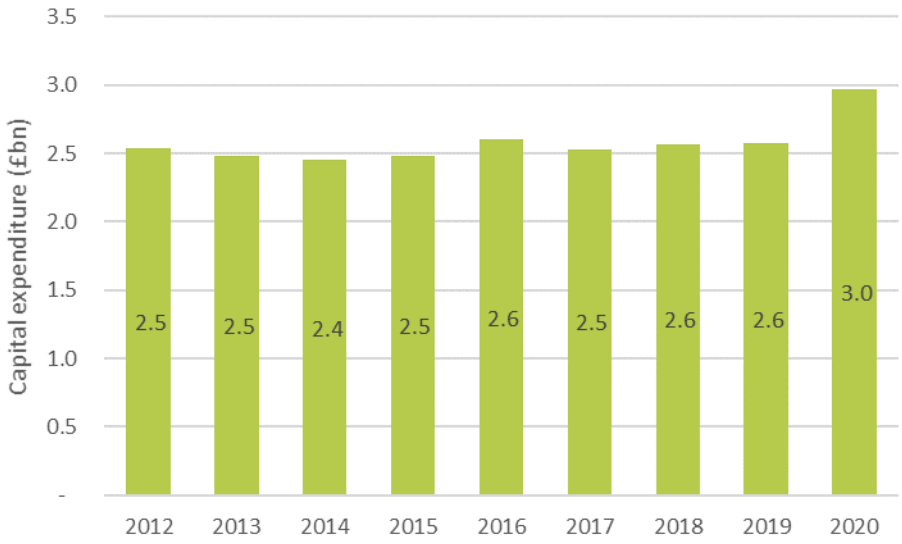
as Apple Pay and Google Pay); for navigation (e.g. Google Maps); and to interact with services verbally (e.g. Siri).

There has been significant, ongoing investment in mobile networks

4.11 Competition among MNOs has driven investment at a broadly constant level of around £2.5bn each year since the launch of 4G in 2012, as set out in Figure 4.2. This has enabled the rollout of 4G technology, providing faster, more reliable networks to support online services, with ongoing increases in capacity and smaller technology upgrades.

4.12 5G was launched in 2019, and industry capital expenditure increased considerably in 2020.[41]

Figure 4.2: Capital expenditure (excluding spectrum) across all MNOs from 2012 to 2020[42, 43]



Source: Company financial statements from Companies House and group financial statements.

4.13 4G mobile connectivity is now widely available in the UK. Ofcom's mobile coverage estimates are summarised in Table 4.3.[44]

[41] This is in line with our finding in Connected Nations 2021 (pages 46 – 47) where we state that mobile telecoms network capital expenditure increased by 25% in real terms to £1.8bn in 2020 (2019: £1.5bn).
[42] The data in Figure 4.2 includes non-network specific capital expenditure (e.g. IT systems/software upgrades, property/facilities and customer focussed capital expenditure). In our Connected Nations 2021 UK Report, we provided network capex information for 2019 and 2020 (this *excluded* non-network specific capital expenditure).
[43] 2012 to 2019 data taken from UK statutory financial statements (Vodafone Limited, Telefonica UK Limited, EE Limited and Hutchison 3G UK Limited), 2020 taken from UK statutory accounts for Vodafone Limited, Telefonica UK Limited and EE limited. Hutchison 3G UK Limited has not yet published UK statutory financial statements for 2020, so 2020 data taken from group disclosures for Three (CK Hutchison Holdings Limited). Capital expenditure includes an element of fixed network capital expenditure (from EE and Vodafone). 2016 capital expenditure for EE has been scaled down as it was based on a 15-month accounting period following the acquisition by BT.
[44] These coverage estimates are based upon MNO predictions of mobile strength thresholds. Ofcom undertakes regular field testing of the suitability of these predictions for national and regional reporting. By its nature, this methodology does not necessarily reflect localised user experiences, because it is based on predictions which may not capture all local variables and cannot fully account for the impacts of any capacity issues the network experiences at busy times. A full summary of the methodology used is provided in the Methodology Annex to Connected Nations 2021.

Table 4.3: The UK's 4G coverage in 2021

	MNO range[45]	All four MNOs
Premises (outside)	99%+	c.98%
Premises (inside)	90% - 95%%	81%
Geographic coverage	79% - 86%	69%
Major Roads[46] (in vehicle)	82% - 88%%	66%
B Roads (in vehicle)	72% - 77%%	59%

Source: Ofcom analysis of data collected from MNOs in September 2021, Connected Nations 2021.

4.14 There is widespread coverage outside premises, though there are differences in coverage between urban and rural areas, with individual operators' 4G coverage outside rural premises ranging between 93-97%, whereas each MNO has coverage outside more than 99% of urban premises.[47]

4.15 There are also some significant differences across the four nations of the UK, with MNOs' reported geographic coverage at 92-94% in England; 87-92% in Northern Ireland; 57-73% in Scotland; and 72-84% in Wales.[48]

4.16 5G deployment by the MNOs is initially focused on improving network capacity to meet demand in congested urban areas. So far, 5G coverage only represents a small part of UK landmass, but we estimate 5G to be available from at least one MNO outside 42% - 57% of UK premises.[49] This investment has significantly increased the capacity of the MNOs' networks to carry data and deliver improvements in the services that rely on those networks.

The available evidence suggests that quality of experience is good overall, though it is patchy in places

4.17 A good quality of experience is important to enable people and businesses to use the services they need, when they need them. Whilst coverage is a prerequisite, quality of experience is multi-dimensional and also encompasses factors such as reliability and performance:

[45] This refers to the range of 4G coverage available from individual MNOs, which most closely matches the experience of most consumers.
[46] This is comprised of motorways and A roads
[47] See Ofcom, Connected Nations 2021.
[48] These figures are based on data from September 2021. See Ofcom, Connected Nations 2021.
[49] Given the current level of deployment, it is challenging to conclude on a single margin to define the reliability of a 5G service being available at this stage. Our estimates vary depending on the signal strength which an operator predicts to provide (in dBm). In this approach, the lower end of the range of coverage is associated with a higher signal level (-100 dBm) at which we have very high confidence of coverage being available. The higher end of the coverage range is associated with a lower signal strength (-110 dBm) at which we have high confidence of coverage being available. See Ofcom, Connected Nations 2021 for further information.

a) Reliability is the ability to use the service consistently without gaps, (which can be caused by factors such as micro not-spots and imperfect optimisation of networks or the temporary non-availability of the service caused by a fault in the network).[50]

b) Performance includes speed and responsiveness which can be affected by network demand and congestion, particularly at busy locations and at busy times of the day:

   - Speed describes the rate at which mobile data is transferred to mobile devices. This affects experiences of activities such as loading webpages, downloading files and streaming content. It is important, but only to the extent that it is required for the service being used. For many services, such as video calling, the continuous reliability of a decent speed is much more important than very high peak speeds.
   - Responsiveness, also known as latency, is important for services where people or machines interact via the mobile network. Whilst low latency is important in everyday services such as calling and web browsing, it becomes essential in areas such as AR and some gaming applications.

4.18 We have a range of data on quality and have developed benchmarks for how this translates into user experiences.[51] However, we do not yet have a granular view of quality of experience at a local level and how this varies across the country.[52]

4.19 Our existing evidence suggests that quality of experience is generally good for most users but can be patchy in places:

a) In terms of customer satisfaction, Ofcom's consumer research indicates that over four in five customers (82%) are satisfied with their mobile reception or signal strength.[53] Though rural residents are less likely than average to be satisfied with reception or signal strength (78% vs 82%).[54] For rail passengers, there are specific barriers to delivering good connectivity and research by Transport Focus identified that users were more likely to say they were dissatisfied than satisfied with the internet they usually get while travelling, with satisfaction particularly low for business travellers.[55]

b) Crowdsourced data shows that users could access 4G data on the vast majority of occasions (96%) when they attempted to do so, and that this does not vary significantly

[50] Micro not-spots may not be picked up in our coverage model, which uses 100m x 100m areas and levels of probability, but by this model's nature small areas within this that do not receive coverage may not be captured. In terms of optimisation, for example, coverage may be present, but a network may be steering devices onto a technology or band which can't provide service to that location at that time.
[51] For example, we have developed benchmarks for coverage which underpin the data in Table 4.3. For 4G, we undertook work in 2017 to establish a predicted signal strength which could be associated with certain facets of a quality experience. In particular, we determined that where this signal strength was available, 90 second voice calls could be sustained at least 95% of the time, and 2 Mbps data services were reliably available. Consumers also indicated that they tended to be happy with their mobile experience where these signal levels were present.
[52] For example, coverage projections from MNOs are informative but do not always correspond with people's lived experience due to factors such as geography, indoor or outdoor use, weather conditions, and demand on the network.
[53] Ofcom, Satisfaction Tracker Winter 2020 Table 33 M4. How satisfied are you OVERALL with the RECEPTION OR SIGNAL STRENGTH that you get on your mobile phone service from <Mobile>? Base: All Mobile respondents
[54] Ofcom, Customer Satisfaction Tracker, Winter 2020.
[55] Overall, 43% of respondents were dissatisfied compared to 30% who were satisfied. Among business travellers, 54% reported being dissatisfied, compared to 23% who reported being satisfied. See Transport Focus, Keeping connected: passengers' experience of internet connectivity on Great Britain's railways, July 2020.

by MNO, nation, or rurality.[56] Such reliability may though vary at different times of the day, and we have found that failures are more likely at peak times in busy areas than at other times of the day.[57]

c) There are also a number of international surveys that seek to compare quality of experience across countries. It is difficult to make reliable comparisons between different countries, [58] and these comparisons often focus on the narrow metric of speed rather than a more comprehensive set of quality of experience metrics. However, the general pattern across a range of studies is that the UK appears to generally be 'middle of the pack' though some suggest it is lower than this.[59]

Customers have a range of choices and many customers are now getting more for less

Most customers have a wide choice of mobile providers and tariffs

4.20 Customers have a wide choice of mobile providers. They can choose from four MNOs as well as a number of MVNOs and independent resellers.[60]

4.21 Providers offer different combinations of services, tariffs, as well as type and duration of contracts. There are four broad types of mobile tariff on offer, which give the customer the ability to buy with and without a device, with and without a contract, and with varying contract lengths (see Figure 4.4).

[56] Ofcom, Mobile Matters 2021 Report, data from Jan-March 2021. The crowdsourced reliability data draws on background data collection that includes an automated 'connection test'. This connection test is a lightweight measurement, testing the availability and accessibility of a data connection to a cloud-based server in the internet. The test is attempted every 15 minutes, regardless of the available wireless network technology at the time of the test. For further details see Ofcom, Mobile Matters 2021: Technical methodology.

[57] Analysis of crowdsourced Android data from selected high-traffic areas shows that 3G and 4G connections were almost twice as likely to fail during peak times than at other times throughout the day.

[58] For example, simple cross-country measures may fail to take into account other relevant differences between countries that may explain the different outcomes across countries. One example is the role played by rurality and density of the population in explaining outcomes across countries.

[59] For example: OpenSignal ranks the UK 13th out of 20 countries for 'reliable download speed' from 1 February to 1 May 2021; Tutela ranks the UK 37th out of 100 countries, with an experience score of 67.33% in its Global State of Mobile Experience 2021 Annual Report; and Speedtest ranks the UK as 35th out of 138 countries included in its Global Index December 2021 (median speeds). New research commissioned by Ofcom to review how the UK mobile sector performs compared to a selection of particularly developed markets (Finland, Japan, Norway and Taiwan) draws on existing international comparator data and indicates that the UK's average mobile speeds generally lag behind these leaders. See Plum Report (2022).

[60] Examples of independent resellers include Buymobiles.net, Metrofone, Fonehouse, Mobile Phones Direct.

Figure 4.4: Types of mobile tariffs

Tariff Type	Services	Typical Length[61]
Bundled contract	Provision of an airtime tariff and mobile device for one monthly payment	Contract period of between 12 and 24 months
Split contract	With some providers[62] customers can choose to pay for their mobile device and airtime tariff under two contracts	Subject to maximum contract period of 24 months (with an option of up to 12 months); device contracts can last longer (e.g. 36 months)[63]
SIM-only	Airtime only tariff	Range from 30-day [64] to 12-24-month tariffs
Pre-Pay[65] (also known as pay-as-you-go (PAYG))	Customers purchase a set amount of credit towards mobile minutes, messages and data[66]	N/A

Source: Ofcom

4.22 Customers are also able to choose from a large number of each type of tariff, which typically vary by the size of the data allowance. A search of the MNOs' websites indicates that over 60 pay monthly SIM only deals are available with data allowances ranging from 250 MB per month to unlimited.[67] Some providers also offer different tariffs based on the maximum data speed or with additional services included in the monthly fee, such as the use of Spotify, or roaming calls.[68]In addition, customers can purchase fixed and mobile services together from some providers. Just under one fifth (18%) of mobile customers said that they purchased fixed and mobile services from the same provider in 2021.[69]

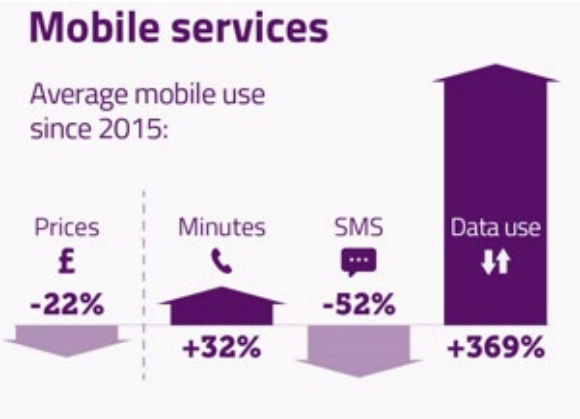
Prices have in general been falling

4.23 In general, mobile prices have been falling in the UK and, on average, customers have been getting more for less: the average price of a basket of mobile services based on average use in 2020 was 22% lower than that of a basket based on average use in 2015. This was

[61] Under General Condition C1.11, commitment periods for phone and internet access services are limited to a maximum of 24 months. Since 17 December 2021, this limit also applies to bundles (including terminal equipment). C1.13 also requires phone and internet access providers to offer a contract with a maximum commitment period of 12 months.
[62] For example, O2, Virgin Media, Sky, Tesco Mobile and Vodafone
[63] Virgin Media O2 and Vodafone allow devices to be paid over up to 36 months.
[64] Includes both rolling contracts and tariffs with an upfront monthly cost.
[65] Traditional pre-pay services used to be a very popular way of purchasing mobile services, but is now only offered by a limited number of providers. Notably, Three is the only MNO that offers a PAYG service to new customers without an inclusive usage allowance (although there are MVNOs that offer these tariffs). This allows a customer to make a minimum top-up of £5 which gets zeroed after a period of time (in this case 6 months) of no use. As such, this allows the option of mobile connectivity for less than £1 per month which could be attractive for occasional mobile users.
[66] Alternatively, customers can purchase a monthly tariff (a 'hybrid' pre-pay service), which can be cancelled at any time, and has inclusive data, calls and text message allowances, similar to a 30-day SIM-only tariff.
[67] Websites reviewed in December 2021.
[68] Accessed August 2021 – Roaming offered as part of a 24-month bundled contract by Three.
[69] Ofcom, Technology Tracker 2021, Table 156, MOBILE (PERSONAL) STANDALONE - DEFINED BY SUPPLIER USED FOR MOBILE AND OTHER SERVICES.

despite average data use and call minutes having increased by 369% and 32% respectively during the intervening period (SMS messages declined by 52%) (Figure 4.5).

Figure 4.5: Average prices have fallen since 2015 despite significant increases in data use



Source: Pricing trends for communications services in the UK 2021. Based on prices adjusted for inflation.

4.24 Our analysis also shows that in comparison with France, Germany, Italy, Spain and the USA, the UK had the lowest standalone mobile prices in 2020.[70] It had the joint-cheapest weighted average standalone mobile prices with France, and the joint-cheapest lowest-available prices, with Italy.[71]

4.25 However, prices appear to be rising for low use customers,[72] and there have been some recent increases in prices announced for PAYG customers[73] and some pay monthly customers.[74]

4.26 We recognise that some customers may have less choice than others, and that some may see prices rises in the next few months. We have encouraged providers to take account of the growing pressure on their customers when considering any increases and provide advice to consumers about getting a better deal.[75] We are also continuing to monitor the affordability of internet access.[76]

[70] The UK ranked first overall across three mobile connections using data provided by Teligen. See Ofcom, Pricing trends for communications services in the UK, 2021, page 60.
[71] Ofcom, Pricing trends for communications services in the UK, 2021, page 60.
[72] This analysis, used in Ofcom's Pricing trends for communications services in the UK report, 2021, compares six customer profiles representing a range of mobile consumer usage types, between 2019 and 2020. The two profiles with no data allowance saw price increases of 19% and 26%. In comparison, the four profiles with data requirements saw average prices fall between 10% and 22%. (see page 42).
[73] In February 2021, Three announced significant price increases for all of its PAYG customers from 16 February 2021. GiffGaff, O2's sub-brand, has also raised its traditional PAYG pricing: in February 2021 it doubled the price of data usage from 5p per MB to 10p for customers not taking its hybrid PAYG Goodybag tariffs. Meanwhile, it has increased the data allowance for its standard (4G) £8 Goodybag from 2 GB to 3 GB. Pricing Trends Report July 2021, page 46. Virgin Mobile have also entirely shut down their PAYG services, the phasing out occurred between October 2021 to February 2022.
[74] Some leading fixed and mobile providers increased prices at above-inflation rates for new, and many existing, customers in 2021. For example, EE increased prices by CPI +3.9% from April 2021; Three has introduced price increases of 4.5% (independent of CPI) to be applied each April; and Vodafone has introduced price increases of CPI +3.9%, also to be applied each April. See Ofcom, Pricing trends for communications services in the UK, 2021, page 5.
[75] Ofcom, Telecoms price rises – could you get a better deal?, January 2022.
[76] Affordability of communications services - Ofcom

Customers are generally satisfied with their mobile tariff and provider

4.27 The vast majority of consumers are satisfied with the value for money offered by their mobile services (83%).[77] However, a minority (5%) are not satisfied with value for money, and similarly a minority (6%) reported having had an affordability issue in the past month.[78] We consider outcomes for financially vulnerable households in more detail later in this section.

4.28 Overall, nine in ten (90%) mobile customers are satisfied with the overall service from their provider. This is higher than customer satisfaction with broadband and landline providers, and in line with customer satisfaction with banks for current accounts and with electricity providers.[79]

There is some evidence that engagement among mobile customers is starting to increase

4.29 It is important that customers engage in the market so that the full benefits from competition can be realised (e.g. in relation to choice, innovation and prices). Where customers are less engaged, they may be less likely to obtain a good deal and may, for example, face higher prices as a result. In mobile, this is particularly the case for customers on bundled contracts who do not take action at the end of their minimum contract period. These customers risk paying more than they could do for a comparable SIM-only contract.

4.30 One measure of engagement is the extent to which people re-contract with their current provider, or switch to an alternative provider, rather than remaining out-of-contract. On this basis, engagement among mobile customers has been broadly stable in recent years, but there is some evidence that this is now increasing. The proportion of mobile customers who were out-of-contract fell slightly between 2019 and 2020 (from 27% to 25%).[80]

4.31 The introduction of end-of-contract notifications (ECNs)[81] appears to have prompted an increase in engagement among mobile customers. For example, engagement among bundled customers whose contracts ended in September 2020 was higher than in the

[77] Ofcom, Satisfaction Tracker February 2021, Table 31, M3.
[78] Ofcom, Affordability report, July 2021, page 18.
[79] Ofcom, Ofcom Customer Satisfaction Tracker 2020.L1/M2/IN2/PT1/B1/BM3/BM8/BM10: In terms of your (SERVICE) how satisfied are you with the overall service provided by (PROVIDER)? Base: All Landline decision makers (1,997), All Mobile decision makers (2,556), All Fixed Broadband decision makers (2,274), All Pay TV decision makers (1,300), All Bundle decision makers (2,004), All Main Current Account decision makers (2,476), All Gas ONLY decision makers (197), All Electricity ONLY decision makers (493).
[80] Ofcom, Helping customers get better deals: A review of the impact of end-of-contract notifications and pricing commitments by broadband and mobile providers, 2021, page 3. The proportion of customers out-of-contract varies by type of contract. Around two-fifths of SIM-only customers (42%) were out of contract in 2020, compared to 11% of customers on bundled contracts, which likely reflects the lower cost savings for SIM-only customers from engaging compared to bundled customers.
[81] Under our ECN requirements, which came into effect from February 2020, providers must tell their residential customers about any changes to their price and services at the end of their minimum contract periods, and the best tariffs available from their provider, as well as discounts available to new customers (so that customers are made aware of the benefits of switching). The notification also has to include at least one SIM-only contract for customers on bundled mobile handset and airtime contracts. Business customers must also receive a notification to inform them of the end of their minimum contract period and how they may terminate the contract.

comparable period in 2019 (76% in 2020, up from 70% in 2019), while for SIM-only customers, engagement increased from 27% in 2019 to 32% in 2020.[82]

4.32 In addition, all customers who remain out-of-contract must now be given information about their contract and their provider's best tariffs at least annually. These are known as annual best tariff notifications (ABTNs). This means customers are told about the best tariffs for the services they buy and can see if they are on the best deal.[83]

Levels of switching have also been rising

4.33 The level of switching between mobile providers has gradually increased over time, and increased significantly recently: from 12% in 2019 to 16% in 2020;[84] it was also higher than the switching rates for other communications markets.[85] This recent rise may in part reflect the introduction of the new, simplified 'text to switch' process that came into effect in July 2019. The process is designed to make it quicker for the customer to leave their provider, giving them more control over how much contact they have with that provider.[86] In addition, the increased levels of switching may also partly be explained by customers increasingly switching to SIM-only tariffs, as they hold onto devices for longer.

The most financially vulnerable customers are more likely to rely on mobile services and to have lower satisfaction in some areas

4.34 Some people face circumstances which may make them temporarily or permanently vulnerable, including financially vulnerable. While mobile services are affordable for most, there is evidence that a small minority (6%) of users face affordability issues,[87] and around 3% of mobile customers were in arrears between January 2020 to January 2021.[88]

4.35 People who are on lower incomes or more financially vulnerable engage with mobile markets differently in some respects. For example, households on the lowest incomes are around twice as likely as the overall population to rely on their mobile as their only source of internet access.[89] The most financially vulnerable households[90] are also more likely to

[82] Ofcom, Helping customers get better deals: A review of the impact of end-of-contract notifications and pricing commitments by broadband and mobile providers, 2021, page 8.
[83] Ofcom, Helping customers get better deals: A review of the impact of end-of-contract notifications and pricing commitments by broadband and mobile providers, 2021, page 14.
[84] Ofcom Switching Tracker 2020, Q28 – Have you or your household ever changed the company that providers your mobile phone service? Takes account of those who say they have switched in the last year.
[85] Compared with Landline, Broadband only, Pay-TV, Dual-play bundles and Triple-pay bundles. Ofcom Switching Tracker 2020. Q29B.
[86] Ofcom, Text to switch: it's never been simpler to switch mobile network, 28 June 2019.
[87] Ofcom, Affordability of communications services: summary of findings, July 2021. Customers who are disproportionately likely to have had an affordability issue in the last month include those on receipt of benefits, those with household incomes below £26,000, and those with physical vulnerabilities.
[88] This is slightly higher than for fixed broadband (around 2% on average). Ofcom, Review of measures to protect people in debt or at risk of disconnection: call for inputs, July 2021.
[89] Those who are unemployed and seeking work, or on incomes below £11,500, are more than twice as likely to be in this situation than the overall population (12% and 11% compared to 5%). Ofcom, Affordability of communications services: summary of findings, July 2021.
[90] Ofcom categorises households into three types by using a combination of household income, working status and the size of the household (including the number of children). These household types are referred to as the 'most financially vulnerable', those who are 'potentially financially vulnerable' and those 'least likely to be financially vulnerable'.

use traditional PAYG tariffs,[91] and as such may be affected by changes in market conditions such as recent price increases for PAYG tariffs referenced in paragraph 4.25.

4.36 In some areas, customers who are the most financially vulnerable experience poorer outcomes than customers overall. For example, our consumer research finds that, in comparison to customers overall, the most financially vulnerable customers are:

- less likely to be satisfied with their overall mobile service (86% vs 90%)[92]
- more likely to have had a reason to complain with their mobile service (16% vs 10%)[93]
- less likely to be satisfied when having made a complaint (52% vs 57%)[94]

4.37 There is evidence that some other potentially vulnerable groups of users have different engagement with the mobile markets or different outcomes in some areas. For example, people with limiting conditions are much less likely to own a smartphone (59% compared to 84%).[95] Ofcom has an ongoing programme of work to help ensure that vulnerable customers can get the support they need, as set out further at Annex 5.

Business customers also have a choice of providers

4.38 Business customers also have a choice of provider and contract type. All MNOs and some MVNOs, such as Tesco Mobile, offer services to businesses. These include standard mobile business contracts aimed at very small businesses, which are broadly similar to the types of tariffs offered to residential customers, (e.g. on a bundled contract or SIM-only basis). Mobile providers sometimes also offer adjacent services such as software, or legal or business services.

4.39 Previous research (2017) found that small businesses' satisfaction with mobile services is high: around four fifths (78%) felt that their mobile services offered value for money, and 75% were satisfied with the reliability of their mobile signal/connection.[96] When asked about the possibility of switching provider, the majority felt they had a wide choice of providers to choose from.[97] However, many agreed it could sometimes be difficult to compare services across providers, especially in relation to network quality, customer service and/or prices, and a general lack of differentiation.[98]

4.40 Recent qualitative research suggests some small businesses consider reliability and service to be more important than cost when deciding whether to stay or switch provider.[99] It also

[91] Benefits to these users of PAYG services may include such as greater flexibility or the lack of credit checks compared to taking out a contract. Overall, 22% of mobile customers are on prepay / PAYG using top ups. This is higher than average amongst the most financially vulnerable (28%), as well as mobile customers in DE households (28%) and those with an impacting or limiting condition (25%). See Ofcom, Customer Satisfaction Tracker, 2020, Table 27.
[92] Ofcom, Customer Satisfaction Tracker 2020, Table 30.
[93] Ofcom, Reasons to complain survey, 2020, Tables 23 and 24.
[94] Unpublished analysis of Complaints Handling Tracker 2020.
[95] Ofcom, Use of communication services, consumer omnibus 2020: Focus on people with impacting and/or limiting conditions, September 2021.
[96] Ofcom, The SME experience of communications services: research report, 2017, page 42.
[97] 71% disagreed with the statement that 'there is not enough choice of suppliers to my organisation'.
[98] Ofcom, The SME experience of communications services: research report, 2017, page 76: 64% for network quality (reliability and coverage); 56% for customer service; 43% for prices and 54% for a general lack of differentiation.
[99] Ofcom, SME Communications research: qualitative summary report, 2022.

suggested that experiencing poor reception has prompted some SMEs to switch provider, or to plan to do so at the end of their contract.

4.41 Ofcom is currently carrying out further research into small businesses' experience with the communications market, which we will be able to incorporate into our conclusions later this year.

4.42 Services offered to larger businesses are much more bespoke and individually negotiated. Some very large businesses choose to have their own private network and, as we discuss later, there is the potential for a significant rise in the use of private networks in the coming years.

Competition in the mobile sector

4.43 When the use of mobile internet was still nascent, the provision of mobile services revolved around the MNOs.

4.44 As the use of mobile internet has grown, operating systems, app store platforms and online content have all become important, and revenue from apps and mobile advertising[100] is now of a similar scale to that from mobile services.[101] Technological giants (Big Tech),[102] in particular Apple and Google, now play an important role, with a significant share of the value of services.[103] As a result, the value chain has become more complex and, while the MNOs still play a critical role, the model of competition is evolving.

4.45 We provide below an overview of how competition is important in driving good outcomes, before discussing competition at the network and then the retail level. We discuss potential future market developments in the provision of mobile services in Section 5.

Competition is important in driving good outcomes in the mobile sector

4.46 Competition among MNOs continues to be central to the delivery of good outcomes in mobile markets. MNOs compete directly with each other at the retail level, and also support retail competition indirectly by supplying wholesale network access to MVNOs that subsequently provide retail mobile services.

4.47 Ofcom has previously found that the key drivers of consumers' choice of mobile provider are price and network quality (with the main aspects of quality relating to network coverage and reliability),[104] and these parameters have determined how mobile providers have competed to win and retain customers in the UK.

[100] Mobile advertising means any form of advertising that appears on mobile devices.
[101] In 2020 UK app spend was around £2.5bn (App Annie, State of Mobile 2022) and UK mobile advertising spend was around £9.7bn (Ofcom, Online Nation 2021 report, June 2021, pages 121-123), while UK retail mobile revenue was £12.5bn (Ofcom, Communications Market Report 2021, July 2021).
[102] Big Tech includes Amazon, Apple, Facebook, Google, Microsoft, and potentially other large tech companies like Samsung.
[103] For example, as outlined later in this section, the CMA has provisionally found Apple and Google to have an effective duopoly in the supply of mobile operating systems, app stores and browser engines, the key gateways by which content providers access mobile users (CMA, Mobile ecosystems: Interim report, December 2021).
[104] Ofcom, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands – annexes, 2020, paragraph A3.7.

4.48 Competition based on both price and quality has driven firms to deliver good outcomes across a range of metrics. For example, offering wider coverage and a more reliable service is important for MNOs, as it allows them to differentiate their service from that of their competitors and meet customer expectations. This benefits customers, as they can choose the combination of prices and quality that best meets their needs.

At a network and wholesale level, there is competition among four MNOs

4.49 There are significant barriers to constructing a new national mobile network,[105] including the high fixed cost and time of building a national network of competitive quality (particularly the RAN), the high fixed cost of acquiring sufficient spectrum and the time it takes to build a customer base.

4.50 The high fixed costs give rise to economies of scale, whereby the average unit costs of an MNO decline as output/scale increases. As a result, an MNO needs to serve a sufficiently large share of the market to be economically viable. While the precise minimum viable scale (MVS) will vary by operator depending on its overall cost efficiency and revenue per customer, where there are economies of scale, an MNO with a larger subscriber base is likely to face lower per unit costs than a much smaller MNO.[106] This market feature shapes the nature of competition in the market and provides an incentive for national mobile network operators to win subscribers, and therefore volumes, and may in part have driven the desire for market consolidation in the past.[107]

4.51 Today the four MNOs operate at different scales. On a consumer subscriber basis, in Q1 2021 Virgin Media O2 had the largest share (c. 35%), followed by EE (c. 34%), Vodafone (c. 18%) and Three (c. 13%).[108] These differences in shares may translate into different per unit costs for the operators, reflecting economies of scale. Over the last ten years, there have been some variations in subscriber shares. Most notably in 2016/17 when O2 (now Virgin Media O2) overtook EE as the MNO with the highest proportion of subscribers. These historical variations have led to a small decline in market concentration.[109]

[105] See, for example, Ofcom, Assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, Annex 6, paragraphs 5.47-5.54, 2011.
[106] See, for example, Ofcom, Assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, Annex 6, paragraph 6.45, 2011.
[107] For instance, the sector changed from having five operators to four in 2010 when Deutsche Telekom (T-Mobile) and France Telecom (Orange) agreed to merge their UK mobile operations into Everything Everywhere (now EE). EE was acquired by BT in 2016. There was a further attempt at consolidation in 2015 when Three agreed to acquire O2's UK mobile operation, which would have reduced the number of MNOs in the UK to three. This proposed merger was blocked by the European Commission in 2016, although in 2020 its decision was annulled by the General Court of the European Union. In 2021, Virgin Media and Telefonica merged to create Virgin Media O2, a converged fixed and mobile network operator.
[108] Ofcom, Main Technology Tracker 2021 data tables, pages 157-159, QD10: "Which mobile network do you use most often?". Figures for Virgin Media O2 include giffgaff, Sky Mobile, TalkTalk and Tesco Mobile; figures for EE include BT, Plusnet, Utility Warehouse and Virgin Media; figures for Three include iD Mobile and Smarty; and figures for Vodafone include Asda Mobile, Lebara, Lyca Mobile, Talk Mobile and Voxi.
[109] For example, see Ofcom, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands, Annexes 5-18, 2020, paragraph A6.25 and Table A6.1.

MNOs purchase RAN equipment from a concentrated market

4.52 The current mobile networks have been built using a traditional architecture whereby each piece of equipment has a closed and vendor-specific interface, and uses proprietary hardware and software. This means that MNOs have tended to use a single vendor at a particular cell site (or collection of cell sites).

4.53 Over time there has been consolidation in the RAN equipment market.[110] Globally, the market is now dominated by Nokia, Ericsson and Huawei who had a combined market share of over 80% in 2019-2020.[111] These vendors are also the main suppliers of RAN equipment for the networks of the UK MNOs. A number of factors have contributed to this consolidation, including: a) operators' preference for established reliable and stable suppliers;[112] and b) economies of scale and high levels of R&D investment required to compete in the traditional equipment market.[113]

4.54 The Government's restrictions on the use of high-risk vendors require MNOs to stop purchasing and deploying Huawei equipment, reducing the number of large vendors to two.[114] In the DCMS's supply chain review, it noted that while both Nokia and Ericsson are well established and leading telecoms equipment suppliers, the number of vendors represents, among other things, a significant resilience and competition risk. The introduction of Open RAN architecture, currently being developed, could change this in future (see Section 5).

Network competition has driven significant ongoing investment in mobile networks

4.55 Competition among the four MNOs has been a key driver of the significant investment in mobile networks over the last 10 years.

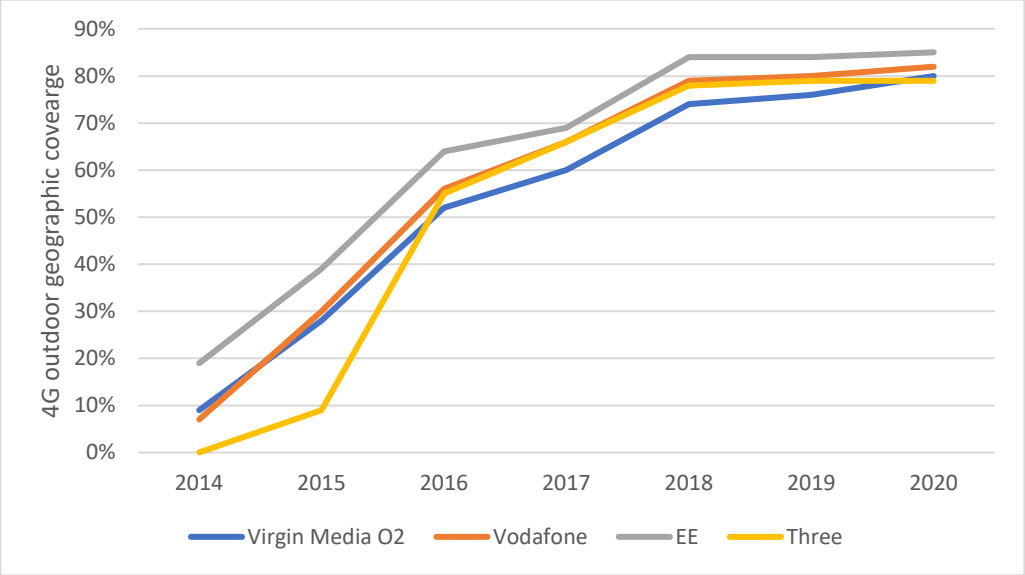
4.56 EE gained an early advantage in its deployment of 4G, enabled by having 4G-capable spectrum ahead of the other MNOs.[115] This allowed EE to launch a 4G service in October 2012 – around a year ahead of its rivals – and it proceeded to carry out a rapid rollout of its 4G network (see Figure 4.6).[116]

4.57 Fast customer take-up was fuelled by noticeable improvements in service quality on 4G – particularly for video – and a retail handset subsidy model that encouraged customers to replace handsets regularly, which enabled fast adoption of 4G capable devices.[117] As a

[110] For example, in 2016 Nokia finalised its acquisition of Alcatel-Lucent, a French-American global equipment vendor (Nokia finalizes its acquisition of Alcatel-Lucent, ready to seize global connectivity opportunities).
[111] DCMS, 5G supply chain diversification strategy, November 2020.
[112] Some MNOs outsource technical and network operations personnel to their equipment vendors to enable network deployment and operation to be managed entirely by that equipment vendor (i.e. a managed service).
[113] DCMS, 5G supply chain diversification strategy, November 2020.
[114] DCMS, Huawei to be removed from UK 5G networks by 2027, 2020.
[115] In August 2012 Ofcom decided to make a variation to EE's 1800 MHz Wire Telegraphy Act 2006 licence to allow the use of 4G technologies. This spectrum had previously been authorised to use 2G and 3G technologies only. Ofcom, Decision to vary Everything Everywhere's 1800 MHz spectrum licences to allow use of LTE and WiMax technologies, 21 August 2012.
[116] Vodafone and O2 launched their 4G service in August 2013. Three launched its 4G service in December 2013.
[117] By way of illustration of the fast take-up of 4G, evidence from Ofcom's Technology Tracker indicates that by 2016 around two-thirds of smartphone owners had 4G connectivity.

result, other MNOs were incentivised by the risk of losing customers to EE to invest in deploying their own 4G networks to catch up, while EE continued to have the incentive to invest and expand its own 4G network to stay ahead of its rivals. This pattern of investment and 4G network deployment is reflected in the expansion of 4G coverage of each of the MNOs since 2014, with EE's 4G deployment being ahead of its rivals but the gap closing by the end of the decade.

Figure 4.6: 4G outdoor geographic coverage



Source: Ofcom, Connected Nations. EE launched its 4G service in October 2012; Vodafone and O2 launched their 4G service in August 2013; and Three launched its 4G service in December 2013

4.58 Competition continues to be a driver of the rollout of 5G networks and of improving 4G networks.[118] MNOs are deploying the spectrum they own to more of their sites, for both 4G and 5G, to deliver more capacity and are also building more sites to improve coverage. This allows providers to support more customers and to carry more data on their networks, which would otherwise bring congestion and service degradation.

4.59 While competition has helped drive network investment and deliver widespread mobile networks, there have been limited commercial incentives to roll out networks in some rural areas, that would otherwise leave complete and partial not-spots. Ofcom and Government have aimed to address the issue of not-spots through interventions, as outlined later in this section.

At the retail level, there is competition among a range of mobile providers

4.60 The four MNOs are the main providers of mobile services at the retail level, using their own brands as well as a number of sub-brands, such as Plusnet (EE), giffgaff (Virgin Media O2),

[118] Evidence we have gathered from MNOs through our formal powers suggests that the threat of losing customers to competitors continues to be an important driver of investment for MNOs.

Smarty (Three) and VOXI (Vodafone). Combined, they account for the large majority of retail customers.[119]

4.61 The remaining customers take services from independent MVNOs.[120] Around 150 have launched in the UK in the last ten years,[121] including Sky[122] and Tesco Mobile, who are currently the largest independent MVNOs.

4.62 Some customers purchase mobile services through independent retailers and use price comparison websites to compare the deals offered by different providers. Large independent retails such as Carphone Warehouse (latterly Dixons Carphone) played an important role in driving retail competition over the last ten years, but their role has diminished significantly, and Dixons Carphone has now closed all of its standalone stores.[123] Nonetheless, the presence of numerous price comparison websites can act to enhance competition by offering customers a clear and easy way to compare deals across the market and in turn increase competition.[124]

Competition is primarily focussed on price

4.63 Price is one of the most important factors driving consumers' choice of mobile provider and services.[125] For example, Ofcom data from 2018 and 2020 suggests that those customers that are either considering switching providers, or who had switched providers, were most likely to do so for reasons relating to the price of their service.[126]

4.64 That said, there is some evidence of a range of prices across comparable plans.[127] While the existence of such price dispersion does not in itself suggest a competition problem, in some cases it can indicate frictions in the competitive process which make it harder for consumers to find and select the combination of price and quality that best suits their preferences. In Section 8, we set out our intention to do more work to better understand the extent of price dispersion and in turn the potential gains from switching in the market.

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[119] Ofcom, Main Technology Tracker 2021 data tables (ofcom.org.uk), pages 157-159,, QD10: "Which mobile network do you use most often?" The four MNOs alone accounted for 76% of the customer share: EE 22%, (BT 4%), O2 19%, (Virgin Media 6%), Three 10% and Vodafone 15%.

[120] Including Sky Mobile, iD Mobile, Lebara Mobile and Lycamobile.

[121] CMA, LIBERTY GLOBAL PLC AND TELEFONICA, 20 May 2021, page 11.

[122] Sky currently has around 2 million mobile customers. See Sky Group, A Silver Data Lining, March 2021.

[123] Techradar, Carphone Warehouse announces the closure of 531 stores, March 2020.

[124] However, there is also a risk that the charges (usually commission rates) price comparison websites levy on firms in return for sales (in this case mobile providers) are reflected in higher overall prices to consumers. See for example: Warwick Economics Research Papers, Price Comparison Websites (No. 1056), October 2015.

[125] 46% of customers decided not to switch away from their current provider because it was still the best deal/cheapest. See Ofcom, Switching Experience Tracker 2020.

[126] Ofcom, Switching Experience Tracker 2020 and Ofcom, Switching Experience Tracker 2018. In 2020, when asked "What made you first think about switching your services?" 63% of customers that switched mobile provider provided one of the following responses: "Found out about a better/price with another provider" (27%), "Wanted to reduce cost of services" (23%), "Previous provider increased cost of services" (13%).

[127] Ofcom analysis indicates that MVNOs (including MNO sub-brands) have offered the lowest average prices for SIM-only mobile services (plans covered in the analysis were those with over 10 GB and up to 100 GB of inclusive monthly data) for all but three months from December 2016 to March 2021 and that the savings between the lowest price offered and the average price offered is above 50%. (See Ofcom, Pricing trends for communication services in the UK, July 2021, Figure 8). However, we are aware that this analysis may not reflect the actual savings available to consumers since it is based on offered prices which are not weighted by actual purchases (i.e. the analysis does not use actual prices weighted by the number of customers on each plan).

Competing through quality of experience is more challenging

4.65 Quality of experience is also important to customers, with network quality being an important driver of consumer choice of mobile provider.[128]

4.66 Given this, MNOs have an incentive to compete by offering a good quality of experience to retain customers and win new ones. As outlined earlier, over the last decade all MNOs have invested heavily, which has delivered significant improvements in the capacity and therefore the quality of their networks. In addition, all the MNOs invest in monitoring the quality of service of their networks and benchmarking this against rivals as a means of improving the overall customer experience.[129] It is now commonplace for MNOs to refer to the quality of their networks in marketing information to their customers or prospective customers.[130]

4.67 However, delivering high quality services nationwide can be challenging. Although the coverage information that we provide is well suited at a national level, there is limited data to enable customers to judge which is the best network to be on for where there want to use it. In addition, it can be difficult for people to predict where they will go and need service beyond the places they visit regularly. Often, it is only by signing up for and using a mobile service that customers are able to determine whether the service meets their needs.

4.68 The benefits to an MNO of competing through improving quality of service may be less strong than they could be if there were better information available to consumers to make informed choices.

Big Tech have a strong position in the provision of mobile devices, operating systems, apps and content

4.69 Over the last ten years, Big Tech (specifically Apple and Google) have become key players in two parts of the mobile value chain: a) devices and operating systems; and b) apps and content. In its market study, the CMA has been assessing competition in mobile ecosystems which is directly relevant here.[131]

4.70 In relation to mobile devices and operating systems the CMA has provisionally found:

a) Apple is the largest manufacturer of mobile devices and has a share of [50-60]% of active smartphones as well as [50-60]% of active tablets in the UK. As Apple's operating

[128] For example, in our July 2017 Statement on the Award of the 2.3 and 3.4 GHz spectrum bands we found that these two factors were the "most essential drivers of consumer choice". We drew the same conclusion in our Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: "[p]rice and network quality remain the key drivers of consumer decisions about which service provider to choose." In addition, when asked "What made you first think about switching your services?" 13% of customers that switched mobile provider answered "Technical issues with previous provider". See Ofcom, Switching Experience Tracker 2020.

[129] Information provided in response to Mobile Strategy Review and Mobile Spectrum Demand: Notice requiring the provision of information under section 32A of the Wireless Telegraph Act 2006, dated August 2021.

[130] For example, on EE's website (EE Network claims and recognition), it refers to being named the UK's best network for 4G and 5G and publishes information to substantiate this claim; and on Three's website, it refers to building the UK's fastest 5G network.

[131] CMA, Mobile ecosystems, Market study interim report, December 2021

system (iOS) is the only operating system that can be used on Apple devices, Apple's share of mobile devices mirrors its share of mobile operating systems.

b) Google has a small presence in the manufacture of mobile devices, with most Android devices being manufactured by third parties. But Google's Android is the second largest mobile operating system, with Android devices accounting for around [40-50]% of all active smartphones and between [20-30]% of active tablets in the UK in 2020.

4.71 In relation to apps and content, the CMA has made the following provisional findings about app stores and browsers, which serve as a key gateway between consumers and online content providers:

a) The App Store on iOS and Play Store on Android accounted for over 90% of native app downloads between them in the UK in 2020.

b) The combined share of supply for Apple's and Google's browsers on mobile devices in the UK amounts to around 90%, with Safari having a share of close to 50% and Chrome a share around 40%. In 2020, at least 97% of all mobile web browsing in the UK was performed on top of Apple's and Google's browser engines.

4.72 We discuss the potential for Big Tech to grow into other parts of the value chain in Section 5.

Regulation and policy have also helped deliver good outcomes

4.73 Regulation and public policy interventions (including by Ofcom, UK and devolved governments) have also played an important role in ensuring the delivery of good outcomes. Measures have been designed to:

- **Ensure the availability and efficient use of spectrum, a critical input to the provision of mobile services**. Ofcom has released significant amounts of spectrum to enable improved mobile services, generally using auctions to help promote its efficient use. We also set and charge Annual Licence Fees (ALFs) for continued use of spectrum, typically after an initial 20-year period. ALFs are set to reflect the market value of the spectrum (based on its opportunity cost), again to help promote the optimal use of spectrum.
- **Promote widespread mobile coverage to help get everyone connected.** The Government reached an agreement with the four MNOs to provide coverage to many of the remaining outdoor not spots in the UK, and is due to be completed in January 2027. The Scottish Government also launched the Scottish 4G Infill programme to deliver 4G mobile infrastructure to up to 55 mobile not-spots across the country by March 2023.[132]
- **Empower and protect consumers and help ensure they are treated fairly**. We have taken significant steps here with the introduction of rules on end-of-contract notifications and the new simplified "text-to-switch" process. The success is reflected in an increase in engagement among mobile customers and switching between providers which play an important role in making competition work effectively. In 2019, we

[132] Ofcom, Connected Nations 2021: Scotland, p. 29.

launched the Fairness for Customers commitments, to promote the fair treatment of customers.

- **Promote net neutrality**, which is the principle that all traffic is treated equally, so that users of the internet (rather than their service provider) can control what they see and do online. Ofcom is currently carrying out a review of how the net neutrality framework is functioning.[133]
- **Strengthen network security.** To help protect customers, businesses and the UK economy from major network failures or security breaches, the Government recently introduced a number of new measures under the Telecommunications (Security) Act 2021. This includes new powers for the Government to control industry's use of suppliers that are considered to pose a high security risk – also known as high risk vendors (HRV).[134] It has decided that all Huawei equipment should be removed from 5G networks by 2027.

4.74 We set out a number of key measures at Annex 5.

[133] Ofcom, Call for evidence: Net neutrality review, September 2021.

[134] The Act introduces new powers for the government to manage the risks posed by 'high risk vendors'. This means the government can control the extent to which equipment provided by these companies are used in telecoms networks, if that equipment is considered to be a risk to safety and security. In some cases this also means the government can require telecoms networks to remove existing equipment that has been sourced from these companies.

5. Key future market developments

5.1 In this section we set out the key changes that may occur over the next five to ten years in terms of:

a) how people and businesses use mobile services;

b) how mobile networks are provided; and

c) the sale and purchase of mobile services.

5.2 We discuss the implications of these key changes in Section 6.

We expect mobile services to become more important over the coming years

5.3 Today, the majority of time spent online (68%) is spent on smartphones rather than computers or tablets.[135] While much of the time such use relies on Wi-Fi, mobile services provided over national mobile networks continue to be important, particularly for use on the go. As we set out below, over the next five to ten years, we may see:

a) mobile data use continuing to increase, with a growing demand for higher quality mobile services to support the services customers want to use when and where they want to use them;

b) growth in the use of consumer smart technology, some of which relies on mobile services;

c) some further increase in the use of mobile services to provide fixed wireless access (FWA) services, at least in the short term; and

d) more significant new uses to emerge in industry and the public sector.

We expect data use to continue to rise, with a growing demand for higher quality mobile services

5.4 Over the last ten years we have seen an average 40% year-on-year growth in demand for mobile data provided over public mobile networks.[136] This growth has coincided with the declining use of traditional mobile messaging services, such as SMS and MMS,[137] the rising popularity of online services and apps like WhatsApp and Google Maps, and the evolution of mobile technology standards – in particular the introduction of 4G and more recently 5G.

[135] Comscore MMX Multi-Platform, Total Internet, Age: 18+, Sep 2019 and 2020, UK. Note: TV set and smart device online use not included, as included in Online Nation 2021 report.
[136] Total data uploaded and downloaded (PB) over UK mobile networks sourced from data underpinning Ofcom's annual Connected Nations reports (Connected Nations and infrastructure reports).
[137] The average mobile connection sent 51 SMS messages per month in 2020, a 25% decline from 2019. Source: Ofcom Communications Market Report, 2021.

5.5 We expect people's use of data to continue to grow. This is likely to be driven in part by people making greater use of existing applications that require higher bandwidth, such as video streaming,[138] video calling and cloud gaming on the go,[139] as well as higher quality services that entail higher data consumption (e.g. UHD video streaming).[140] We expect these trends to continue over time, facilitated by demographic changes,[141] (while also recognising that individual consumers are likely to use their mobile devices to different extents).[142]

5.6 In the longer term, new uses of the latest technology may become mainstream and be used more extensively on the go. These, and other applications, are discussed in our Mobile Networks and Spectrum discussion paper, which takes a longer-term view of potential future developments. It is difficult to predict what future uses might become commonplace and take-up will always vary between consumers. Nevertheless, possibilities include:

a) **More widespread use of augmented and virtual reality**: Augmented Reality (AR) involves overlaying electronic information onto the real world, often using a smartphone. Virtual Reality (VR) involves visually simulating a virtual world, typically using a special headset. Faster speeds and improved capabilities like low latency should enable more sophisticated applications of these technologies[143] outside the home, over mobile and other wireless networks. Provided the right connectivity[144] is available, these technologies can also be used in a range of other settings such as in retail (e.g. AR allows customers to visualise how furniture would look in their home via their smartphone camera) and in tourism (AR can enable customers to see additional information at museums and tourist sites and enjoy a more immersive experience).

b) **Connected cars:** Vehicles may increasingly use mobile networks to access things like real-time HD maps, traffic or hazard warnings, and entertainment. There may also be demand for 'tele-operated' vehicles, allowing them to be controlled from a remote location over the mobile network. We may see an increase in take-up of existing

[138] Including video-intensive social media, as services such as TikTok become more popular.
[139] Mobile games have been around since the early days of mobile phones and single-player games do not necessarily require connectivity. However, as coverage improves, connectivity may become the default. For example, Microsoft's cloud gaming service is already available on mobile phones. See Xbox Game Pass Supported Devices | Xbox.
[140] Streaming ultra-high definition (UHD) video can use far more data than standard (SD) or high definition (HD). SD and HD typically require around 2-5 Mbit/s, which mobile networks can deliver today, whereas 4K UHD requires around 25 Mbit/s (source: Netflix Help Centre). However, as mobile speeds increase, applications may deliver content in higher definition by default. In addition, as people switch from using old 4G phones to new 5G phones they will use more data without any change in behaviour.
[141] There is a correlation between an individual's age and their data usage. Older people are less likely to use a smartphone, whereas today's young people have grown up using mobile devices and online applications. Over time this 'digital native' generation will represent a larger proportion of the population, embedding behaviours that consume mobile data. The younger generations of the future will likely play a similar role, driving new technologies which might consume even more mobile data.
[142] A breakdown of crowdsourced data from Android users from 1 January to 31 March 2021 shows that 57% of users are light users (defined for the study as <500 MB per month), 30% are medium users (>=500 MB and <2.5 GB per month), and 13% are heavy users (>=2.5 GB per month). This analysis suggests that the majority of data traffic from Android users on mobile networks is driven by a minority of heavy users. See Ofcom, Mobile Matters, 2021.
[143] Such as better graphics and features like real time interaction with the world and other users.
[144] Throughput requirements for AR and VR can vary significantly, particularly in the case of VR where it can range from 25Mbps to multiple Gbps depending on quality, while latency for both is ideally below 10ms.

services like Apple car key, CarPlay and Android Auto,[145] as well as new technology that improves the connectivity these services use. For example, the DCMS-funded AutoAir project is testing the delivery of high-speed infotainment to moving vehicles using 5G.[146]

We expect people to make greater use of wearables and IoT, some of which will connect to mobile networks

5.7 We expect to see greater use of wearables and consumer IoT over the coming years. This includes devices like smartwatches, video doorbells and heating systems which connect to the internet. Between 2015 and 2020, there was a sixfold increase in the number of people who reported using a smart watch or other form of wearable tech, from 3% to 18%,[147] and we expect this trend to continue. [148]

5.8 Many wearables today connect to a smartphone via Bluetooth[149] and don't offer stand-alone mobile services (i.e. users can't take a call or answer a message without having their phone nearby). However, wearables are becoming more sophisticated and more devices are coming on to the market that enable people to untether the devices from their smartphone. In sports and fitness tracking this improved functionality allows users to do things like go for a run or cycle without the need to carry a smartphone, while still being able to send/receive calls and messages on the go.

5.9 As adoption of consumer IoT and wearables becomes more mainstream, people are likely to rely more on mobile services to make the most of their functionality and flexibility while on the go. For example, whilst many smart home devices use Wi-Fi or other technologies for internet access in the home, people could use their smartphone to turn on the heating while on the way home, or answer the doorbell via video call while out and about. While individual devices may use limited bandwidth in such scenarios, collectively the increase in demand for data could be more significant as take up increases.

We may see greater use of mobile services instead of fixed broadband, at least in the short term

5.10 There may also be some increase in the use of mobile services to provide internet access in the home via Fixed Wireless Access (FWA).[150] We expect to continue to see some use of

[145] See Apple CarPlay and Android Auto. Apple car key uses near-field communication so does not rely on mobile coverage to function.
[146] DCMS, AutoAir: 5G Testbed for connected and autonomous vehicles, 2018.
[147] Source: Ofcom Technology Tracker data in the 2020 Communications Market Report (device take up section in interactive report).
[148] Forecasts from CCS Insight indicate that growth in fitness trackers and smart watches will continue over the next few years and shipments will reach almost 380 million devices worldwide by 2025. The anticipation of new wearables such as the Google Pixel Watch (see The Verge, Google is making its first in-house smartwatch that could launch in 2022) may also contribute to growth in consumer demand and take-up.
[149] Bluetooth is a technology that uses wireless to communicate over short distances between devices.
[150] FWA via mobile networks is offered on 4G and 5G networks, usually to an indoor router. These services share the network capacity with mobile users, meaning that the capacity has to be carefully managed between the demands of existing mobile users and FWA customers. There may be areas of higher mobile demand where a reliable FWA service cannot be offered. It is worth noting that FWA can also be provided by Wireless ISPs (WISPs). The majority of these services

FWA in fixed broadband not-spots, but also in households that prefer the shorter contracts available with FWA compared to many broadband connections. More generally, however, use of FWA is likely to be focused on locations where fixed broadband is not available (for example, in more rural areas where securing a connection would be prohibitively expensive)[151] and where there is a good enough mobile signal.[152]

5.11 Users' experience of an FWA service can be affected by factors including the capacity available in the radio access network. For instance, the low frequency spectrum used to provide coverage in many rural areas may lack the capacity to support FWA. Furthermore, the average data use on fixed broadband connections, including over Wi-Fi, is around 100 times greater than that of mobile.[153] Were lots of people to wish to use their mobile connection in a similar way to their fixed one, mobile networks would require substantially more capacity.

For businesses, there is the potential for more significant new uses

5.12 In the nearer term, the most transformative effects of 5G for businesses may relate to the development of very large-scale machine-to-machine applications (M2M), as part of the digitisation of manufacturing and service provision. Collectively, these are often referred to as the Industrial Internet of Things and are likely to require features such as high reliability, security, bespoke capabilities and speeds. These can support a number of "Industry 4.0" type applications across a range of industries.

5.13 The following examples are speculative, but illustrative of the capabilities of new mobile and other wireless technology:

a) In **manufacturing and logistics**, the low latency, reliability and speed of 5G could generate improvements in processes that lend themselves to being highly or fully automated, such as the use of robots in grocery packing in warehouses,[154] and allow for safer remote operation of heavy machinery.[155] Sensors could also allow for the creation of a 'digital twin' of a factory or production process, supporting asset monitoring and even pre-emptive maintenance based on fault prediction.

are delivered over wireless networks that communicate via a wireless link between a provider's mast site and an external antenna fixed to a customer's premise. These networks generally use license exempt or lightly licensed spectrum.

[151] Under the Universal Service Obligation (USO), where an affordable service with certain characteristics is not available or due to become available through a publicly funded intervention in twelve months, the customer is eligible for the USO if the costs of providing the connection are below £3,400 or where the costs are above £3,400, if the customer agrees to pay the excess. Data analysis by BT indicates that in many cases, the costs to connect premises eligible under the USO will be above £3,400, so customers will receive excess cost quotes. See Ofcom Connected Nations Report 2021, p.20.

[152] We estimated that FWA via MNOs is available to 94% of UK premises. This includes 528,000 out of 651,000 premises (81%) that do not have access to a decent broadband service from a fixed network. See Ofcom Connected Nations Report 2021, p.17.

[153] The average monthly data consumption per fixed broadband connection was 453 GB per month in 2021 (Source: Ofcom Connected Nations Report 2021, p.28). The equivalent figure for average monthly data used per mobile data connection in 2021 is not yet available. However, the 2020 figure was 4.5 GB (Source: Ofcom Communications Market Report 2021, p.3.)

[154] The Verge, Welcome to the Automated Warehouse of the Future, May 2018.

[155] For example the 5G Connected Automated Logistics project, which received DCMS funding to deliver 5G-connected, autonomous 40-tonne trucks as assemblies across the Nissan plant in Sunderland, and the Port of Felixstowe 5G Create project.

b) In **agriculture and rural industries** we may see greater investment in smart tracking and remote monitoring of livestock and resources.[156]

c) **Drones and autonomous robots** could be used more widely in the delivery of goods and services to remote areas (e.g. last mile delivery for parcels[157] or carrying out safer remote inspection of industrial sites).[158] These uses require low latency, secure, reliable connectivity across specific areas. Today, drones are not typically controlled over mobile networks; instead alternative spectrum is available for line-of-sight remote control. But Ofcom is currently assessing the impact of a number of spectrum options for drone wireless control and data delivery, which may enable drones to be controlled over mobile networks.[159]

5.14 In addition to the uses above, businesses and large organisations are likely to make use of similar on-the-go services to consumers. For example, engineers could use AR devices to overlay important information when undertaking manual repairs or maintenance checks of complex machinery, with the aim of improving safety and efficiency by providing real-time system data.

There is also potential for greater use of mobile services in the public sector

5.15 There are also potential benefits of improved mobile connectivity in the public sector, some of which have been highlighted in recent Government guidance and draft policy.[160] For example:

a) **Smart cities** may make greater use of sensors and mobile services to provide enhanced monitoring of waste, air and water quality management, street lighting and traffic sensors. Having access to real-time sensor data may enable better forecasting of future demand, help reduce energy consumption and lead to more efficient management of resources.[161]

b) **Healthcare provision** may make increasing use of remote monitoring via wearables, offering patients and healthcare professionals 24/7 access to reliable information that could help with medical diagnoses. The high bandwidth offered by 5G could allow ambulance crews to perform scans and send high-resolution images to hospitals while in transit, giving clinicians earlier access to vital information and speeding up treatment on arrival.[162]

[156] Examples include 5G-enabled live video monitoring of salmon in a Scottish salmon farm and InTouchGo which uses data to adjust cow's feed for optimal milk yield.
[157] BBC, Drones used to deliver post to remote Orkney island, October 2021.
[158] "Combined with traditional techniques, drones can dramatically increase the efficiency of inspection. For an underdeck inspection of an oil platform, a drone can complete in five weeks would take eight weeks with a traditional scaffolding approach." See PwC, Skies without limits, 2018, p.9.
[159] As noted at A 1.37 in Ofcom, Statement: Supporting the UK's wireless future, July 2021.
[160] See for example DCMS, Findings and lessons learnt to date from the 5G Testbeds and Trials Programme, August 2021 and DCMS, Data saves lives: reshaping health and social care with data (draft), August 2021.
[161] An example of smart city innovation is the MK:Smart project, which aimed to support sustainable growth in Milton Keynes by collecting vast quantities of data relevant to city systems e.g. electricity consumption, soil moisture and traffic flow. The MK Data Hub was developed with input from local government, BT and other commercial partners.
[162] Ericsson, 5G enables the UK's first remote diagnosis.

Key changes in how mobile networks are provided

5.16 As outlined in Section 4, the MNOs have played a central role in the provision of mobile networks. However, a number of changes are taking place which may lead to substantial changes in how networks are run, and in the players involved.

5.17 In particular, we expect to see:

a) further rollout of 5G non-standalone to provide additional capacity in high demand areas, and deployment of 5G standalone to further improve mobile networks;

b) MNOs continuing to separate out infrastructure from the rest of their businesses, and we may see greater sharing of infrastructure, or new network sharing and ownership models emerge;

c) greater use of cloud, which will bring efficiency benefits to MNOs, and also increase the role of hyperscalers in the provision of networks;

d) Open RAN growing alongside traditional RAN architecture and allowing MNOs to diversify their equipment vendors; and

e) growth in the use of private networks, supported by MNOs and a range of alternative providers.

5.18 These changes are likely to lead to a more fragmented value chain for the provision of mobile networks.

Further rollout of 5G, including 5G standalone, to further improve national mobile networks

5.19 5G is the latest generation of wireless technology. While in May last year 5G only accounted for 3% of total mobile traffic in the UK, we expect this to increase significantly over the coming years as: 5G coverage increases; more customers have 5G-compatible devices; and applications that rely upon the capabilities of 5G become available.[163]

5.20 5G services can be much faster than previous generations, offer greater capacity, allow thousands of devices in a small area to be connected at the same time, and potentially be more responsive with lower latency.[164] However, the capabilities of 5G depend, among other things, on the technology used, as set out in Table 5.1.

[163] See Ofcom Connected Nations Report 2021, p.34.
[164] For example, according to Opensignal, 5G now provides average download speeds of 138.1 Mbp/s in the UK. See Opensignal, 5G download speed is now faster than Wifi in seven leading 5G countries, 2020.

Table 5.1: Illustrative summary of use cases for 5G mobile technology

Technology	Typical use cases (subject to demands on capacity)
5G standalone (mid frequency, 1 GHz - 24 GHz & high frequency, above 24 GHz)	Fastest connection speed, highest capacity, potential for ultra-low latency applications
5G non-standalone (mid frequency, 1 GHz - 24 GHz)	Capacity to support more people undertaking high data rate services, such as higher volumes of demanding 4K video users
5G non-standalone (low frequency, up to 1 GHz)	General web browsing, social media, gaming, video streaming

Source: Ofcom

5.21 MNOs are currently deploying 5G networks on a **non-standalone (NSA) basis using low and mid frequency spectrum,** which involves deploying 5G RAN[165] alongside the existing 4G RAN and 4G core.[166] Deploying 5G NSA first enables a quicker deployment relative to 5G SA. 5G NSA delivers some improvements to the network, in particular an increase in capacity, which would support current uses of mobile services such as video streaming, gaming, general web browsing, and social media. This allows MNOs to support greater use of these services as demand continues to grow without the congestion and degradation of service quality that would result without the additional capacity provided by 5G.

5.22 We expect all MNOs to upgrade to **5G SA using mid and high frequency spectrum**[167] with some already trialling the technology.[168] This entails deploying a 5G core network in addition to the 5G RAN, which can enable, among other things, ultra-low latency, advanced virtual network functions, including slicing[169] and potentially faster data throughput and improved coverage. 5G SA can enable new uses that require the fastest connection speeds, highest capacity and ultra-low latency, such as AR/VR and robotics.

5.23 To support the deployment of 5G networks, MNOs are also upgrading their mobile backhaul to allow faster connection between the core network and the RAN.

[165] As noted in Section 4, the RAN connects mobile phone masts to customer devices (e.g. handsets) using radio spectrum.
[166] This means 5G devices can connect to the 5G network for faster data transfer but still use the 4G network for the control of the connection (e.g. session and mobility control).
[167] We will consult on our approach to make high frequency (mmWave) spectrum available shortly. For further discussion on spectrum for mobile see Mobile Networks and Spectrum discussion paper.
[168] Vodafone in 5G Standalone commercial pilot in London, Manchester, Cardiff, June 2021.
[169] Network slicing is a form of virtual architecture which is a feature of 5G SA networks. It allows an MNO to create multiple virtual networks (slices) on top of its common shared physical infrastructure. The virtual networks are then customised to operate with specific quality of service and meet the specific needs of applications, services, devices, customers or operators.

5.24 6G standardisation is still in very early development.[170] Therefore, while we may start to see 6G networks being deployed in the late 2020s, we do not expect any scale 6G deployments within the next ten years.

5.25 To help deliver network improvements, MNOs plan to switch off 2G and 3G legacy systems, which will allow the spectrum currently used on these technologies to be available for 4G and 5G, and will also enable MNOs to make cost savings (e.g. through reduced network maintenance requirements associated with fewer different network elements). Some MNOs have announced plans to switch off their 3G networks,[171] and they have confirmed to the Government that they do not intend to offer 2G and 3G mobile networks past 2033 at the latest.[172]

5.26 Switching off these networks may impact customers who have not upgraded their 2G/3G devices yet, as well as services that currently rely on these legacy technologies.[173] It is therefore important that, as MNOs start to switch off these networks, adequate mitigation is in place to minimise the impact on customers. Ofcom will work with mobile providers to support the process and help make sure issues are identified and addressed with the aim of protecting customers from harm and minimising disruption.

MNOs may continue to separate out their infrastructure from their services, and we may see more infrastructure sharing, or new network sharing and ownership models emerge

5.27 There is a trend – both in the UK and overseas – towards greater separation of network assets as MNOs seek to monetise their assets. We see the following changes:

- **Changes in network sharing arrangements.** The network sharing arrangements used by the MNOs are evolving to have a greater emphasis on passive sharing.[174] The MBNL and CTIL towers have in the past been mostly by their respective MNO partners and there is very little cross-provision of towers between the two groups. However, this bifurcation is starting to change. Vodafone, Virgin Media O2 and Three have agreed to build and share 222 new towers across the three MNOs to improve coverage as part of the SRN[175] and the recent move to commercialise CTIL opens the way for more sharing.

[170] Its features are currently uncertain but is expected to deliver faster speeds, and may feature greater automation with an increased Artificial Intelligence. See Ofcom, Mobile networks and spectrum discussion paper, February 2022 for further details.
[171] For example, EE has announced plans to phase customers off their 3G network by 2023 (EE to offer 5G solutions across the entire UK, as BT Group unveil new mobile and convergence ambitions, July 2021) and Vodafone has announced that it will be switching off its 3G network in 2023 (We're switching off 3G in 2023 | Vodafone).
[172] DCMS, A joint statement on the sunsetting of 2G and 3G networks and public ambition for Open RAN rollout as part of the Telecoms Supply Chain Diversification Strategy, December 2021.
[173] Based on data provided to us by MNOs, we estimate that more than 4m active devices continue to rely on 2G and 3G. Services that currently rely on 2G and/or 3G include emergency voice calls and some IoT communication, such as smart meters. See Ofcom, Connected Nations Report 2021, p.46.
[174] Active sharing within MBNL is limited to 3G, which is itself becoming less important and, when a shared 3G base station reaches capacity, it is typically replaced with separate base stations for each of EE and Three. Vodafone and O2's active sharing arrangements are progressively being unwound in larger urban areas resulting in the sharing of just passive assets at many of the sites concerned. See video statement by Vivek Badrinath (Vantage Towers CEO) mentions this will result in 2,000 sites becoming passive-shares, available at Cornerstone | Vantage Towers
[175] O2, Three and Vodafone agree new deal to enhance rural coverage, January 2021.

- **Restructuring and commercialisation.** Vodafone and Virgin Media O2 have agreed to commercialise their towers infrastructure in CTIL.[176] Vodafone subsequently put its 50% share of CTIL's towers into Vodafone's new Europe-wide Vantage Towers business, in which Vodafone has now sold an initial stake of c.19% through an IPO and has indicated its intention to reduce its shareholding further – either through a public sale or to a strategic partner.[177] Separately, Three has recently proposed to sell its towers assets (including Three's tower asset rights in MBNL) to Cellnex, the largest independent towers provider in the UK.[178]
- **New models.** BAI Communications has adopted a neutral host model for providing mobile internet access in the London Underground and has entered into an agreement with Sunderland City Council to provide 5G in the city using a neutral host model.[179,180] BAI has subsequently reached commercial agreements with MNOs to provide services over its infrastructure in the London Underground.[181] in Poland, Polkomtel Infrastruktura is using Cellnex as an outsourced provider of both passive and active RAN infrastructure (neutral host).[182]

5.28 As the trends of commercialisation and divestment continue, in the future we may see greater sharing of infrastructure, or new network sharing and ownership models emerge.

Growing use of the cloud will bring efficiency benefits for MNOs and will enable hyperscalers to play a greater role in the provision of networks and cloud IT services

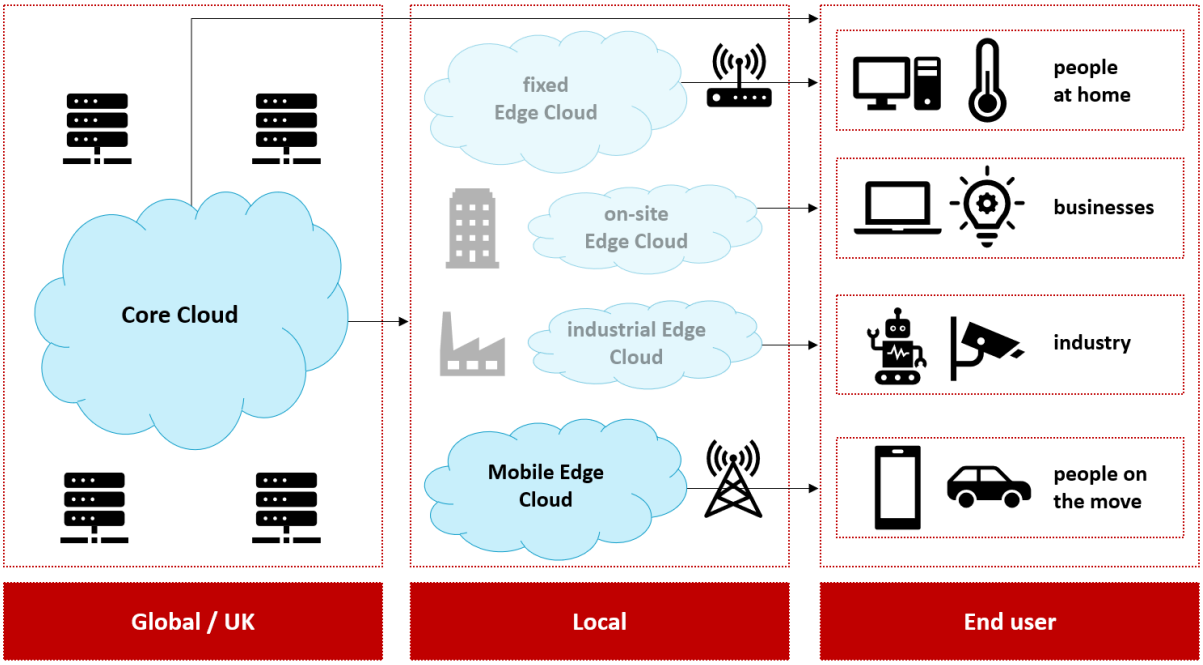
5.29 Cloud computing, also known as "the cloud", is a type of computing where users have ubiquitous access[183] to scalable computing resources, such as processing and storage, that allow for reduced management on behalf of the user.[184] We can differentiate between two main types of cloud deployment (as shown in Figure 5.2):

- **Core Cloud** refers to storing and processing data close to the core of the network, i.e. further from the user end and typically outside of the local access network. Core Cloud is used for applications that require high processing power and/or vast storage space, and/or do not depend on low latency (e.g. storing large databases and training algorithms).
- **Edge Cloud** refers to storing and processing data close to the edge of the network, i.e. the physical location where users connect with the network and so within the local

[176] Cornerstone, Vodafone and Telefónica commercialise Cornerstone, the UK's largest tower company, January 2021.
[177] Vodafone has referred to likely "deconsolidation and monetization over time", see Vodafone H1 FY22 Results, p.33.
[178] This is subject to a Phase 2 investigation by the CMA. The CMA has published its Provisional Findings.
[179] TfL, Mayor fulfils commitment and confirms high speed mobile coverage across Tube network, June 2021.
[180] MySunderland, Sunderland City Council and BAI Communications announce new partnership to create the UK's most advanced smart city, October 2021.
[181] BAI Communications, Three and EE agree deal to provide high-speed mobile connectivity across whole London tube network for the first time, December 2021.
[182] In this model, Cellnex provides both the towers and the active radio network equipment on its sites. See Cellnex to acquire Polkomtel Infrastruktura, February 2021.
[183] Ubiquitous access means access which is independent of the user location.
[184] The cloud allows users to: (i) reduce their upfront costs (capex) and potentially save costs or improve their quality of service; (ii) focus on where they add value, with their IT run by specialists; and (iii) access very high computing power when and where they need it.

access network. In the context of a mobile network, we refer to this as Mobile Edge Computing (MEC).[185] Edge Cloud enables applications that require low latency, high bandwidth, enhanced data privacy and/or autonomy such as AR/VR. It can bring network efficiencies and improve security and resilience. However, the Edge Cloud needs to remain in contact with the Core Cloud where any heavier computing processes take place.

Figure 5.2: Simplified deployment of core and edge cloud



Source: Ofcom

5.30 Telecoms providers can use cloud infrastructure to run any network function that has been virtualised (i.e. Virtualised Network Functions or VNFs).[186] This way they can deliver a more flexible, scalable and cost-efficient network.

5.31 The cloud infrastructure could either be:

- self-supplied, for example, Three has launched a virtualised core network running from 20 of its own data centres[187] and Vodafone is self-supplying its 5G SA core network in partnership with VMware;[188] or
- sourced from third-party cloud infrastructure. This process is known as "cloudification". The largest third-party cloud providers are three technological giants, Amazon,[189] Microsoft and Google, also known as hyperscalers.[190] Collectively they account for more

[185] Also known as Multi-access Edge Computing.
[186] Network virtualisation decouples the network functions, for example policy control, from the underlying hardware by converting them into software (i.e. VNFs) which can run on general-purpose servers such as the ones used in cloud. Current network virtualisation typically refers to the core network being implemented in software but increasingly network virtualisation will be used for parts of the RAN.
[187] ISPreview, Three UK Launch Fully Integrated Cloud Core Network – 5G Ready, July 2019.
[188] Vodafone, Vodafone and VMware extend strategic partnership, November 2021.
[189] Amazon provides cloud services through its subsidiary Amazon Webs Services (AWS).
[190] The hyperscalers are part of the Big Tech group.

than 50% of the world's major data centres,[191] and provide cloud services of all types, including for the telecoms sector, allowing them to benefit from economies of scale and scope. Some MNOs in other countries are already using hyperscalers' cloud infrastructure.[192] We expect to see cloudification being adopted more widely, including in the UK.

5.32 In addition:

- Like cloud infrastructure, VNFs can be self-supplied or sourced from third parties, including hyperscalers.[193] In the UK, MNOs are well advanced in the process of virtualising their network functions.
- MNOs are also starting to deploy Edge Cloud infrastructure for MEC supporting retail services (as opposed to VNFs) and some are choosing to partner with hyperscalers to do so.[194]
- MNOs use cloud IT services that support them in providing their mobile services and operating their businesses – from finance resource planning and control through to customer relationship management systems. Some MNOs have chosen to use hyperscalers for this purpose. We expect this use to grow in future.[195]

Hyperscalers' greater role in the provision of networks and cloud IT services should bring benefits but could also raise risks longer term

5.33 A greater role for hyperscalers could bring potential benefits such as lower network costs, and access to better technologies.[196] Hyperscalers could enable private network providers and MVNOs to efficiently deploy core VNFs in the cloud with minimum expertise and capital expenditure.[197]

5.34 Hyperscalers' economies of scale and scope mean their positions are likely to remain strong and, over time, they may be able to establish strong positions in the provision of cloud infrastructure and VNFs for the mobile sector.[198]

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[191] Plum Report (2022), page 135.

[192] In the US, the new (fourth) MNO, Dish, has entered into a strategic partnership with Amazon Web Services to provide a cloud-based network, Amazon, DISH and AWS Form Strategic Collaboration, April 2021. In addition, the biggest existing MNO, AT&T, has moved its 5G core to Microsoft Azure after Microsoft acquired AT&T's network cloud business. Microsoft, AT&T to move its 5G mobile network to the Microsoft Cloud, June 2021.

[193] For example, Microsoft has recently acquired two companies that supply VNFs - Affirmed Networks and Metaswitch Networks (See Microsoft announces agreement to acquire Affirmed Networks to deliver new opportunities for a global 5G ecosystem - The Official Microsoft Blog and Microsoft announces definitive agreement to acquire Metaswitch Networks, expanding approach to empower operators and partner with network equipment providers to deliver on promise of 5G - The Official Microsoft Blog).

[194] For example, in June 2021, AWS and Vodafone made their MEC infrastructure available to mobile users in London. See Announcing general availability of AWS Wavelength in London, June 2021.

[195] See Plum Report (2022), pages 139-140.

[196] This is because hyperscalers already have advanced technology, facilities, expertise in infrastructure, and a strong track record of innovation.

[197] MVNOs that run a core network are able to provide additional and differentiated mobile services, and have full control of aspects such as interconnection with other operators which allows such MVNOs to charge for call termination.

[198] For example, the Plum Report (2022) notes that distributed data centre capacity is essential for technology giants wanting to play in the mobile field. Amazon, Microsoft and Google now collectively account for more than 50% of world's major data centres. The increased demand for digital services and a shift to remote working supported by cloud facilities during the COVID-19 pandemic has driven demand for data centre capacity, with data centre investment reaching US$37bn and more than 100 new hyperscale data centres being built in 2020. See Plum Report (2022), pages 131-148.

5.35 In principle, hyperscalers have incentives to actively compete for the provision of services to the mobile sector: a) to win mobile providers as new clients (i.e. to grow their cloud businesses); b) to help ensure high-quality mobile connectivity to deliver their broader set of digital services to retail customers; and c) as they may face the threat of new competitive entry in such services. Should they actively compete, we expect the cloud sector to continue to deliver benefits to mobile providers and their customers. However, we will monitor the development in the sector to ensure we understand any factors that might lead to reductions in competition, for example dominance by a single hyperscaler or undue barriers to switching.

Apple may also play a greater role in the provision of networks

5.36 Apple, while not a hyperscaler, has substantial cloud capabilities and offers cloud services to its mobile customers. Given its strong position in mobile devices, operating systems and apps, this could allow Apple to grow its importance in the provision of networks. For example, Apple recently launched a cloud-related service called iCloud Private Relay which restricts mobile providers' visibility of their customers' traffic. This could represent a significant change to the way in which telecoms providers are able to run their networks and manage traffic through congestion management and network optimisation.[199]

Open RAN will grow alongside traditional RAN architecture and allow MNOs to diversify their equipment vendors

5.37 As noted in Section 4, the current mobile networks have been built using traditional architecture, and equipment from one vendor does not interoperate easily with equipment from another,.

5.38 Following the Government's decision to remove Huawei equipment from UK 5G networks, the UK MNOs are now largely reliant on two RAN equipment vendors - Nokia and Ericsson. Against this background, Open RAN is an initiative to build RAN products based on an open architecture and on disaggregating hardware from software by using commercial off-the-shelf hardware and software-defined technologies. Open interfaces between the different RAN elements ensure interoperability between different hardware and software vendors.

5.39 Open RAN could help MNOs diversify their supply-chain with different vendors supplying individual components.[200] It could also increase competition for supply by lowering barriers to entry and drive innovation.[201]

[199] iCloud Private Relay was developed as an extension of Apple's iCloud+ service for all devices running the iOS 15, iPadOS 15 and macOS Monterey operating systems. It was launched in Beta form on 20 September 2021 on a default-off basis for now, meaning that users need to proactively turn on the service for it to work. See About iCloud Private Relay – Apple Support (UK).

[200] Other equipment vendors include smaller tech companies, such as Mavenir (US), NEC (Japan) and Parallel Wireless (US), and Big Tech companies, such as the hyperscalers and Samsung.

[201] Ofcom has published an Economists Insights paper on the relationship between competition and innovation and the potential implications for the RAN market. Economics Insights papers are intended to encourage debate in areas of Ofcom's remit. However, they do not necessarily represent the concluded position of Ofcom on particular matters. See Ofcom, Open RAN and the link between competition and innovation, January 2022.

5.40 However, Open RAN needs to further mature to be able to provide a complete alternative to traditional RAN. It could also raise some new security and resilience challenges that would require further R&D to address. All four MNOs are either running Open RAN trials or are in the early stages of considering their deployment plans.[202] The Government has announced, together with UK mobile network operators, a joint ambition for 35% of the UK's mobile network traffic to be carried over Open RAN by 2030.[203]

Private networks will grow, supplied by MNOs and a range of other providers

5.41 A private mobile network (also referred to here just as a 'private network') is a mobile network that has been dedicated to a closed group of people and devices. Private networks are deployed using mobile technologies[204] such as 4G and 5G and the features of their mobile connectivity can be configured (e.g. performance and security).[205]

5.42 Private networks can be delivered in three forms:

a) **Dedicated private networks**. These networks are deployed through standalone infrastructure such as 5G core and RAN on the premises of the client.

b) **Hybrid public-private networks**. These networks use some standalone infrastructure on the premises of the client which is operated in conjunction with a public mobile network.

c) **Network slice on a public mobile network**. These are virtual networks relying on the public 5G SA network infrastructure.[206]

5.43 Private networks can use licensed or shared spectrum and would require other technological capabilities such as cloud computing and system integration.[207] When deployed in industrial units, private networks can be combined with MEC to allow the integration of industrial processes and cloud services, leading to improved data processing, as well as enhanced control of applications in the industrial production process.

We expect to see competition among a range of players to provide private networks

5.44 While some large businesses already have private networks, industry analysts forecast that the use of such networks will grow significantly in the coming years.[208]

[202] Vodafone has recently switched on its first Open RAN cell cite. See ISPreview, Vodafone Switches On UK's First Scaled 5G Mobile OpenRAN Site, January 2022.
[203] DCMS, A joint statement on the sunsetting of 2G and 3G networks and public ambition for Open RAN rollout as part of the Telecoms Supply Chain Diversification Strategy, December 2021.
[204] Non-mobile private networks use other wireless technologies, such as Wi-Fi.
[205] The choice of mobile technology and the configuration of mobile connectivity are agreed between the network provider and the client.
[206] Also known as network slicing. It allows an MNO to create multiple virtual networks (slices) on top of its common shared physical infrastructure. The virtual networks are then customised to operate with specific quality of service and meet the specific needs of applications, services, devices, customers or operators.
[207] For example, the provision of private networks may require the provision of services such as network analytics, professional advice services for customers, quality control for service orchestration.
[208] Analysys Mason predicts that the number of private LTE/5G networks worldwide will grow from a small base of several hundred networks in 2019 to 20,600 by the end of 2026, and other analysts project similar levels of growth. Analysys Mason, Private LTE/5G networks: worldwide trends and forecasts 2021-2026, March 2021.

5.45 We expect private networks to be provided by a range of players:

a) MNOs. To date, live commercial offerings of MNO private networks remain limited,[209] but we expect some MNOs to become increasingly involved in the provision of private networks for businesses, specifically based on 5G, given their expertise in working with mobile technologies and the potential synergies with their national networks.[210]

b) Other third party providers such as equipment vendors (e.g. Nokia), managed service providers, and system integrators (e.g. Accenture) that are already active in the UK.[211] In addition, we expect to see private networks from hyperscalers (e.g. Amazon).[212]

c) Businesses with strong IT and networking capabilities that decide to self-deploy.

5.46 We may also see private networks providing mobile coverage in areas that otherwise do not have coverage from public networks. Although in these cases we may instead see a neutral host model adopted, provided by localised mobile network providers using a range of wireless technologies depending on the requirements of the area and the users.[213]

Some MNOs have raised concerns about the impact that other private network providers might have

5.47 Some MNOs have raised concerns that providers of dedicated private networks may only compete for high-value customers and, by doing, so could reduce MNOs' incentives to invest in national 5G networks. They argue that such targeted entry would: (a) reduce revenue opportunities in what might be quite high value segments; and (b) reduce MNOs' ability to capture economies of scale and scope associated with national network deployments. In addition, some MNOs have argued that providing private networks over a national 5G network using network slicing would be a more efficient approach than the use of dedicated private network deployments.

5.48 While some high value private networks could raise the overall expected profitability of 5G investments, we have not seen strong arguments that the ability of MNOs to win a sufficient share of private networks would be critical to the overall deployment of 5G on national networks.

5.49 Furthermore, MNOs are also able to offer dedicated private networks and do not need to wait until they have deployed a national or near-national 5G SA network before they can offer private networks to businesses.[214] This could allow MNOs to establish a footprint of private networks until their 5G SA deployments progress and they are in a position to offer private networks using their public 5G networks (for example through network slicing).

5.50 MNOs could also have some competitive advantages over other private network providers. For example, they could leverage their national networks to provide private network

[209] As of September 2021, the number of fully operational commercial private networks run by MNOs stands at 7. See Ofcom, Connected Nations Report 2021, pp. 38-39.
[210] Analysys Mason, Private networks: trends and analysis of LTE-based and 5G-based networks.
[211] See Private wireless | Nokia and Private Wireless Network | Communication | Accenture.
[212] See Private 5G Mobile Networks – AWS Private 5G – Amazon Web Services.
[213] See, for example, Real estate providers | Freshwave (freshwavegroup.com).
[214] For example, Virgin Media O2 recently launched a dedicated private network using 4G technology. See British Sugar and Virgin Media O2 Business launch first multi-site private mobile network - Virgin Media O2.

customers with connectivity outside of the private network itself. This could enable them to offer business customers a more seamless package of mobile internet access (e.g. a contractor at an industrial site could take a connected device away from that site and handover seamlessly between the private and national networks).

Key changes in the sale and purchase of mobile services

5.51 The retail part of the value chain has evolved over time. As noted above, customers now use mobile devices principally for data, and are purchasing mobile services with more data. They are using that data for online services provided by content providers, including messaging services, which are not charged for.

5.52 Many airtime tariffs now include unlimited call minutes and text messages, resulting in retail tariffs that are primarily differentiated by the single monthly charge and data allowance.[215]

5.53 Customers are increasingly buying devices separately from airtime[216] and purchasing SIM-only tariffs.[217] This may in part be explained by consumers replacing their phones less frequently, potentially due to higher handset prices[218] and a growing market for refurbished handsets.[219] We have also seen more customers buying mobile devices online,[220] and buying devices from parties other than mobile providers, including direct from manufacturers such as Apple.[221]

5.54 There is the potential for further change in the sale of mobile connectivity to customers, in particular we may see:

a) Big Tech companies such as Apple and Google play a greater role.

[215] This fundamental shift in the pricing of mobile services, away from voice and towards data, was noted in Pricing trends for communications services in the UK, Ofcom, 15 March 2017. The report stated that in the five years previous, the shift had occurred, resulting in most post-pay tariffs including large allowances of calls and texts, with tariffs tiered according to the inclusive data allowance. By way of illustration, all SIM only deals on Vodafone's website (accessed 11 January 2022), include unlimited voice minutes and SMS: Vodafone SIM-Only Deals.

[216] The number of people buying new handsets without contracts rose from 20% in 2020 to 32% in 2021, Ofcom Technology Tracker, QD46. (In addition, in 2021, 53% purchased a brand new device (as part of a contract), 7% purchased a refurbished/used phone, 7% had the phone handed down to them, 1% answered 'something else' and another 1% answered 'other').

[217] We observe that from 2016 to 2019 take-up of SIM-only increased from 10% to 21%. Please note data from 2020 and 2021 is not directly comparable to previous years due to a change in methodology. As a result of the COVID pandemic, the Technology Tracker moved form a face-to-face interview approach to an approach where respondents were posted an invitation and self-completed the questionnaire online or on paper. We also note that during the COVID pandemic, we are also likely to see more 'abnormal' behaviour, such as people having more time on their hands, communication via mobile becoming more important than ever and people having financial difficulties. Ofcom Technology Tracker data at W1, 2012-2014; H1 2015-2018. Base: Adults 16+ who personally use a mobile phone (W1 2012, 2073) (W1 2013, 2070) (W1 2014, 2366) (H1 2015, 2475) (H1 2017, 2518) (H1 2018, 2528).

[218] CMA, Mobile ecosystems: Market study interim report, December 2021, found that some high-end smartphones can cost up to £1,500. Of all new smartphones purchased in the UK, 40-50% are Apple devices, none of which sell for less than £200.

[219] CCS Insight: refurbished units surpassed an estimated 3 million in 2020, our Technology Tracker also indicates that the number of people purchasing new handsets as part of a contract has reduced, from 66% in 2020 to 53% in 2021, Ofcom Technology Tracker, QD46.

[220] CCS Insight, 63% of mobile phone purchases occurred online in 2020, compared to 52% in 2019, January 2021.

[221] Our Technology Tracker indicates that the number of people purchasing new handsets as part of a contract with an MNO or MVNO has reduced, from 66% in 2020 to 53% in 2021.

b) An increase in the sale and purchase of mobile services as part of a bundle with fixed telecoms or other services.

Although uncertain, Big Tech players such as Amazon, Apple and Google could play a greater role in the sale of mobile services

5.55 Currently, Big Tech companies (in particular Apple and Google) play a significant role in the provision of devices, operating systems and online services. It is uncertain whether, over the next five to ten years, such players would seek to expand their role into the sale of mobile services. However, we can identify the potential for two changes in the coming years:

a) Big Tech players may sell mobile services directly, for example by becoming an MVNO.

b) Apple and Google may start to act as a retailer / platform for the sale of mobile services. Their operating systems could become platforms on which customers can choose their mobile provider (this could include consumers choosing between existing MNOs and MVNOs as well as Apple and Google should they start to operate as MVNOs).

Big Tech players could start to provide mobile services

5.56 Currently, Big Tech companies do not typically directly retail mobile services in the UK.[222] However, Apple and Google have important positions in the provision of mobile ecosystems and strong direct customer relationships at the retail level, which they may wish to strengthen further.[223] Amazon also has a strong position as an online retailer and in online services and smart speakers. There are already examples of Big Tech providing mobile or similar services in other countries. For example, Google already operates as an MVNO in the US (Google Fi)[224] and Amazon has launched a mobile internet access service in the US (Amazon Sidewalk discussed further below). In addition, MNOs have suggested that Apple and Google in particular may enter retail mobile services markets in the UK in due course.[225]

5.57 There are various ways in which players such as Amazon, Apple and Google could choose to provide mobile services to customers. For example, they may decide to:

- **become an MVNO:** they may enter into an MVNO agreement with an MNO or buy an existing MVNO.

[222] However, Amazon's Kindle Oasis model includes free mobile data for a higher upfront price (Amazon UK – Kindle Oasis). Apple's iPad Cellular also allows users to use the onboard eSIM to set up a mobile data connection straight from the iPad or to insert a mobile provider's activated SIM card (Apple UK – iPad + Mobile Data).
[223] For example, some Apple device owners are used to paying monthly for their services such as Apple Music or its iCloud service which provides a user with cloud storage so a user can save photos, videos and other data to the cloud rather than only stored locally on the device.
[224] Google Fi - A Phone Plan That Can.
[225] BT response to CMA's mobile eco-systems market study (Response: BT Group PLC (publishing.service.gov.uk); Vodafone response to CMA's mobile eco-systems market study (Response: Vodafone UK (publishing.service.gov.uk)).

- **use mesh networks**: they may decide to use their own mesh networks of IoT devices to supply connectivity for IoT devices.[226] Mesh networks could also potentially be used to provide connectivity for smartphones (see below).

5.58 The growth of eSIMs (see Box 5.3) could also facilitate a move by Big Tech players into the provision of mobile services.[227] Google has, for example, used eSIM enabled phones in the US to roll-out its Google Fi service.[228] Google has made deals with multiple US mobile providers, and eSIMs enable Google to switch the user automatically to the service provider with the best service in a particular area.[229]

Box 5.3: eSIMs

With eSIMs, the SIM is embedded into the device and is not tied to one specific network. This makes it easier for customers to switch provider and to use more than one mobile provider on the same device.

In the past, switching between networks was constrained by the network provider controlling the physical SIM card in the phone, but new eSIM technology removes that barrier. eSIMs allow customers to select and set up a new mobile provider directly on their device, and to have more than one virtual SIM on their device at a time (multi-homing), thereby enabling users (or an algorithm) to switch between mobile providers and obtain the service they require.[230] This could lead to a marked change from the current position, where devices typically remain on a single network for the duration of the airtime contract.

5.59 Entry by Big Tech players at the retail level as MVNOs could increase competition in the provision of retail mobile services, bringing benefits to consumers in the form of lower prices.

5.60 It could also lead to increased service innovation. Apple and Google already have a significant presence in the mobile ecosystem. If mobile internet access were added to this, Apple and Google would potentially develop a richer understanding of customers' needs and preferences, such that they are better placed to innovate and bring improved services to the market.231 These may come in the form of new online services (including MEC) or new bundles of services that enable customers to address a wider range of needs under

[226] For example, in the US, Amazon launched Amazon Sidewalk which is an IoT mesh network that uses spectrum to increase the connection range of low-power, low-bandwidth IoT devices (e.g. smart lighting, cameras, location trackers). This allows customers to install their IoT devices in areas that are usually out of Wi-Fi or Bluetooth range.
[227] While providers are already delivering services based on eSIMs today, the expectation is that more devices will start shipping with eSIMs in future. It is predicted that eSIM-enabled phones will rise from 5% of all smartphones in 2020 to 20% by 2024. This could mean that eSIMs will connect 2.4 billion devices in 2025, up from 36 million in 2019. Source: 5G.co.uk, 'Which operators offer eSIMs?', May 2021.
[228] Google Fi.
[229] The end-user has a single retail contract with Google, while the MNOs have a contractual relationship with Google.
[230] For example, a person going on holiday could find a provider offering cheap overseas data roaming and would be able to add that service to their phone in a few clicks. Allowing customers to switch more easily in this way would be expected to increase competition in the market. But for some consumers, they may still value the simplicity associated with a predictable monthly payment with one provider, so they may not spend their time looking for multiple deals with different MNOs. Therefore, the impact of eSIMs may well vary between different users.
[231] There are certain regulatory limits on what data Big Tech could collect and use.

one umbrella. In turn, this could generate take-up of new services that make use of features of 5G and enhance the investment case for 5G deployments.

Apple and Google may be able to use their operating systems as platforms on which customers can choose their mobile provider

5.61 The CMA recently found that Apple and Google are likely to have an "enduring position of market strength" in the provision of operating systems which they may be able to use to their advantage (see Box 5.4).

Box 5.4: CMA Mobile Ecosystems Market Study and Interim Report[232]

The CMA's market study investigates the implications of Google's and Apple's role in the provision of mobile devices, operating systems and mobile apps (collectively referred to as mobile ecosystems). The CMA's initial findings suggest an effective duopoly in mobile ecosystems: just over half of all mobile devices in the UK are made by Apple and come with its iOS operating system, while most other smartphones and tablets come with Google's Android operating system.

The CMA's Interim Report has indicated that users of mobile operating systems are very sticky - existing iOS and Android users rarely switch to the rival operating system - and there are also considerable barriers to other operating systems providers entering.[233] This is likely to give Apple and Google an enduring position of market strength in the provision of operating systems, which they may be able to use to their advantage.

The CMA's Interim Report also found that Apple and Google control the key gateways through which users access content on mobile devices and through which content providers can access potential customers, including app stores and browsers. Apple and Google are, for example, able to determine which apps are allowed in their store, how apps are ranked and discovered, and also often charge significant levels of commission (up to 30%) on app developers' revenues from in-app transactions, by requiring these transactions to be made through their own in-app payment systems. At the same time, Apple and Google also offer their own 'first-party' apps to users, leading to concerns over favouring own services over third party services.

5.62 The rollout of eSIMs could enable Apple and Google to embed the ability to switch mobile provider into their mobile operating systems. Just as users access third-party software and load it onto their device via the Apple and Google app stores, mobile operating systems could become platforms for purchasing mobile services. If so, a concern could arise if they

[232] CMA, CMA Mobile Ecosystems Market Study Interim Report

[233] This is due to network effects (which relate for example to the number of users of the operating system and the willingness of app developers to support their apps on different operating systems), the complex licencing deals in place for operating systems, and barriers to switching. Apple face limited user-driven competition from each other because most users purchasing a device are buying a replacement, and those existing iOS and Android users rarely switch to the rival operating system – this is in part due to material barriers to switching CMA has identified. These switching costs are asymmetric, with iOS users generally facing higher switching costs than Android users.

did not face sufficient competitive constraints, such that they were able to charge elevated commissions, which ultimately would be borne – at least in part – by consumers.[234]

5.63 Concerns in relation to Apple and Google's control over gateways to consumers could be exacerbated if Apple and Google were simultaneously operating as an MVNO, as this could create incentives to foreclose rival mobile providers (either by only offering its own service or steering customers towards its own service).[235] Such behaviour could harm competition and consumers, as highlighted by some stakeholder responses to the CMA's mobile ecosystems market study.[236]

We may also see more customers buying mobile services as part of a wider bundle

5.64 Most users tend to purchase mobile services on a standalone basis, rather than bundled with services such as home broadband and TV services. In future, we could see an increase in customers' purchasing mobile services as part of a wider bundle of services:

- Providers may seek to encourage greater take-up of bundles to increase revenue and retention. Such strategies can increase revenue if providers can boost demand by offering discounts as part of a bundle, without having to offer across the board price reductions to users only taking one service.[237] In addition, if rivals are not in a position to offer similar bundles, then this approach may enhance differentiation and also aid customer retention, as customers may find it inconvenient and more expensive to switch providers and/or buy services separately.
- Consumers may be motivated to take bundles if they offer a discount relative to buying services separately or where it is more convenient to buy services from one provider, particularly where they are using a large number of connected devices.

5.65 There are different ways that mobile providers could bundle mobile services with other services. One such bundle is a **fixed-mobile bundle.** The purchase of fixed-mobile bundles has not been a strong feature of the UK market to date.[238] In contrast, the take-up of such bundles has been much higher in a number of other European countries.[239]

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[234] This type of concern was raised in the CMA's interim report on mobile ecosystems, where the CMA suggests that app store commissions are likely to be above competitive levels. See CMA Interim Report (December 2021), paragraph 12, page 9.

[235] BT highlights concerns about digital firms with gateway power becoming MVNOs and self-preferencing, (Response: BT Group PLC (publishing.service.gov.uk)), paragraph 25.

[236] For example, BT's response for example raises concerns about digital firms with market power in related markets entering the mobile connectivity segment using eSIMs (Response: BT Group PLC (publishing.service.gov.uk)).

[237] Bundling is a form of price discrimination, whereby a fixed-mobile provider might look to offer price discounts to certain customers to encourage additional take-up, e.g. offering fixed customers a lower cost for adding a mobile service to their tariff, which they might otherwise not take if they purchased mobile services on a standalone basis. But if most consumers would take fixed-mobile services from the same provider such discounts for bundles may not result in more demand, so there may be less incentive for operators to offer a discount for taking a fixed-mobile product.

[238] Only 18% of UK mobile users purchase both these services from the same provider. Ofcom Technology Tracker 2021, Table 156, MOBILE (PERSONAL) STANDALONE - DEFINED BY SUPPLIER USED FOR MOBILE AND OTHER SERVICES.

[239] This difference might in part reflect the historical position in the UK where fixed providers were not also mobile network operators, whereas in some countries where converged services are more prevalent, there are longer-standing fixed-mobile providers that mostly own or co-own fixed and mobile networks. For example, see discussion of Spain, Portugal, France and Netherlands in Section 3 of the Plum Report (2022), pages 96-130.

5.66 Following the recent merger of Virgin Media and O2 to create a second significant mobile network operator with its own fixed network in the UK, it is possible that the sale of fixed-mobile bundles could start to increase in importance here. We note, for example, Virgin Media O2 has already launched its Volt bundles for users taking Virgin Media's cable/TV and O2's mobile services together.[240]

5.67 It is not clear what impact this would have, but we note non-converged providers are able to offer fixed-mobile bundles using regulated wholesale services from Openreach, or commercial wholesale services from other wholesale providers.[241] Furthermore, the CMA's recent assessment of the merger between Virgin Media and O2 did not identify any competition concerns.[242]

5.68 In addition, we may see:

- **bundles bringing together mobile devices, smart home devices, and wearables**: as noted earlier, we expect to see significant growth in the use of smart home devices and wearables, and we may also see greater use of mobile services for these. This could lead to mobile providers offering bundles of mobile devices, smart devices, wearables and mobile services, and simple ways to configure and manage these in a single place. Given high smartphone penetration, this could also give mobile providers a way of growing their revenues. In addition, Big Tech firms such as Amazon, Google and Apple have a range of smart devices and wearables that could follow this model of bundling mobile services with the sale of devices. Mobile services could either be included in the upfront price of the device (as is currently the case with Amazon Kindle 4G)[243] or by providing mobile services as an add-on.
- **digital services** – apps and online services in which mobile services are sold as an add-on. This could be an approach driven by Apple and Google were they to enter the retail market.

[240] Volt. For market commentary, see Enders Analysis, Virgin Media O2 Finding its feet, November 2021.
[241] They might also use other forms of connectivity such as fixed-wireless access (FWA).
[242] CMA, Anticipated joint venture between Liberty Global Plc and Telefónica S.A. – Final Report, May 2021.
[243] For a higher initial price this device comes packaged with 'free' mobile services using AT&T in the US (and partner networks worldwide). In this case, the Kindle user has no direct contract or relationship with AT&T or other mobile providers.

6. Delivery of good outcomes by the market over the next five to ten years

6.1 In this section we set out our initial views on how well the market is likely to deliver good outcomes, potential risks, and what our future approach to mobile markets should be. We cover the following:

- whether the market is likely to continue to play a key role in delivering good outcomes;
- potential changes to the model of competition over the next five to ten years, and the implications of these;
- the growing importance of quality of experience and the need to develop better information on quality to help customers make more informed decisions; and
- the potential for wider benefits from having mobile networks of higher quality than the market will deliver.

The market is likely to continue to play a key role in delivering good outcomes for the next few years

6.2 As discussed in Section 4, the mobile sector has delivered good outcomes to date, with competition among MNOs playing a key role in:

- driving investment in strong, secure networks that meet the future needs of customers;
- providing the widespread availability of reliable mobile services to people and businesses; and
- delivering quality, value for money, and choice to customers.

6.3 In addition, Ofcom and Government have taken steps to empower and protect customers and improve 4G mobile coverage in areas where there are limited commercial incentives to deploy networks. These measures will continue to bring benefits in the years ahead.

6.4 Given the potential for significant change in the coming years, we have considered whether competition is still likely to continue to deliver good outcomes for customers.

Significant ongoing investment will be key to meeting future connectivity needs

6.5 The expected significant growth in the demand for mobile data means that substantial ongoing investment will be needed to deliver additional capacity, as well as to roll out new technologies to enable future demand to be met.

6.6 Mobile networks will need to evolve to meet future demand for mobile data and deliver a good quality of experience. A number of approaches are available to grow capacity (see Box 6.1), with different potential cost impacts. The Mobile Networks and Spectrum discussion paper sets out our initial assessment of how these different approaches may help grow capacity in future.

Box 6.1: Approaches for delivering additional capacity on mobile networks

A number of approaches are available to increase network capacity over the next ten years, including:

- **Investment in technology upgrades to increase the amount of data that can be carried over a given amount of spectrum (spectral efficiency).** This can be achieved through upgrades, such as the rollout of 5G, re-farming 2G and 3G spectrum, and the use of new antenna technology.
- **Deploying current spectrum holdings more widely on the current sites (and making use of planned spectrum releases).** Ofcom has released significant amounts of spectrum for mobile use to date. MNOs could extend their existing use of spectrum to sites where capacity is needed. In addition, we have identified a large amount of additional spectrum for mobile, such as the higher 5G frequency (mmWave) bands. We will be consulting on proposals to enable mmWave bands to be used for new and innovative services, including 5G, in Q1 2022/23.
- **Increasing the number of sites in areas where capacity is needed (densification).** We believe that densification will be needed in the medium to long term to meet anticipated growth in demand, including the use of mmWave spectrum in capacity-constrained locations.

MNOs have suggested that the business case for investing in mobile networks is challenging

6.7 The MNOs have said that they face an uncertain and challenging investment climate, which may limit their ability to undertake significant investment. They have set out two broad reasons for this.

6.8 First, some MNOs have highlighted a **worsening in their financial performance** over the last five to ten years and suggested that this is not supportive of significant future investment. They say that the average industry returns of the MNOs have been falling and remain at the lower end of international benchmarks and that this has been reflected in poor performing shareholder returns. They say that, as a result, parent groups and the shareholders which back them are less attracted to investing in the UK mobile sector. Some MNOs have also suggested their UK businesses need to compete for capital across divisions or with non-UK businesses where an MNO is part of an international group, and that the financial performance of the UK mobile business relative to other parts of the group can be a factor in deciding where capital is allocated.

6.9 Second, some MNOs have said that **the commercial incentives for investing in 5G networks are weaker** than they were for investing in 4G networks. This is because the step change in quality for mobile customers from switching from 3G to 4G was more noticeable than switching from 4G to 5G today. As a result, MNOs had strong commercial incentives to invest in upgrading 3G to 4G networks, to avoid the risk of losing customers to their competitors. By comparison, MNOs have suggested that since the change in quality for mobile data customers from upgrading from 4G to 5G is less marked. Therefore the risk of

losing a customer to a rival if they do not invest is lower and therefore the commercial incentives to invest and rollout 5G quickly are weaker.

6.10 Some MNOs have also said that the strength of the business case for 5G SA is contingent on MNOs capturing profits from services relating to new 5G uses, which are currently uncertain. They say there is uncertainty over:

- the demand for services relating to new uses, given these are still under development (or are not yet proven); and
- their ability to monetise investments as a result of new players in the value chain capturing the direct relationship with customers.[244]

6.11 As a result, some MNOs have said that these challenges could mean that there is a slower, more incremental roll-out of new networks, and that the deployment of 5G SA may not extend to the whole of the UK. They suggest that this could mean that the UK fails to tap the full economic potential of 5G and that the Government's aim of the UK being a world leader in 5G is not realised.

At an industry level, financial performance appears to be supportive of investment, but we recognise performance varies among MNOs

6.12 Investment decisions are primarily based on expected future returns.[245] However, we recognise that historical performance can give an indication of how well existing investments have performed to date, which could impact market sentiment and act as a sense check on future expected performance.

6.13 Measuring the historical performance of the UK mobile industry is not straightforward. There are data limitations, including the difficulty in:

- separating out mobile-only revenues and costs from other revenues and costs appropriately (particularly where fixed and mobile contracts are sold together and/or some costs are shared across fixed and mobile);
- assessing the impact of accounting changes over time; and
- identifying all the relevant costs and assets, in particular for UK businesses that are part of wider international firms.

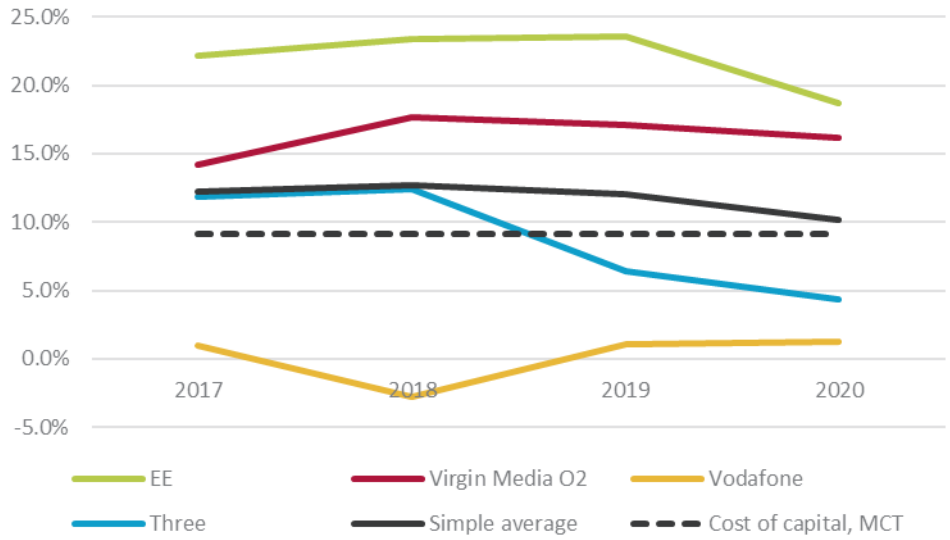
6.14 Bearing these limitations in mind, our analysis of MNOs margins and return on capital employed (see Annex 6) suggests that:

[244] In Section 7, we discuss points made by MNOs relating to the impact of regulation on their incentives to invest. This includes concerns around net neutrality requirements constraining their ability to effectively manage traffic on MNOs' networks and clarity around how new services should be treated.
[245] For example, on the basis of the expected Net Present Value or expected Internal Rate of Return of the investment.

- Average industry margins (% EBITDA)[246] have been broadly flat over the last five years.[247] UK MNO margins tend to be lower than European and US MNO margins (although there could be several reasons why margins are different in these countries).[248]
- Average industry free cash flow margins (% EBITDA less capital expenditure) have also been broadly flat over the last five years, although we note a fall in 2020 for some operators as capital expenditure increased.[249] These margins also tend to be lower than European and US MNO margins.
- On an economic basis, average industry return on capital employed (ROCE)[250] has been above the cost of capital (see Figure 6.2),[251] but there is significant variation between operators, and our analysis suggests that not all MNOs have covered their cost of capital.[252] We also note that UK average industry ROCE has declined over the past three years. Based on recent reports from a number of different equity analysts, falling returns are a common trend across Europe, suggesting that declining returns in the mobile market is not a UK specific issue.
- On an accounting basis, taking all the capital employed as given (including historical amounts paid for spectrum and any goodwill associated with previous acquisitions), average industry ROCE has been below the cost of capital. We note that some MNOs report accounting ROCE in their financial statements as a measure of financial performance.[253]
- On an accounting basis, taking all the capital employed as given but excluding any goodwill associated with previous acquisitions, average industry ROCE has been above the cost of capital.

[246] Earnings before interest, taxation, depreciation and amortisation divided by revenue.
[247] Accounting changes over the past few years have made like-for-like comparisons over time more challenging. However, EBITDA margins in 2019 and 2020 are available on a consistent basis and were similar across both years. The two major accounting standards that impacted EBITDA margins for MNOs were: 1) IFRS 15: Revenue on contracts, which was implemented in 2018; and 2) IFRS 16: Leases, which was implemented in 2019.
[248] For example, accounting policies, varying business models, country demographics and the relative costs of labour, property and capital play a key determinate in EBITDA margins.
[249] EBITDA less capital expenditure is a generally accepted proxy for free cash flow i.e., cash flow available to the company after investment.
[250] ROCE is a measure of profitability that explains how well a company's capital base is at generating returns. When ROCE is above the cost of capital it means that the returns outstrip the costs to finance the business.
[251] Between 2017 and 2018 the cost of capital was taken from the Mobile Call Termination statement (MCT) 2015-2018 (paragraph 7.46) and between 2018 and 2021 this was taken from MCT 2018 - 2021 (paragraph 5.40). A pre-tax real cost of capital of 7% equates to a pre-tax nominal cost of capital of 9.1% assuming CPI of 2%. More recently, a cost of capital of 7.8% was used in the MCT 2021-2026 (A2.39).
[252] Economic profits which are substantially above or below the benchmark cost of capital could be an indicator of limitations in the competitive dynamics of the market. Enders Analysis have also estimated current ROCE for the UK MNOs (See Enders Analysis, What's to become of H3G, 25 January 2022 available from Enders Analysis), with results broadly in line with our analysis. They estimate industry average ROCE of 13%; EE:24%, O2:15%, Vodafone:8% and Three:5%.
[253] For example, one of Vodafone's priorities is to deliver a sustainable improvement in ROCE through a combination of consistent revenue growth, ongoing margin expansion, strong cash flow conversion, and disciplined allocation of capital. It also states its medium-term ambition is for Group ROCE to be above the cost of capital, demonstrating the importance of ROCE for Vodafone Group, and the prioritisation of investments in businesses where the expected return on investments is higher than the current ROCE (Vodafone Annual Report 2021, Pages 3 and 17).

Figure 6.2: Economic ROCE by MNO, pre-tax nominal



Source: Ofcom calculations based on publicly available information from financial statements and Ofcom ALF decisions. The cost of capital (pre-tax nominal) comes from Ofcom's charge control decisions for mobile call termination over the relevant period. Ofcom's latest view of the appropriate pre-tax nominal cost of capital for a UK MNO has declined based on the latest market evidence and is 7.8% (MCT 2021-2026).

6.15 The main reason why average industry ROCE is higher on an economic basis than on an accounting basis is because we exclude goodwill from the capital employed. This is appropriate if the purpose of the profitability analysis is to understand whether the market dynamics allow operators to earn sufficient returns to continue investing (i.e. above the cost of capital). As such, economic ROCE is our preferred measure of returns. However, we recognise that investors may consider goodwill when evaluating how successful management has been at investing historically and inferring the likely future direction of returns and thus rely on something closer to accounting ROCE.

6.16 In a well-functioning competitive market not all market participants may earn similar levels of returns. As Figure 6.2 shows, some MNOs have earned higher returns than others and in recent years, Vodafone and Three may not have covered their cost of capital. If ROCE (on an economic basis) was to fall, or was expected to fall, below the cost of capital for a sustained period of time for any MNO, this could dampen its incentive to invest.

6.17 However, based on current business plans, all MNOs are planning to continue investing in their networks (see below). As highlighted above, this may be because, while historical returns are useful to consider, expected returns on new investment are more important when considering future investment and capital allocation.[254] Importantly, our latest estimate of the cost of capital (7.8%) is lower than that presented in Figure 6.2, and any future returns would be compared against this lower benchmark.

[254] ROCE on an economic and accounting basis (excluding goodwill) are both above any objective measure of the cost of capital which is based on MCT decisions which at the most was 9.1% and lower still based on more recent evidence (7.8% pre-tax nominal).

There are commercial incentives to continue to invest in mobile networks

6.18 While MNOs have said that the investment climate is more challenging, we consider that MNOs are likely to have commercial incentives to invest for at least the next few years, because:

- 5G RAN equipment is more efficient for carrying the expected increases in data compared to older technologies.
- MNOs that invest in 5G will be able to increase the capacity of their network to reduce issues of congestion that could otherwise result in customers switching to rivals.[255] Indeed, the rollout of 5G may also represent an opportunity for MNOs to differentiate themselves and gain new customers.[256]
- Although there is uncertainty over the value of new uses, this is likely to reduce over time as those uses and customer demand both become clearer, and provide a stronger basis for making commercial investment decisions. MNOs are therefore able to make initial investments in rolling out 5G today and then make commercial decisions on further investments in light of market developments.

The evidence suggests that MNOs plan to continue to invest significantly in their networks for at least the next few years

6.19 Furthermore, evidence from MNOs' business plans and related documents show that they all plan to continue to invest, driven by competition.[257]

6.20 In the near term, MNOs are likely to continue to focus their 5G deployments of greater additional capacity (including 5G SA) in higher demand areas (for example, more urban locations), including by deploying higher frequency spectrum in those areas. They will therefore be well placed to offer services that require very high speeds and the other capabilities of 5G SA in such areas.

6.21 In contrast, they may not have commercial incentives to offer such services in areas where low frequency spectrum is being relied on. There may therefore be some geographical variation in customer experience, with those in low demand areas potentially not experiencing the same very high speeds and responsiveness as in high demand areas.

[255] Therefore, while there appear to be differences between the drivers for investing in 5G networks (and improving 4G networks) compared to investing in 4G over the last decade, they are also similar in respect of mitigating the risk of customers switching to rivals.
[256] For example, we note that EE compares the quality of its network with rivals as part of its marketing. See EE Network Claims & Recognition.
[257] Based on information provided in response to Mobile Strategy Review and Mobile Spectrum Demand: Notice requiring the provision of information under section 32A of the Wireless Telegraph Act 2006, dated August 2021. This information is commercially confidential so is not set out in our document.

6.22 However, overall, based on the network deployment plans we have seen,[258] MNOs are on track to exceed the Government's target for 5G coverage in the majority of the country by 2027.[259]

Changing market dynamics have the potential to change investment incentives longer term

6.23 We consider that competition between the MNOs is likely to continue to play a key role in delivering good outcomes for customers for at least the next few years.

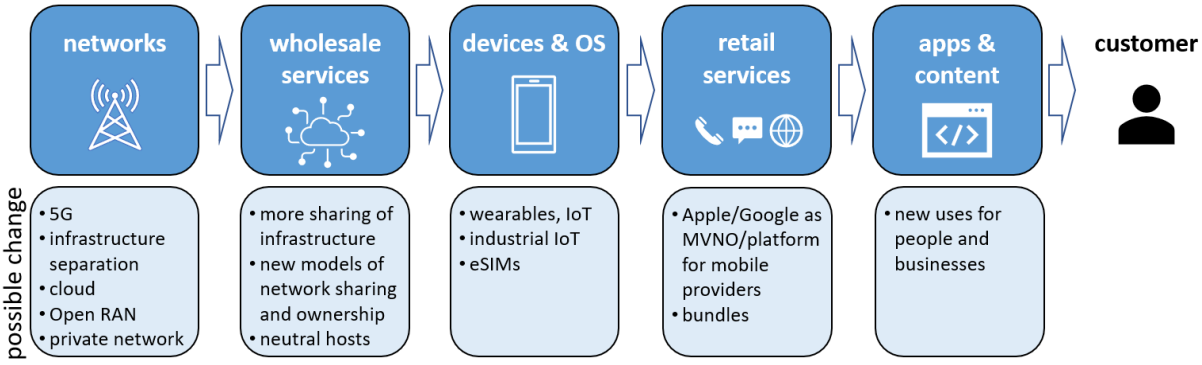
6.24 However, we also recognise that the model of competition may change in the medium term. Changes in the model of competition that alter market dynamics could affect price competition as well as competition based on quality, by affecting the ability and incentive to invest. Below, we explore the potential for the model of competition to change and the risk to the good outcomes this poses.

We will monitor how competition evolves, ready to engage where necessary

We expect to see a more complex system of competition across a fragmented value chain, and it is uncertain what the impact will be

6.25 We outline in Section 5 a number of potential changes that may take place over the next five to ten years, as summarised in Figure 6.3.

Figure 6.3: Summary of potential key changes across the mobile internet access value chain



Source: Ofcom

6.26 We expect these changes to lead to greater fragmentation of the mobile value chain but it is uncertain what the impact is likely to be on competition and the delivery of good outcomes overall.

6.27 We may see the mobile sector – including new entrants – continue to deliver good outcomes for people and businesses in terms of prices and investment to meet customers' future needs.

[258] Based on information provided in response to Mobile Strategy Review and Mobile Spectrum Demand: Notice requiring the provision of information under section 32A of the Wireless Telegraph Act 2006, dated August 2021. This information is commercially confidential so is not set out in our document.
[259] As noted in Section 4, around 42-57% of the UK already has 5G coverage from at least one MNO.

6.28 Conversely, we may see market dynamics change in a way that leads to weaker competition across one or more parts of the value chain that affects the delivery of good outcomes. We have identified two broad potential risks, on which we would welcome stakeholders' views.

6.29 First, future market developments may reduce the economic prospects of one (or more) MNOs, such that they become a weaker competitor. This could arise if, for example, scale becomes more important, (as set out in Box 6.4 it is difficult to say at this stage whether or not this will be the case). In which case, in the short term, smaller providers may be less able to exert a strong price constraint on other operators. Longer term, a weakened MNO may be less able, or have less incentive, to invest as fully in its network. It may instead opt to scale back investment, which could affect its quality and potentially its ability to retain or gain market share. In turn, this may weaken the incentives of rival operators to invest in improving their networks.

Box 6.4: Future market and technology changes may affect the importance of scale in the provision of national mobile networks

Economies of scale in the mobile sector mean that MNOs need to serve a sufficiently large market share to achieve a minimum viable scale (MVS) - the minimum level of scale required for each MNO to be viable at the prevailing price level.

Beyond this minimum level, an MNO would be expected to earn a positive margin at the current price level, assuming its per unit costs continue to decline in line with its scale. We note that differences in the cost efficiency of different operators, or differences in the revenues they earn, mean that the MVS can vary between operators.[260]

Future market and technology changes could see scale becoming more, or less, important if they alter the MVS for MNOs relative to their scale. In turn, these changes could affect the profitability and the competitive constraint that a given operator can exert. Future changes could include those affecting MNOs' costs, prices and revenues; and the entry of new players in the value chain, which can affect the market segments that an MNO competes for and their service share. For example, if MNOs lose business, this could reduce their scale and bring them closer to their MVS (and vice versa).

6.30 Second, we may see bottlenecks develop in the value chain that undermine the ability of the sector to deliver the outcomes we want to see. For example, if hyperscalers develop a strong position in the provision of cloud infrastructure to mobile providers, competition problems may arise as a result. In addition, if Apple's and Google's operating systems become platforms on which customers choose their mobile provider, under certain circumstances this could result in weaker competition, raising potential concerns about higher prices and reduced incentives to invest.

6.31 Overall, we would be concerned if the market transitioned from its current state in which we see good outcomes, in terms of value for money and investment, to one where one or

[260] See, for example, Ofcom, Assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues, 2011, Annex 6, paragraph 6.45.

more MNOs starts to pare back its investment and others follow suit (perhaps because of a lack of incentive to "invest to get ahead of the market" or to maintain parity with rivals).

We will continue to monitor market developments, and assess any key risks that might affect the delivery of good outcomes

6.32 Given the uncertainty over how competition might develop, and the potential concerns highlighted above, we will continue to monitor developments across the value chain so that we better understand their impact and are able to respond in an agile way. Where relevant, we would consider what action we should take in accordance with our general duties.

6.33 As part of our monitoring of developments across the value chain, and to help us better understand what consumer outcomes look like, we plan to carry out some further monitoring in the following areas in particular:

- *Retail prices.* We aim to do an analysis of the dispersion of retail prices in the market for comparable mobile contracts, to understand the extent to which there may be gains from switching tariff for some mobile customers. This will help inform our understanding of the competitive process in the sector today. We also plan to gain a better understanding of the impact of market developments on pricing over time.
- *The position of Big Tech.* We will consider further the potential implications of Apple and Google extending their strong position in the mobile value chain to affect outcomes, and will engage with the CMA to consider to what extent any potential concerns, should they arise, could be addressed under the new proposed regulatory regime for online platforms with Strategic Market Status.[261] In addition, as our traditional sectors evolve in the online environment, we are developing Ofcom's approach to competition in digital communications markets more generally, and will be looking to share more on this in the first half of this year.

We will develop better information on quality to allow customers to make more informed decisions

Quality of experience is likely to become more important over time

6.34 We have previously defined a good mobile service as one that provides a download speed of 2 Mbit/s.[262] Such speeds enable the use of the vast majority of existing services, including activities such as video streaming on a mobile handset.

6.35 In Section 5, we set out that customer needs are likely to evolve over the next ten years and that some uses will require higher quality connections on the go, such as better quality

[261] The CMA's interim report in its Mobile Ecosystems market study provided an initial view that both Apple and Google would meet the government's conditions (as currently proposed in its consultation) for possible SMS designation by the DMU for each of the main activities within their respective mobile ecosystems.
[262] Ofcom has defined a decent mobile experience for consumers based on nearly all (at least 95% of the time) connections offering data services of at least 2 Mbit/s, which is fast enough to allow users to browse the internet and watch glitch-free mobile video, and 90 second calls without interruption. See Connection Nations, 2017.

video streaming and AR services. Users may have higher expectations, based on use of new online services and driven by improvements in homes broadband (in particular full fibre, which is typically faster and more reliable than mobile). New online services enabled by new technology, including standalone 5G, may also require different types of mobile internet access, and in different types of places, to those we see today.[263]

6.36 At present however, it is difficult to say exactly what customer needs will be and what improved quality of experience will be required over the next decade. This is particularly the case because so far 5G has primarily been used to provide more capacity to meet growing demand for existing services, rather than to deliver new uses. Nonetheless, this is something that we will monitor both in terms of the quality of service delivered (see below) and in terms of consumer attitudes such as satisfaction with mobile services and reception.

We expect the market to deliver improvements in quality, as it has in the past

6.37 Our evidence suggests that the market has generally delivered good quality of experience outcomes for customers (including by delivering significant improvements in capacity to carry ever-increasing volumes of mobile data), but quality can be patchy in places (see Section 4).

6.38 As set out earlier in this section, we expect competition to continue to give MNOs an incentive to invest and to improve network quality, and MNOs are already taking measures that should help deliver improvements in quality of experience. In particular, we consider that the market is likely to be effective in delivering:

a) additional capacity where required, [264] which should improve or maintain the consumer experience in the face of ongoing demand growth, particularly in relation to reliability.

b) site-specific private networks and industrial applications for business customers as described above.

6.39 In addition, some measures are being taken that will further improve current quality of experience. In particular, the SRN is helping to deliver widespread availability of mobile services to 95% of the UK landmass by 2027,[265] and some specific measures have been taken to improve coverage on roads[266] and on trains.[267]

[263] For example, there may be greater demand for mobile services when people are travelling. Potential drivers of new demand include increased use of video calling on the move, or AR navigation services. Ofcom has previously modelled future demand for train use, setting out potential ranges of five to twenty-fold increase in average data demand between 2017 and 2025. See Ofcom, Advice to Government on improving rail passenger access to data services, 2018.
[264] Information provided in response to Mobile Strategy Review and Mobile Spectrum Demand: Notice requiring the provision of information under section 32A of the Wireless Telegraph Act 2006, dated August 2021.
[265] As well as improving outdoor coverage, the SRN may increase in-car and indoor coverage. See DCMS, Shared Rural Network, March 2020.
[266] The UK Government has proposed changes to allow building-based masts to be placed nearer to highways. See DCMS, 'New laws to wipe out rural mobile 'not spots' and speed up rollout of next-generation 5G technology,' April 2021.
[267] For example, Blu Wireless and FirstGroup have conducted trials involving the installation of purpose-built base stations on tracksides, backhauled by fibre. Blu Wireless, Setting a new benchmark for passenger connectivity with 5G mmWave technology, April 2021. Further examples of industry schemes are provided on page 45 of Connected Nations 2021.

There are particular challenges to improving indoor coverage

6.40 We recognise that there can be particular challenges in ensuring high-quality indoor mobile coverage, some of which are beyond the control of MNOs.[268] In addition, the higher frequencies that are increasingly being used to provide bandwidth for 5G increase the difficulty of propagation.[269] Such factors may limit the ease with which future quality of experience improvements can be delivered to support indoor use, which accounts for a significant proportion of current demand for mobile data.

6.41 For indoor coverage, the availability of Wi-Fi based solutions to support mobile voice and SMS services indoors is becoming increasingly widespread. Most of the largest providers, including all four MNOs, now offer Wi-Fi calling, though there are still some factors limiting uptake or experience,[270] and there may be scope for providers to do more to promote wider uptake of these services.

6.42 Where Wi-Fi is available, we expect that it will help meet the future needs of most mobile device users at home and at many other indoor locations (particularly given the ongoing rollout of gigabit capable networks, and improvements in Wi-Fi standards).

6.43 Nonetheless, we recognise that, in some cases, relying on Wi-Fi to fill gaps in indoor mobile coverage may not be sufficient.[271] In these circumstances, various alternative solutions are available ranging from self-installed repeaters,[272] to femtocells,[273] and neutral host solutions. Private networks might also be part of the solution for some business premises. We would welcome input from stakeholders on any other measures that could reduce the barriers to providing good indoor coverage.

6.44 In some settings, such as for users of road vehicles and trains, specific issues beyond the control of MNOs may also continue to affect the services users receive.[274] Further improvements in quality of experience in such cases are likely to depend on factors including the extent of further collaboration, innovation and investment from stakeholders.

[268] In-building coverage depends on a range of factors, including the thickness of walls, building materials used (including addition of insulation) and where in a building people are using their phone.
[269] MNOs have traditionally relied on an "outdoor in" solution to this problem using their lower-frequency spectrum. However, there is not enough of this spectrum to address capacity demand even if more were made available.
[270] For example, some mobile providers do not: offer Wi-Fi calling services on all of their tariffs and some MVNOs do not offer services on any of their tariffs; offer Wi-Fi SMS services; offer a seamless transition between Wi-Fi and mobile connections; offer services on a large range of handset devices; or provide service automatically without the need for customers to opt in through their phone settings.
[271] For example, users without fixed connections will not be able to use Wi-Fi and it may not provide a seamless solution for some users visiting new premises frequently (such as tradespeople).
[272] Ofcom also extended the range of static indoor repeaters available that can be installed without a licence in 2021. These repeaters can boost a good outdoor signal to improve indoor reception. In particular, we allowed the use of two additional types of repeater: provider-specific repeaters and multi-operator repeaters. Both types of repeater may amplify the frequencies of more than one mobile provider at a time, provided they meet appropriate technical requirements specified by Ofcom. See Mobile Phone Repeaters, 2021.
[273] A femtocell is very small low power basestation for indoor use.
[274] Signal loss occurs, for instance, when penetrating cars or train carriages as it does with buildings. As set out in Section 4, additional challenges include geographic issues when railway lines pass through areas with poor geographic coverage, as well as specific obstacles such as trackside trees and railway cuttings, and the fact that demand is fleeting but highly concentrated as trains pass through.

There is a risk that quality of experience may not meet customers' needs due to limited customer information

6.45 As noted in Section 4, it can be difficult for customers to judge which is the best network to be on from a quality perspective. [275] As a result, competition on the basis of quality is likely to be less strong than on price.

6.46 The difficulties in measuring quality of experience also mean that we do not have a clear view of how well mobile services meet the needs of customers and society today. We have data on consumer satisfaction, and know where mobile services are more likely to be available, but we do not have a holistic view of quality of experience.

We will develop better information on quality of experience to inform customers and future policy

6.47 Looking ahead, as customer needs evolve and new uses become available, it may become *more* important that customers understand the quality of experience they need, and which providers can offer it in the places they want to go.

6.48 We therefore want to develop a richer understanding of the extent to which quality of experience outcomes meet the needs of people and society. We plan to continue our work to develop improved data through Ofcom's Mobile Reporting Project,[276] which - alongside developing new metrics for reporting on the availability of 5G - is exploring new approaches to report on the quality of mobile performance to present a consistent picture across 4G and 5G. This will help inform customers' choice of provider as well as future policy.

We are inviting further input on potential wider benefits from having mobile networks of higher quality than the market will deliver

6.49 The scale and type of investment made by MNOs in network improvements will largely be determined by the expected returns of those investment options. Where benefits can be accrued (or 'internalised'[277]) by MNOs, this will factor into their investment decisions.

6.50 However, an investment gap may occur if there are significant market[278] or regulatory failures. For example, there may be an investment gap due to the presence of wider benefits (or 'positive externalities') to society, that might result from improvements in

[275] In general, they are not in a position to compare quality between different networks in the places where they want to use it and because there is limited data to inform their choice of provider. There is limited data on network reliability and quality of experience by location, while coverage data is typically based on predictions which do not always give accurate picture of situation in specific location.

[276] We will also continue working with industry with the aim of improving the accuracy and commonality of indoor coverage information Ofcom and the industry provides. See Ofcom's plan of work 2021/22.

[277] Internalised costs and benefits from an activity are those that are felt by the operator, whereas those that are externalised are felt by third parties. External benefits might exist in situations where there are wider benefits flowing from a product, service, or investment.

[278] We discuss potential changes in the competitive process later in this section. We also discuss evidence on possible positive externalities below. Beyond these, we have not received compelling evidence of other market failures which might create an investment gap.

quality but which MNOs are not be able to (fully) monetise. These benefits may include improved social inclusion, improved access to and quality of healthcare and education, environmental benefits, and greater UK productivity and innovation.[279] If there are significant externalities, this could lead to under-investment in mobile networks such as 5G from a societal perspective,[280] which could in turn provide a rationale for policy intervention to support investment.

6.51 We have reviewed a range of studies on the potential benefits of 5G (using the framework set out in Box 6.5.[281] Many of the examples put forward relate to private benefits that would accrue to individual consumers or businesses (such as productivity benefits to industries that are customers of 5G connectivity providers). Such benefits should be reflected in the willingness of customers to pay, and so feed into the market-based investment decisions of MNOs.[282]

Box 6.5: Framework for the assessment of the potential wider benefits of 5G

In assessing potential benefits, we consider the following three criteria:

1. **External nature of the benefits**. To what extent do the cited benefits accrue to unrelated third parties and/or society as a whole?
2. **Specificity of the benefits to 5G**. To what extent do the cited benefits relate specifically to 5G mobile technology, for example compared to the expected evolution of existing Wi-Fi, FWA and 4G technologies? Are the benefits specific to standalone 5G over and above non-standalone 5G?
3. **Scale**: Are the cited 5G benefits substantial enough to merit a potential market intervention? Are the cited 5G benefits reliable: to what extent are the assumptions used to derive the estimates plausible, and do the estimates account sufficiently for uncertainty?

6.52 Where examples of potential external benefits from 5G technology have been provided (for example, those relating to reductions in carbon emissions from 5G-enabled smart

[279] For example, a business which is considering whether to adopt 5G to make its industrial processes more efficient will reflect the value of these efficiencies in deriving profit in its willingness to pay for 5G. However, the business may not reflect the full value of the reduction in emissions to society in its willingness to pay, because it will not experience the full value of these benefits. Such environmental benefits would therefore be external – and could lead to under-investment.
[280] In this scenario, the socially optimal level of investment would take account of these wider benefits (and costs) of 5G deployment. This level would occur where the marginal social benefit equates to the marginal social cost of provision. Under-investment could take the form of less investment or delayed or slower rollout of high-quality networks.
[281] These include: a report by Analysys Mason for Ericsson and Qualcomm (Cost-benefit analysis on Full 5G deployment - UK results); a report by WPI Economics for Vodafone (Levelling Up: How 5G can boost productivity across the UK, June 2020); a report for one MNO on supporting 5G investment in the UK mobile market; a report by Strategy and Policy Consultants Network for one MNO on consumer benefits from 5G mobile; and a report by Compass Lexecon for Vodafone (Mobile Market Structure: Policy and Investment, November 2021).
[282] For example, a WPI report for Vodafone notes that 5G could overhaul operation of production lines and provide significant cost savings from more efficient buildings, and one MNO notes the benefits of agri-tech 5G robotics and data precision and accuracy in farming which could be enabled through 5G. See WPI Economics report for Vodafone UK, Levelling Up: How 5G can boost productivity across the UK, June 2020

factories), it is unclear to what extent those are likely to be large.[283] Similarly, so far we have seen limited evidence – whether qualitative or quantitative – on potential social benefits specific to 5G connectivity, e.g. relating to greater social inclusion. [284]

6.53 Nevertheless, we are mindful that better infrastructure has the potential to enable economic growth and innovation and promote social inclusion and environmental benefits.[285] We would welcome stakeholders' further input on the nature and size of any externalities or other potential market or regulatory failures relating to investment in 5G that might warrant consideration of interventions to support a quicker and more widespread rollout of high-quality networks than that which the market is likely to deliver.

[283] Estimation of the benefit would not only need to consider factors such as the expected reduction in emissions arising from increased efficiency and substitution to less carbon intensive use cases, but also increases in emissions from increased economic activity, for example. We would also expect to see a distinction between the impact on those emissions which are currently capped under UK ETS, including electricity, and those that are not.

[284] One MNO cites a potential multiplier effect, but does not provide a specific quantification of it – pointing instead to the overall benefits found in a WPI report for Vodafone which is based on assumptions of the overall productivity gains of incremental change in mobile technology extrapolated across ten years.

[285] There have for example been wider benefits from having a more widespread rollout of 4G networks than that which the market would deliver. Studies have found that in, addition to delivering economic benefits, mobile broadband services have also delivered wider benefits including consumer value (such as unlocking new forms of innovative apps available at low or free cost) and economic spillovers (such as higher employment levels). Deloitte, The impacts of mobile broadband and 5G: a literature review for DCMS, June 2018.

7. Clarifying our future regulatory approach to encourage investment

7.1 In this section we set out our initial views on our future regulatory approach to encourage investment in mobile networks. More specifically we:

- Set out what MNOs have said about the impact of regulation on investment.
- Explain that competition rather than regulation should continue to be the key driver of investment.
- Propose steps to provide greater clarity over our future regulatory approach.

MNOs have said that the regulatory climate is not supportive of investment

7.2 The MNOs have put forward three main reasons why the regulatory climate is not supportive of future investment in mobile networks in the UK.

7.3 First, they have said that regulation, either introduced by Ofcom or other bodies, has reduced their financial returns by imposing additional costs and reducing their commercial flexibility to generate revenues. For example, MNOs have raised concerns over the following:

- *Annual Licence Fees (ALFs)*. MNOs have said that the current methodology for setting ALFs risks setting fees at too high a level and the methodology should be reviewed to ensure it is consistent with promoting investment.
- *Consumer regulation*. MNOs have said that Ofcom's consumer initiatives have imposed significant costs on the industry and limited their commercial flexibility. They have called for an improved balance between consumer protection initiatives and investment incentives.
- *Network security and requirements*. MNOs have referred to the additional costs that have, and will be, incurred as a result of complying with high-risk vendor equipment removal rules.

7.4 Second, MNOs have said that the scope of regulation has increased in recent years (referring in particular to the increase in consumer regulation, as well as the new network security requirements). Some MNOs have argued that this expansion generates greater uncertainty about how regulation might further expand in the future. In short, they have raised a concern that financial returns from investing in mobile networks are at risk of being regulated away in the future through further interventions.

7.5 In addition, some MNOs have indicated that the growing role of Big Tech in the value chain could undermine MNOs' future investments in mobile networks. They have stated that Big Tech currently extracts a lot of value from the market, and may not invest to support policy goals such as network coverage because they are not regulated by Ofcom. In this context, MNOs have raised the following regulatory issues:

- *Net neutrality framework*. MNOs have argued that demand for mobile data is increasing and this is largely driven by mobile customers choosing to access content from a small number of large content providers. This increasing demand is driving higher network costs for MNOs. MNOs have argued that the net neutrality requirements limit their ability to set retail packages to respond to this growth, or to seek to recover costs from the content providers driving growth. The rules also limit how they can prioritise traffic on their networks to manage increasing demand. They have also argued that the net neutrality rules are unclear on how innovative 5G services (e.g. with speed and other quality of service guarantees) can be delivered, which limits their ability to differentiate the services they offer.
- *Asymmetry of regulation*. Some MNOs have argued that traditional regulated voice and messaging services have increasingly been replaced by online services (such as WhatsApp, Google Duo and MS Teams), which are unregulated.[286] Some MNOs have also argued that as hyperscalers play an increasing role in providing inputs to mobile networks (e.g. cloud infrastructure), they should share the costs of security and resilience requirements.

7.6 Looking ahead, MNOs have said that regulation needs to better support investors by giving greater long-term certainty and clearer signals of the opportunity to make returns from future investments. They have argued that the regulatory approach in the mobile sector needs to shift from a narrow focus on price to encouraging investment (as it has in the fixed sector), and that, if they could earn higher returns, they would be able to make greater investments in mobile networks.

Competition rather than regulation should continue to be the key driver of investment

7.7 In the fixed sector, our regulation of wholesale markets, including our approach to setting charge controls on wholesale prices, is used to influence the incentives to invest and encourage network investment, where possible.[287] With the exception of the regulation of wholesale mobile call termination, we do not regulate wholesale services in mobile markets and so do not have similar regulatory levers to incentivise investment. Instead, competition among MNOs has largely driven investment decisions.

7.8 Where MNOs incur costs as a result of regulation, they may be able to adjust prices to recover those costs. In addition, where regulation places constraints on particular sources

[286] For example, for mobile voice services, MNOs must ensure that the customer can access the emergency services using 112 and 999.

[287] By way of illustration, in our Wholesale Fixed Telecoms Market Review 2021-2026, in geographic areas where there was potential for material network competition, we set an inflation indexed charge control on Openreach's entry-level superfast broadband service and included a small premium for the higher quality full fibre service, and we did not impose a charge control on the prices of Openreach's higher speed services. This was aimed at providing incentives for competing networks and Openreach to invest. Whereas, in geographic areas where Openreach was expected to be the only operator providing a large scale network, we incentivised Openreach's investment by setting a cost-based control which allowed Openreach to recover the costs of both its existing copper network and its investment in a new full-fibre network.

of revenue, this will not necessarily reduce overall revenues if prices rise elsewhere to offset lost revenue.[288]

7.9 Moreover, we only intervene where we expect any such costs to be outweighed by the benefits the intervention brings, such as by helping customers get a better deal, which can in turn lead to more effective competition, or by protecting customers from harm.[289]

7.10 We note the view put forward by some MNOs that higher revenues and returns would lead to greater investments in mobile networks. However, we treat this view with caution. Our evidence suggests that competition drives investment.[290] Measures to increase the overall profitability of MNOs will not necessarily improve incentives for future investments or result in more investment (particularly where increased profitability is achieved through reduced competition). They could instead result in higher costs for consumers without offsetting benefits in the form of say higher quality services.

Proposed steps to provide greater clarity over our future regulatory approach

7.11 We recognise that regulation can influence investment incentives by affecting the expected future returns of potential investments, and the risks associated with making those investments.

7.12 We consider it important that our future regulatory approach is clear to create as much certainty as we can to encourage investment. This should help MNOs and others to better navigate the uncertainty generated by changing market conditions.

We plan to set out more explicitly how we have considered investment when making future policy decisions

7.13 Considering how proposed policy interventions would impact investment has always informed our approach. In line with our duty to further the interests of citizens in relation to communications matters and consumers in relevant markets, we are required to have regard to the desirability of encouraging investment and innovation in relevant markets (see Section 2).

7.14 Nevertheless, we recognise that we could set out our considerations more explicitly. Therefore, where appropriate, we intend to set out how we have considered investment when making future policy decisions. This should help underline the importance we place on investment and enable stakeholders to engage directly with our assessment.

[288] This is commonly referred to as the 'waterbed effect'. The extent of any waterbed effect will depend on the nature of competition in the market affected and the nature of the intervention.
[289] In Annex 5, we summarise the main areas where Ofcom and others have intervened in the mobile sector and the rationale for those interventions.
[290] Indeed, even though in our recent Wholesale Fixed Telecoms Market Review 2021 regulatory enablers such as indexed (higher) charges and pricing flexibility formed part of the package of measures, our approach was designed to promote network competition and for that competition to drive incentives to invest and provide a constraint on prices.

Looking ahead, we do not expect to introduce new consumer pricing rules

7.15 Some MNOs have argued that there have been a large number of consumer initiatives recently and suggested that there is uncertainty over the extent to which further interventions will be introduced going forwards.

7.16 Our recent consumer empowerment and protection initiatives have helped address a range of concerns, and we expect these initiatives to deliver significant benefits for consumers over time. In addition, the Fairness for Customers commitments set clear standards for providers, to help ensure they treat their customers fairly. Having set these clear standards, we now expect to shift our focus to promoting effective compliance, monitoring and understanding the impact of our recent interventions. We will also continue to monitor the affordability of internet access for low income households and the fair treatment of customers who might be vulnerable.

7.17 Overall, we want to see providers complying with existing rules and delivering against the Fairness for Customers commitments, without the need for further intervention. Although we have no plans to intervene further, should problems emerge, we would be ready to engage. [291]

We do not have a fixed position in relation to future mobile consolidation

7.18 Some investors consider that Ofcom has an entrenched position against MNO consolidation. This follows our support for maintaining competition among four MNOs during the proposed merger between Three and O2 in 2015 and in light of the steps we have taken to help maintain such competition in auctions for mobile spectrum. [292]

7.19 While it is the CMA that assesses mergers, the CMA as a matter of course engages with sectoral regulators in relation to mergers in regulated sectors.

7.20 The question of whether a particular merger is likely to result in a substantial lessening of competition will turn on the effectiveness of competition that can be expected in the market after the merger, rather than just the number of competitors. Our stance on a potential merger would therefore be informed by the specific circumstances of that particular merger, taking into account how markets are evolving.

7.21 There has also been ongoing discussion in Europe and beyond about whether higher levels of concentration in mobile telecoms markets result in benefits for consumers, or works against consumers by resulting in higher prices which do not translate into consumer

[291] Should a new policy concern arise, we would consider our Fairness Framework when assessing whether or not we should intervene. Ofcom, Making communications markets work well for customers, A framework for assessing fairness in broadband, mobile, home phone and pay TV, 23 January 2020.

[292] For recent market analysts' views on mobile consolidation, see for example: BNP Paribas Exane (November 2021), Telecom Operators – Struggling to Concentrate and BNP Paribas Exane (24 January 2022), Telecoms Daily; Morgan Stanley (December 2021), Vodafone Group - Tower monetisation and Telco consolidation; Enders Analysis (December 2021), Flat-lining in negative territory, UK mobile market in Q3 2021. Bernstein (January 2022), EU Telecoms 2022 Outlook. See also previous analysts' views on Ofcom's Digital Communications Review (2015) and their reading of the implications for mobile consolidation, for example: Nomura (July 2015), European Telecoms; Bank of America Merrill Lynch (July 2015), BT - Ofcom discussion doc – all doors open but we expect a benign outcome for BT.

benefits. A number of empirical studies have been conducted recently, which have contributed to this discussion.

7.22 As the UK telecoms regulator, we have a strong interest in the relationship between market structure and outcomes. We have reviewed several empirical studies in the area, as well as conducting our own research, as discussed in Box 7.1 below. The conclusion of our review is that, contrary to the findings of some previous studies, there is no evidence to support the hypothesis that service quality and / or investment increases when markets become more concentrated. This supports our view that potential mergers in telecoms markets need to be assessed on a case-by-case basis, rather than on a presumptive view of the appropriate number of competitors.

Box 7.1: Empirical studies have looked at the impact of mobile consolidation on mobile markets

The industry body GSMA has carried out two empirical studies of the relationship between mobile consolidation and quality outcomes. These studies claim to evidence the view that consolidation can improve consumer outcomes by increasing the ability and incentives for MNOs to invest in networks.[293]

We reviewed the GSMA's reports, together with existing empirical studies in the area, and conducted our own analysis.[294] We found significant limitations with the existing empirical evidence, which was either inconclusive or did not support the inferences being made. The results of our own empirical analysis do not support the conclusions the GSMA has drawn based on past research.[295] That is, we find no evidence that service quality increases when markets become more concentrated.

Since conducting our own analysis,[296] we have been made aware of a recent report, which contains some criticisms of Ofcom's analysis. [297] Having reviewed this report, we see no challenge to our main finding that the empirical research that has been performed to date does not provide evidence of a positive link between mobile mergers and quality outcomes.

Clearly empirical analysis of this type is, by its very nature, a simplification of the commercial decisions facing companies. We also recognise that it considers the historical relationship between consolidation and investment/quality, at a time when we anticipate significant change in both the mobile industry and communications markets more broadly, and so past performance may not be the best guide to any future impact.

[293] GSMA, Mobile market structure and performance in Europe: Lessons from the 4G era, February 2020. GSMA, Assessing the impact of mobile consolidation on innovation and quality: An evaluation of the Hutchison/Orange merger in Austria, 2017.
[294] Ofcom, Market structure, investment and quality in the mobile industry, December 2020.
[295] Ofcom, Market structure, investment and quality in the mobile industry, December 2020.
[296] Ofcom, Market structure, investment and quality in the mobile industry, December 2020.
[297] Compass Lexecon, Review of Ofcom's Economics Discussion Paper, Market structure, Investment and Quality in the mobile industry, 19 January 2022. Confidential submission, commissioned by Vodafone.

We are reviewing other aspects of our regulation

7.23 MNOs raised specific concerns relating to the net neutrality framework and the methodology for setting ALFs. In relation to these two areas:

a) We are currently carrying out a review of how the UK's net neutrality framework is functioning and published a call for inputs in September 2021.[298]

b) We will continue to review the appropriate fees for the range of spectrum bands where annual licence fees become due following an initial period secured through an award, with a view to consulting in Spring 2022.

[298] Ofcom, Net Neutrality Review: call for evidence, September 2021.

8. Next steps

8.1 This document sets out our initial thinking on:

a) the key market developments that may take place across mobile markets over the next five to ten years;

b) the potential implications for the delivery of good outcomes; and

c) what our approach should be in light of these.

We are inviting views from stakeholders

8.2 We would welcome views and evidence from stakeholders to further develop our thinking in the above three areas. The topics we are seeking views on are set out below, and details of how to respond are set out at Annex 2.

Areas where we would welcome views and evidence:

1) Do you agree that the key potential market developments over the next five to ten years are those set out in Section 5? Are there any other key developments we should consider?

2) Do you agree that competition among MNOs is likely to continue to play a key role in the delivery of good outcomes, as outlined in Section 6?

3) Do you consider that there are likely to be significant wider external benefits (externalities) from a quicker or more widespread rollout of high-quality networks than that which the market is likely to deliver, as discussed in Section 6? If so, please provide clear examples to help explain your answer.[299]

4) Do you agree with our views on how competition across the value chain may evolve over the next ten years, and the potential implications for the delivery of good outcomes, as outlined in Section 6?

5) As set out in Section 6, do you agree that quality of experience will become more important in the future? Do you agree that developing better information on quality of experience for customers will help further the delivery of good outcomes?

6) Do you think there is more that could be done to reduce barriers to customers receiving good indoor coverage (see Section 6)? If so, please outline what steps could be taken and what impact those steps would be likely to have.

7) Do you agree that clarifying our future regulatory approach will help encourage investment, as outlined in Section 7?

8) Are there any other potential barriers to the delivery of good outcomes over the next five to ten years that we have not considered? If so, please outline what these are

[299] Where possible, please show that the examples provided are external (i.e. economic benefits accruing to third parties that cannot be internalised by MNOs) and are specific to the investment (e.g. 5G benefits that cannot be realised using current technologies).

likely to be, with supporting examples/evidence where possible, and any suggestions for how they might be reduced.

Further work

8.3 In addition to taking stakeholder responses into account, we will be carrying out some further work to help inform our conclusions, which we plan to publish by end 2022.

8.4 We will continue to **monitor market developments**, to further develop our understanding of the changes taking place and the impact they may have, including through the following work:

a) *Further consideration of the position of Big Tech*. We will consider further the potential implications of Apple and Google extending their strong position in the mobile value chain to affect outcomes for consumers, and will engage with the CMA to consider to what extent any potential concerns, should they arise, could be addressed under the new proposed regulatory regime for online platforms with Strategic Market Status. More broadly, as our traditional sectors evolve in the online environment, we are developing Ofcom's approach to competition in digital communications markets, and will be looking to share more on this in the first half of this year.

b) *Develop further evidence on retail pricing*. As discussed in Section 4, we aim to carry out an analysis of the dispersion of retail prices in the market for comparable mobile contracts, to better understand the extent to which there may be gains from switching tariff for some mobile customers. This will help inform our understanding of the competitive process in the sector today. We also plan to gain a better understanding of the impact of market developments on pricing over time.

8.5 In addition, we are:

a) Developing **improved data on the quality of mobile performance** through our ongoing Mobile Reporting Project, as well as new metrics for reporting on the availability of 5G.

b) Carrying out our **ongoing review of how the net neutrality framework is functioning**. We expect to publish the initial findings of our review in Summer 2022.

c) Continuing to **review the appropriate fees for the range of spectrum bands where annual licence fees become due** following an initial period secured through an award, with a view to consulting in Spring 2022.

8.6 Other related ongoing work will also continue, for example in relation to network security and resilience, telecoms vendor diversification, 2G/3G switch off, and consumer protection monitoring and compliance.