Three's response to Ofcom's future approach to mobile markets: discussion paper.

Non-confidential

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Executive Summary.

Three welcomes the opportunity to respond to Ofcom's discussion paper on its future approach to mobile markets. This is a landmark consultation that could have a decisive impact on the future of the market and the competitiveness of the UK economy.

The UK mobile market has included four national MNOs since the Orange / T-Mobile merger in 2010. The consultation provides an opportunity to take stock and assess what this market model has delivered for the UK, and where it has fallen short.

In that context, we welcome Ofcom's acknowledgment that the UK is 'generally middle of the pack' in international quality surveys and that other firms (including Big Tech) are expected to play a greater role in the market. We commend Ofcom for clarifying that it has no fixed position on consolidation and that it is the effectiveness of competition in the market – not just the number of MNOs – that matters.

The '4-MNO' model has delivered poor-quality networks. 3-MNO markets have the best networks in Europe and deliver low prices too.

Government wants the UK to be a world-leader in 5G, with world-class infrastructure and the majority of the population covered by a 5G signal by 2027. Ofcom shares Government's commitment.

The UK mobile market needs to consolidate to achieve this ambition. The four-MNO model adopted by Ofcom to date has delivered poor quality networks by European standards. Today, network investment (including 5G) is thinly spread across too many networks.

There is a fundamental disconnect – the policy ambition is very high but the economic rewards from rolling out 5G networks in the UK are too low. As society becomes increasingly reliant on telecoms networks, quality and investment must move up the policy agenda.

The UK needs fewer, better networks. 3-MNO markets in Switzerland, Netherlands, Austria, Germany, and the Czech Republic consistently top the charts of best mobile networks in Europe. In the latest Umlaut study, the top ten mobile networks in Europe are all in 3-player markets.

With greater scale and better rollout economics, most of these countries also lead the 5G experience in Europe and are rolling out 5G more quickly and extensively than the UK (including in rural areas). There is virtually no 5G in rural parts of the UK today, unlike in Switzerland, Netherlands, Austria, and Germany.

Mobile mergers do not equate to high prices. 3-MNO markets in Germany, Austria, and Ireland (all of which have merged) offer some of the cheapest prices in Europe according to the European Commission (EC). Three sister companies continue to compete aggressively after they merge – in the EC study, Three is the lowest cost MNO in almost every country where it is present (including in Ireland, Austria, and Italy, where it has merged).

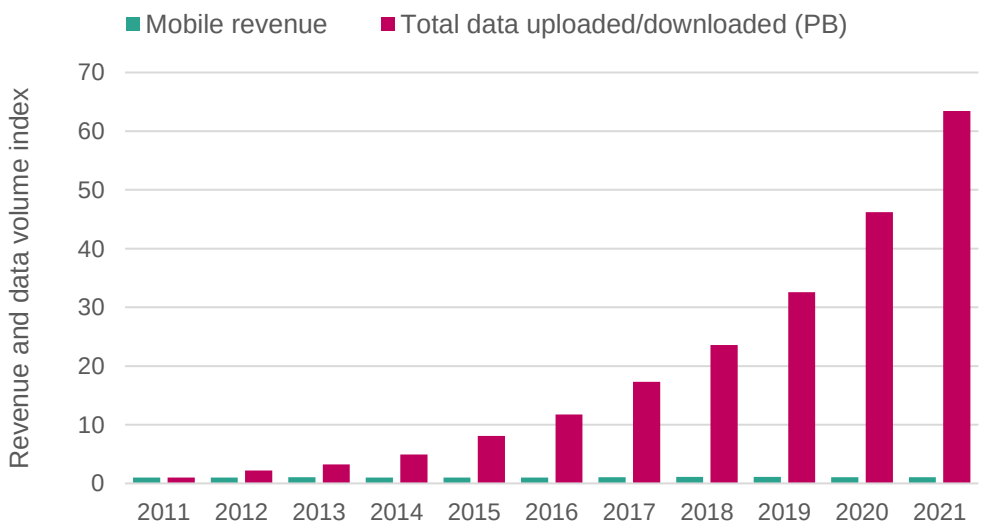
What makes for healthy competition in the market is not the number of MNOs but the presence of operators with enough scale to be able to invest in strong networks. An operator with a strong national network has every incentive to fill its capacity by offering low prices and attracting new customers to the network.

The current market structure in the UK is unsustainable due to explosive traffic growth and the need to invest in 5G

The UK does not fare well in international quality comparisons because it is competing with an inefficient market structure that is being phased out elsewhere – as witnessed by the global wave of mobile consolidation.

The most important challenge MNOs face today – in the UK and elsewhere – is how to invest in 5G and address traffic growth cost-effectively. The capacity required to meet traffic demands in the UK is doubling every two years, but mobile revenues are in long-term decline.

UK mobile revenues and traffic indexed to 2011 (basis: 1 in 2011)

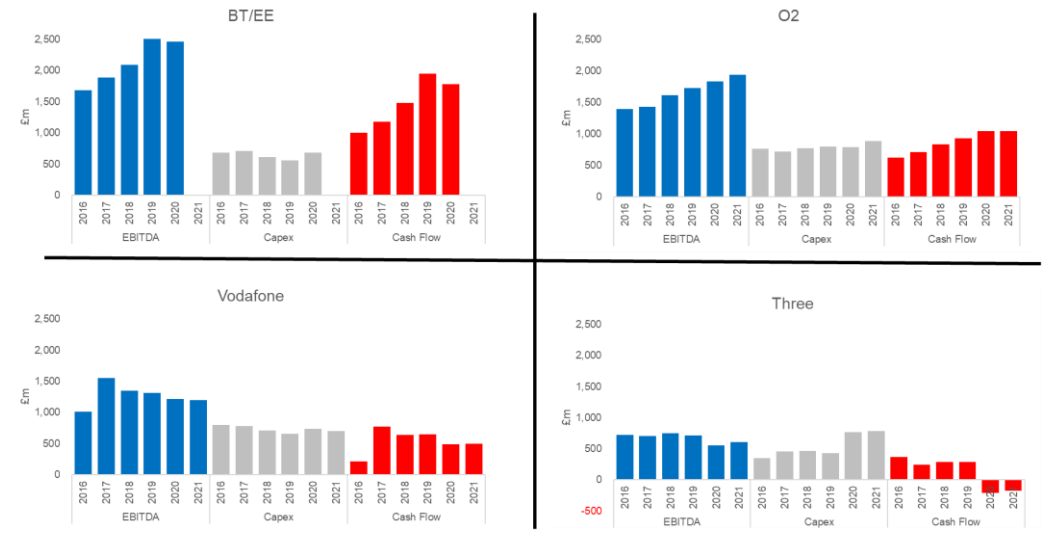


Source: Enders (mobile revenues), Ofcom Connected Nations Report (data traffic)

We know from experience that traffic growth will only accelerate with 5G. Ofcom projects that, by 2030, UK mobile traffic could be between 7.5 times and 52 times higher than in 2021.

An MNO needs scale to be able to address this challenge. [✂]

[✂] EBITDA, Capex and Cashflow (EBITDA-Capex) per MNO



Source: company accounts, Enders Analysis: 'What's to become of H3G' (2021)

The current investment environment – where only some players have the required scale – will not allow the UK to become a global leader in 5G:

- With 5G rollouts now fully underway, the UK has 6.5k live 5G sites as of Sep 2021 – with only c10k people per 5G site, the UK ranks 22nd out of 33 countries tracked by the EC's 5G Observatory, well behind the EU-27 average, South Korea, China, Japan, and the US.

- In the latest study by Ookla, the UK ranks 12th and 10th out of 21 European countries on 5G speeds and availability respectively. London ranks 26th out of 45 world capitals on 5G speeds. Similarly, the UK comes 7th and 8th out of 12 European countries on OpenSignal's study of the 5G experience, trailing the leading 3-MNO markets in Netherlands, Germany, Switzerland, and Austria.

- The UK is unlikely to realise the full potential of 5G – 'full-fledged' 5G requires MNOs with enough scale to be able to deploy tens of

thousands of small cells and invest in new ultra-reliable, ultra-low latency 5G services and IoT. The investment required [✂]

The UK needs to consolidate for all MNOs to have the required scale to invest in high-quality networks and become a global 5G leader

The UK needs three strong players with enough scale to deliver high-quality networks (as seen in other European markets), bring 5G to under-served rural areas and boost competition in 5G Home Broadband, offering households a strong alternative to Openreach and Virgin Media.

Traffic growth and 5G investment needs are pushing MNOs to consolidate in Australia, the US and many European markets. Out of this experience, an understanding is gradually emerging that the 4-MNO market model is not suitable to meet the 5G challenge.

5G investment is wastefully duplicated if undertaken by too many networks, some too small to take advantage of the available economies of scale. 5G requires heavy investment in capacity and coverage, and that is most efficiently provided by having fewer, stronger networks.

One of the key benefits of competition is that it concentrates production in the most efficient firms (i.e. those with lower costs and better quality). In the presence of scale economies, competition drives out weaker players and puts fewer, stronger operators in their place.

Today, a merged MNO can expand capacity and provide better coverage and quality of service at lower incremental cost than two MNOs can achieve on their own. In addition, having greater scale unlocks the economic case for 5G investment in rural areas, in Home Broadband and in ‘full-fledged’ 5G.

A policy that opposes this process in the name of “competition” fundamentally misunderstands the nature of the competitive process. Competition does not perpetuate inefficient market structures or wasteful duplication of infrastructure when scale economies arise. Indeed, competition is the driving force behind the global wave of mobile mergers.

Competition policy should prohibit mergers that reduce output and raise prices, not those that expand capacity and output, improve quality, and lower prices. Opposing consolidation today does not benefit consumers – it only impedes the UK’s digital ambitions by making it more costly to expand capacity, extend 5G into rural areas and deliver the full potential of 5G.

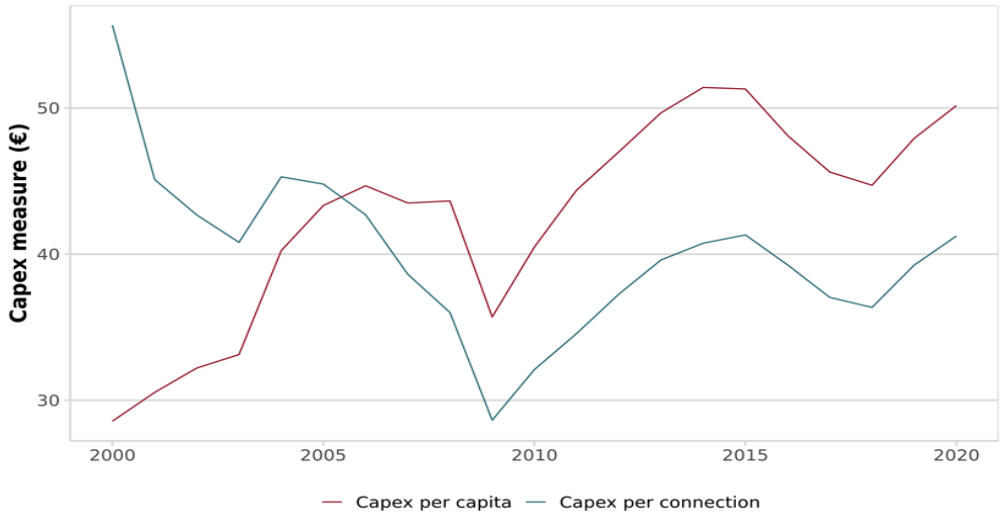
Ofcom's findings in its Dec 2020 consolidation paper cannot be relied upon due to flawed assumptions – mobile mergers of Three sister companies in Ireland and Austria have delivered large benefits for consumers

In December 2020, Ofcom published a discussion paper on mobile market consolidation, finding that investment and speeds are lower in consolidated markets. This has emphatically not been our experience in countries where our sister companies have merged.

We have commissioned Frontier Economics to review Ofcom's paper (attached as Annex A). Frontier concludes that Ofcom's results are not robust for two main reasons:

- The Ofcom study assumes that the average impact of market entry and mergers on investment is symmetrical (i.e. same impact but in opposite directions) – however, as there are more entries than mergers in the Ofcom sample, the effect estimated by Ofcom more closely reflects the impact of market entry than that of mergers.
- The report erroneously uses capex per capita as investment measure, rather than investment per subscriber – these measures diverge in the early 2000s (when mobile adoption was growing rapidly and many MNOs entered the market) and the trends only align from 2009.

Investment per capita vs investment per connection (across 30 European countries in Ofcom's sample)



Source: Frontier Economics (Annex A)

Owing to these two assumptions, Ofcom's finding of a positive relationship between the number of MNOs and investment per capita simply reflects that, during the early 2000s, investment per capita was rising with increased mobile adoption, and there was also a wave of market entry by new MNOs. Once the correct measure of investment (investment per subscriber) is used, Ofcom's results disappear.

Frontier further concludes that statistical models find it challenging to reliably assess the impact of mobile mergers, even when the correct modelling assumptions are made since:

- There have been too few mergers in Europe to make reliable statistical inferences.
- Statistical analyses cannot systematically control for all factors that impact merger outcomes – which materialise differently, over different time periods, following each merger.

Given these limitations, Frontier has complemented its econometric analysis with case studies of mergers involving Three's sister companies in Austria and Ireland. Frontier finds that both mergers have delivered large consumer benefits:

- Our sister companies now boast best-of-class networks and market leading 5G coverage following large-scale investment post-merger. In Ireland, Ookla has named Three the fastest overall mobile network and fastest 5G network in 2021. In Austria, Ookla has also named Three the fastest 5G operator in 2021.
- In Austria, network integration was completed quickly – Three was able to overtake market leaders on 4G coverage and download speeds in a short space of time. Three provided market leading speeds within 18 months, and its 4G coverage went from 25% to 98% within 3 years. Both A1 Telekom and Magenta Telekom improved their average download speeds to keep up with Three.
- In Ireland, network consolidation only completed in 2019 (due to the need to unwind network sharing agreements) – since then, Three's speeds have increased dramatically and Three has become the speed and 5G coverage leader in the Irish market.

As discussed above, the EC study of mobile prices in Europe in 2020 counts both Ireland and Austria among the cheapest countries in Europe, with Three being the lowest cost provider in both countries. Austrian consumers are enjoying intense price competition and low tariffs. In

Ireland, other MNOs have started to compete on price (via low-cost sub-brands) after Three achieved network parity.

These results highlight the quality, price and capacity benefits from mergers which become apparent once effects which cannot be easily modelled or only appear over time are accounted for (such as pre-existing network sharing agreements or the time needed to integrate two networks). Therefore, we welcome Ofcom's intention to assess any future mergers on a case-by-case basis.

The mobile value chain has evolved, so future mobile policy should no longer focus on promoting competition between national MNOs

There is one final reason why the aim of promoting network competition between four national MNOs is no longer appropriate for the UK – namely, that the historic focus of regulation on the figure of the national MNO is increasingly inappropriate.

We welcome Ofcom's acknowledgment that, increasingly, mobile networks are just part of the range of different wireless technologies people use. As Ofcom has found, 5G creates an opportunity for an expansion of the market. New types of firms – with innovative business models – are expected to provide mobile networks and sell mobile services to UK consumers.

For these reasons, the type of competition that now matters in mobile is not between MNOs, but competition from the new technology, the new business model, the new service, the new source of supply, and the new type of organization.

Market entry by new players threatens the viability of the national MNO model and its role in the value chain, [✂]

- At the wholesale level, the emergence of new RAN players – i.e. Towercos, Big Tech, neutral hosts, and private 5G network providers providing mobile networks (locally or nationally) in competition with MNOs.

- At the retail level, key changes in the way mobile services are purchased – with potential for increased take-up of fixed-mobile bundles reducing the market for mobile-only players and the risk of disintermediation of the MNO role by Big Tech (facilitated by eSIM).

In consequence, the historic focus of mobile regulation on the MNO is no longer appropriate. Mobile policy should aim to promote innovation and

investment by all market players, not network competition between four national MNOs.

Conclusion: consolidation of the UK mobile market is in the public interest and would result in a more competitive and dynamic marketplace

As recently as March 2020, Ofcom stated that UK consumers benefit from the existence of (at least) four credible MNOs. We are pleased to see Ofcom clarify in the consultation that it is the effectiveness of competition – not just the number of MNOs – that matters.

We strongly believe that a new policy for mobile is needed to deliver the UK's 5G ambitions. The UK needs fewer players with enough scale to be able to invest in strong networks.

The '4-MNO' policy has delivered poor-quality networks in the UK. Some 3-MNO markets have the best networks in Europe, are leading 5G and are delivering low prices too. Traffic growth and 5G investment needs make the UK's 4-MNO model unsustainable.

In any event, market entry by new players means that future mobile policy should focus not on the specific number of MNOs, but rather on the strength of competition and the ability of all players – MNOs and others – to invest and innovate for the benefit of UK consumers.

We conclude that consolidation of the UK mobile market is in the public interest and would result in a more competitive and dynamic marketplace. The 5G rollout is a chance for the UK to become a global leader in 5G, ensure no area of the UK is left behind, and boost competition in Home Broadband.

Moving from four to three MNOs would enable better, smarter sustainable investment in the UK's mobile networks, free up capital for 5G and unleash greater competition, acting as a spur to innovation and growth.

Executive Director and Group Co-Managing Director of CK Hutchison Holdings Limited Mr. Canning Fok said that mergers "*give the combined business the scale and strength to offer consumers and businesses a state-of-the-art network with greater capacity, better coverage and higher speeds*".

Contents.

1. Introduction: origin and rationale of Ofcom's policy of promoting network competition between four MNOs

This section sets out a brief history of mobile regulation in the UK, focusing on the origin and rationale for Ofcom's policy of promoting network competition between a minimum number of MNOs. The desired number of MNOs has fluctuated over time, but the aim of promoting end-to end-competition between rival networks has remained to this date.

As recently as March 2020, Ofcom stated that UK consumers will benefit from the existence of four credible MNOs in the UK mobile market. We welcome Ofcom's clarification in the consultation that it is the effectiveness of competition in the market – not just the number of MNOs – that matters.

The UK has aimed to promote end-to end-competition between multiple rival networks

Ofcom has previously described the history of mobile telecoms in the UK as a long-running case study into how many competitors are needed to make end-to-end competition effective.[1]

Oftel, the Radiocommunications Agency ('RA') and Ofcom have all relied on end-to end-competition between multiple rival networks to deliver good outcomes for UK consumers. Unlike the fixed sector, the mobile sector did not start with an incumbent operator with a large cost and reach advantage in the access network that could not be profitably replicated in much of the country.

Competition between national mobile RANs has been possible to a much greater extent than in fixed telecoms – where the traditional policy has given regulated wholesale access to BT's bottleneck assets to rival operators. The UK has an active wholesale services market where MNOs supply network access to MVNOs based on commercial (rather than regulated) terms.

The UK was one of the first countries in the world to license four MNOs. The first two cellular licences were granted in 1985 to Vodafone and Cellnet (later O2), which launched 2G services in the early 1990s. From 1994 UK consumers had a choice of four MNOs after Orange and One2One (later, T-Mobile) launched 2G on the back of two licences allocated to them in 1991.

[1] Consultation (ofcom.org.uk)

In 2000, the RA reserved a fifth 3G licence for a new entrant in the 3G auction (eventually won by Three). A market assessment by Oftel had concluded that the mobile market was not yet fully competitive. Government, Oftel and the RA wanted entry by a fifth MNO that would deploy 3G rapidly and incentivise the incumbents to do the same.

In its 2009 Mobile Sector Assessment, Ofcom embraced Oftel's policy, noting that a market structure with five national MNOs had created one of the most competitive mobile markets in Europe. Ofcom stated that the *"multiplicity of competing national RANs determines our approach to mobile regulation more than any other feature of the market*".

The Orange/T-Mobile merger which created EE in 2010 reduced the number of MNOs back down to four. In preparation for the 2013 4G auction, Ofcom took the view that UK consumers would benefit from having at least four credible MNOs, reserving spectrum for a fourth MNO to avoid consolidation. Three obtained this reserved spectrum.[2]

Ofcom reiterated this policy in the 2016 Digital Communications Review,[3] stating that UK consumers are likely to enjoy better services at lower prices "*if there are a minimum number of effective competitors*". That year Ofcom opposed Three's planned acquisition of O2 in the UK on the basis that the merger would leave the UK with only three national networks competing independently on coverage and quality.[4]

As recently as March 2020, Ofcom stated that UK consumers benefit from the existence of four credible MNOs:

"We continue to believe it is in consumers' interests for there to be at least four credible MNOs. The existence of four credible MNOs supports retail competition directly because MNOs are major competitors in supplying retail mobile services to consumers. It also supports retail competition indirectly because the MNOs compete to provide wholesale access to MVNOs".[5]

The MNO has been the focus of the policy by virtue of its control of the Radio Access Network (RAN) and spectrum

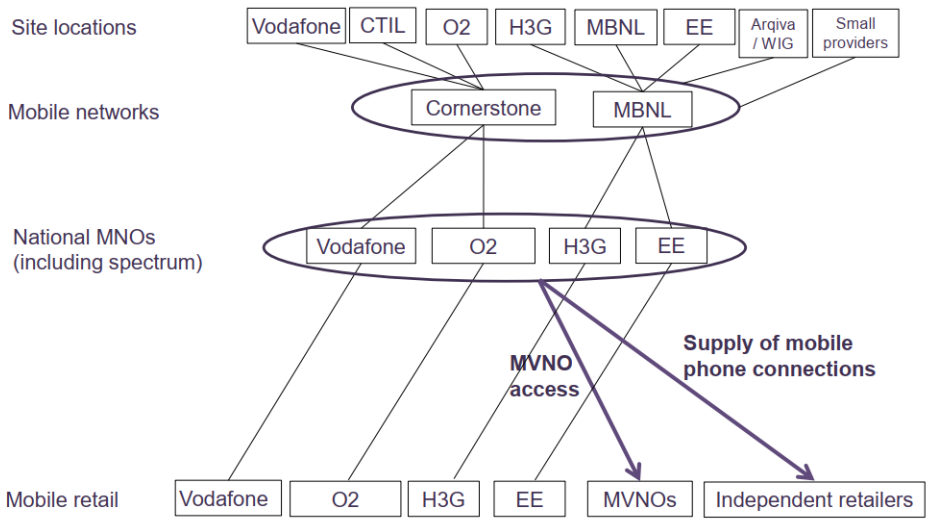
The MNO has been the focus of mobile regulation in the UK. The original justification for this policy was that the MNO plays a central position in the

[2] statement.pdf (ofcom.org.uk)
[3] Consultation (ofcom.org.uk)
[4] Ofcom comment on the proposed merger of Three and O2 - Ofcom
[5] Statement: Award of the 700 MHz and 3.6-3.8 GHz spectrum bands (ofcom.org.uk)

mobile value chain by virtue of its control of the RAN (the national network of sites and base stations needed to provide mobile connectivity across the UK) and radio spectrum licences.[6]

In multiple consultations, Ofcom has illustrated the mobile value chain (and the central role of the MNO within it) as follows.

Figure 1: Vertical structure of the UK mobile industry



Source: Ofcom

The vertical structure of the value chain is depicted as a series of linked activities starting with MNOs' sites locations, the operation of mobile networks (managed by two network sharing ventures, MBNL and Cornerstone), national MNOs who own spectrum and supply wholesale services downstream (including to its own retail operations), and finally the retail level where MNOs, MVNO and independent retailers sell mobile services to consumers and businesses.

When it originally formulated its policy, Ofcom believed that *"MNOs retain most value in the value chain … it is clear that the centre of gravity of the mobile value chain remains firmly with MNOs"*.[7] Ofcom estimated that MNOs retained the largest share (42%) of revenue across all parts of the value chain.

[6] Consultation (ofcom.org.uk), Section 5.
[7] MSA (ofcom.org.uk), para 3.74. See also Consultation (ofcom.org.uk), para 5.32

Table 1: Ofcom's estimate of value retained by players in the UK obile value chain (2000-2005)

Value chain element	Description	Share of value (2000-2005)
Network equipment vendors	Providers of radio and core networks and IT	7.6%
Towers/ transmission/ backhaul	Tower, transmission and backhaul providers, including cell site (e.g. WIG) and service providers (e.g. BT)	2.5%
MNO function	Holders of spectrum licences and RAN	42%
Retail function	Service provision by MNOs & MVNOs	17.5%
Device vendors	Nokia, Apple, etc	14.6%
Content providers	Content owners and aggregators	1.2%
Distributors	Customer-facing distribution function, including direct and online sales channels of MNOs, MVNOs and independent retailers	13.5%

Source: Ofcom

Ofcom said that the MNOs' share of value had been stable over a long period and that MNOs held *"considerable power relative to their suppliers and customers"*. Ofcom found it unlikely that other players in the value chain could "*attain a level of influence on the market comparable to that of an MNO*".

Ofcom's policy has sought to maintain network competition between a minimum number of MNOs for the following reasons:

- The need to purchase spectrum and incur significant fixed and sunk costs in building a national RAN create high barriers to entry – which limit the number of players that the market will sustain.

- Competition at the RAN level supports retail competition between MNOs directly – as MNOs are vertically integrated and supply retail mobile services to consumers through their retail operations.

- Competition at the RAN also supports retail competition indirectly – it is a prerequisite for MVNOs to obtain wholesale access commercially, as MVNOs and other operators need wholesale access to national RANs on terms that allow them to compete.

- Through their control of the RAN, only MNOs can make the mobile signal faster, more reliable and widely available – particularly in relation to speeds (i.e. throughput in Mbps); capacity (i.e. the number of users a network can support); breadth of coverage (i.e. the proportion of the country covered); and depth of coverage (i.e. coverage deep into buildings and in rural areas).

The policy of maintaining competition between four MNOs is neither optimal nor sustainable in the UK

Press reports greeted publication of Ofcom's consultation on future mobile markets as 'opening the doors' to mobile consolidation in the UK. Ofcom states that:

"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".[8]

We welcome Ofcom's clarification that it has no fixed position on mobile consolidation, and that what matter is the effectiveness of competition (rather than just the number of MNOs).

We are strongly of the view that the goal of maintaining competition between four national networks is no longer suited to the evolving needs of the UK market for four main reasons:

- The model has delivered some good outcomes – particularly low prices – but also low returns and poor-quality networks by European standards. As society becomes increasingly reliant on telecoms networks, quality and investment should move up the policy agenda We discuss this in **Section 2**.

[8] Consultation, page 4.

- The UK has too many national networks for the size of the market – [✂] due to new economies of scale from capacity. MNOs are adapting to the new market reality by consolidating in the US, Australia and many European markets. The UK should consolidate too. This is the main topic of **Section 3**.

- Mergers involving Three's sister companies in Austria and Ireland have unambiguously delivered large consumer benefits – we highlight the limitations of econometric studies that pay no attention to market dynamics and ignore consumer benefits that only arise in time. We discuss this in **Section 4**.

- It is no longer appropriate for mobile regulation to focus exclusively on the figure of the MNO – the MNO is no longer the key player in the value chain. New players (Big Tech, equipment vendors, neutral hosts, private network providers) are entering to provide mobile networks and sell mobile services to UK consumers. This is discussed in **Section 5.**

2. The UK's '4-MNO' policy has delivered poor-quality networks and low returns on investment

The UK mobile market has included four national MNOs since the Orange / T-Mobile merger in 2010. It is time to take stock and assess what this model has delivered, and where it has fallen short.

Government and Ofcom want the UK to be a global 5G leader with world-class 5G infrastructure. To assess how the UK is performing in an international context, we have systematically ranked consumer outcomes in the UK and other European countries using official data from the EC, the UK's Competition and Markets Authority (CMA) and independent network quality studies.

In summary, we do not think the UK can achieve its 5G goals while it continues to compete with a 4-MNO structure. Our key findings are:

- **Industry investment** in the UK is spread thinly across too many networks.
- The UK has poor **quality** networks by European standards – 3-MNO markets in Switzerland, Netherlands, Austria, Germany, and the Czech Republic have the best networks in Europe.
- The UK has average levels of **coverage** in Europe – 3-MNO markets in Switzerland, Netherlands, Austria, Germany are rolling out 5G more quickly and extensively than the UK (including in rural areas).
- Mobile networks in the UK are particularly impacted by **congestion** – with London one of the most affected capitals in Europe.
- While UK mobile **prices** sit in the lower to middle range in Europe, many three-MNO markets (including Ireland, Germany, and Austria, all of which have consolidated) have some of the cheapest prices in Europe.
- UK consumers have lower levels of **satisfaction** with mobile than consumers in other European countries.
- The 4-MNO model has delivered low **returns on investment** in the UK – Ofcom should not assume that MNOs will continue to invest.

Industry investment in the UK is spread thinly across too many networks

Ofcom reports significant investment in UK mobile: £3bn in 2020. Three's capex was roughly half that of its peers leading up to 2020, but we nearly doubled our investment in 2020 [✂].

Table 2: UK mobile capex 2015-2020

Annual mobile capex (£m)						
MNO	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
BT/EE	554	680	710	613	557	681
O2	640	767	724	777	801	792
Vodafone	890	800	784	710	657	733
Three	358	352	459	462	426	764
Industry	**2,442**	**2,599**	**2,677**	**2,562**	**2,441**	**2,969**
Annual mobile capex per subscriber (£ per sub)						
MNO	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
BT/EE	22.9	28.3	30.2	27.2	24.9	30.1
O2	28.3	34.5	33.4	36.2	38.7	38.6
Vodafone	48.4	44.6	44.5	41.3	36.4	42.3
Three	39.9	38.3	45.6	46.1	41.4	78.7
Industry	**32.9**	**35.4**	**36.8**	**36.0**	**34.2**	**42.3**
UK mobile capex / mobile revenues (%)						
MNO	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
BT/EE	8.8%	10.6%	10.6%	8.6%	7.7%	9.8%
O2	11.3%	13.7%	12.6%	12.9%	12.9%	13.3%
Vodafone	14.6%	13.8%	12.6%	11.8%	11.6%	13.4%
Three	16.3%	15.5%	18.9%	18.9%	17.9%	32.4%
Industry	**12.0%**	**12.9%**	**12.7%**	**11.9%**	**11.3%**	**14.3%**

Source: Enders Analysis

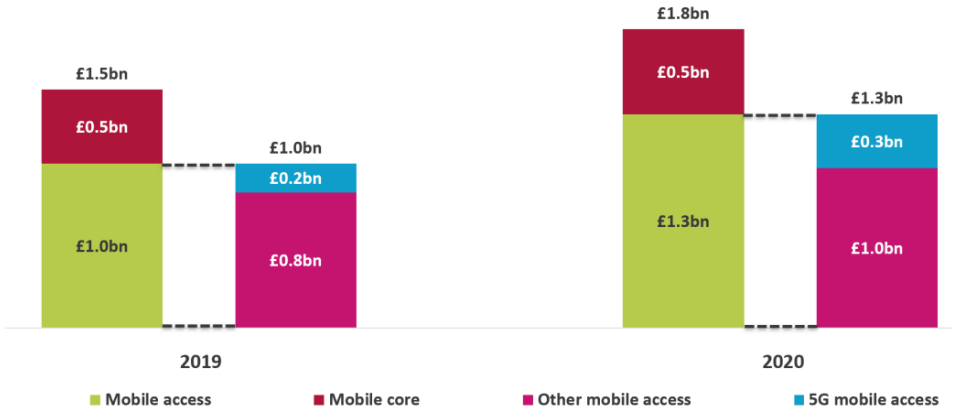
On a per subscriber basis, the industry invested c£35 between 2015 and 2019 (increasing to £42 in 2020). As a percentage of mobile revenues,

industry capex fluctuated between 11% and 13% of revenues over that period (14% in 2020).

However, these capex figures cover a wide range of investments, including network capex (in the RAN, core network, and backhaul) and non-network investment (IT systems, retail estate and customer capex). The figures also include an element of fixed network capex. This makes international comparisons difficult, as many European MNOs are converged and do not separately report fixed and mobile capex.

Ofcom's 2021 Connected Nations report breaks down these capex figures. Of the £3bn industry capex in 2020, £1.8bn was invested in the network. Of that, £1.3bn was spent in the RAN (site acquisition, equipment, and electronics). Only 11% of the total £3bn (£330m) relates specifically to the 5G RAN.[9] In 2019 only £175m of the total £2.5bn investment was in the 5G RAN.

Figure 2: UK MNOs invested £1.3bn in the RAN in 2020 (£330m specifically in the 5G RAN)



Source: Ofcom Connected Nations report 2021

The other network capex (£0.5bn) relates to the mobile core and backhaul. An additional £0.6bn was spent in infrastructure used to provide both fixed and mobile (we presume the rest was non-network capex). Some of this network investment will have been spent in removing Huawei equipment from the UK's 5G networks.

[9] Connected Nations 2021: UK report (ofcom.org.uk), page 47.

We discuss below that this level of investment has not delivered good quality outcomes for UK consumers. This suggests that UK investment is thinly spread across too many networks.

The UK has poor quality networks by European standards – 3-MNO markets in Switzerland, Netherlands, Austria, Germany, and the Czech Republic have the best mobile networks in Europe

Multiple studies of network quality in Europe reveal a worrying gap between the UK's ambition to be a global 5G leader and the reality on the ground:

- The UK appears at or towards the bottom of the list of countries in many of these studies.

- At the other end, 3-MNO markets in Europe generally have better quality networks – networks in Switzerland, Netherlands, Austria, Germany, and the Czech Republic consistently top the charts in most of these studies.

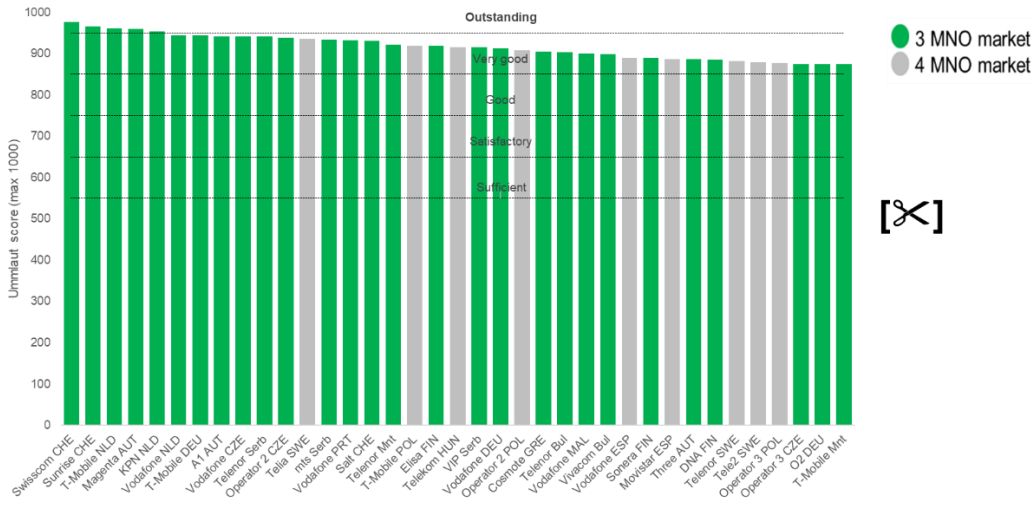
Ofcom seems to discount network quality studies on the basis that reliable international comparisons are difficult and often focus on speeds. We do not think these concerns are warranted – the studies discussed below measure a comprehensive range of quality metrics that affect the customer experience – beyond speeds – and the results are too consistent across all studies and metrics to be coincidental.[10]

For instance, UK mobile networks receive some of the lowest grades in Umlaut's Dec 2021 testing of 66 European networks.[11] [✂]

The top ten European networks all come from 3-MNO markets. Switzerland (Swisscom and Sunrise), Netherlands (T-Mobile, KPN and Vodafone), Austria (Magenta and A1), Germany (T-Mobile), the Czech Republic (Vodafone), and Serbia (Telenor) have the best networks in Europe according to Umlaut.

[10] The studies also measure latency, reliability, coverage, availability, packet loss and the quality of the overall service (voice, video, web browsing, file downloading, gaming, etc)
[11] Umlaut: The international score comparison 2021. Umlaut's testing includes other international networks as well.

Figure 3: UK networks receive some of the lowest quality scores in Europe. 3-MNO markets in Switzerland, Netherlands, Austria, Germany, and Czech Republic lead the charts.



Source: Umlaut's 'Benchmarking. The international score comparison 2021' report

Two other studies by Connect (2020) and Tutela (2021) give similar results.[12] The UK ranks 18th (in the Connect study) and 21st (in the Tutela study) out of 26 European countries assessed in both studies.

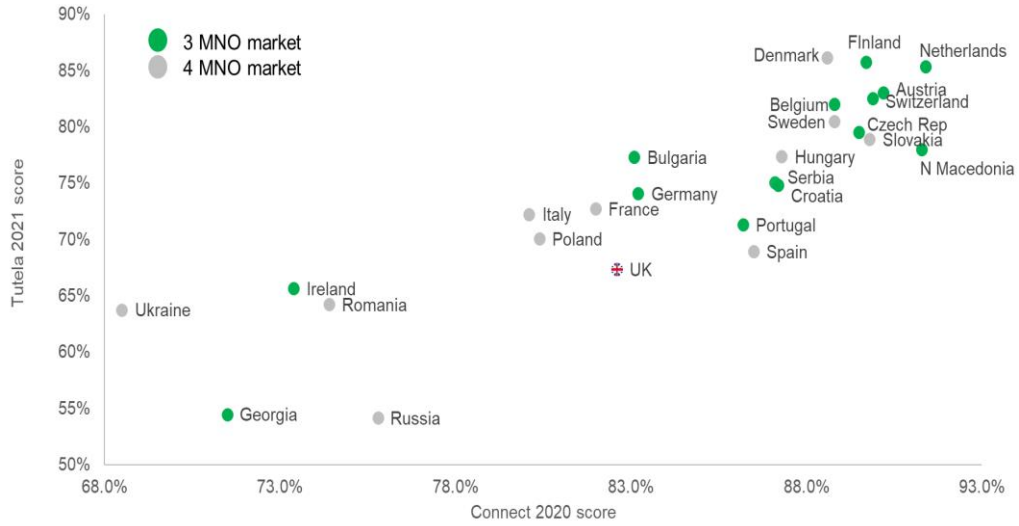
The results at the top end are consistent with Umlaut's – 3-MNO markets (in green) tend to have better networks. The Netherlands, Austria, Switzerland, and the Czech Republic (Finland too) feature some of the best European networks in both studies, although Germany appears behind in these studies.

Sweden and Denmark, two of the few 4-MNO markets to achieve good grades in these studies, are really 3-MNO markets as there are only three networks in those countries (due to network and spectrum sharing agreements).[13]

[12] The studies assess mobile quality across European countries based on crowdsourcing tests, tracking multiple KPIs (such as latency, coverage, download speed, upload speed and packet loss). Tutela 'Global State of the Mobile Experience (2021 Annual report)'. Connect 'Mobile phone comparison: European countries in direct comparison (May 2020)'. Tutela uses its "Excellent Consistent Quality" KPI which measures how often connections are good enough for demanding applications (HD video streaming, HD group video calling, etc) based on 2.3 billion speed and latency tests conducted on user smartphones between August 2020 and August 2021. Connect evaluated 94 MNOs from 28 European countries based on crowdsourcing tests collated between Oct 2019 and March 2020.

[13] Due to MOCN agreements (active sharing plus spectrum), Sweden has three 3G networks: Telia and Tele 2 have national 3G MOCN sharing (SUNAB). Three and Telenor have 3G MOCN outside major cities (3GIS) and separate 3G networks elsewhere. Sweden has three 4G networks (Tele 2 and Telenor set up Net 4

Figure 4: The UK ranks 18th and 21st of 26 European countries on quality. 3-MNO markets lead quality in Europe



Source: Tutela 'Global State of the Mobile Experience (2021 Annual report)'. Connect 'European countries in direct comparison (May 2020)'

The UK also compares poorly against European neighbours on quality metrics assessed by OpenSignal and Tutela.[14] UK speeds sit at the bottom end of the range of European countries in both studies: 19th out of 22 EU countries in the OpenSignal study and 26th out of 28 EU countries in the Tutela study.

The UK achieves similarly low scores on broader metrics (such as Video experience, Excellent Consistent Quality and Core Consistent Quality) that impact the quality of the video, voice, and gaming experience.

Table 3: Network quality studies in UK and EU

	Download speeds (Mbps)	Upload speeds (Mbps)	Mobile video	4G availability (% of time)	Median download speeds (Mbps)	Excellent consistent quality (% of tests)	Core consistent quality (% of tests)
UK	22.9	7.5	71.7%	89.2%	15.7	74.9%	93.6%
UK rank	19 / 22	19 / 22	16 / 22	13 / 22	26 / 28	21 / 28	18 / 28

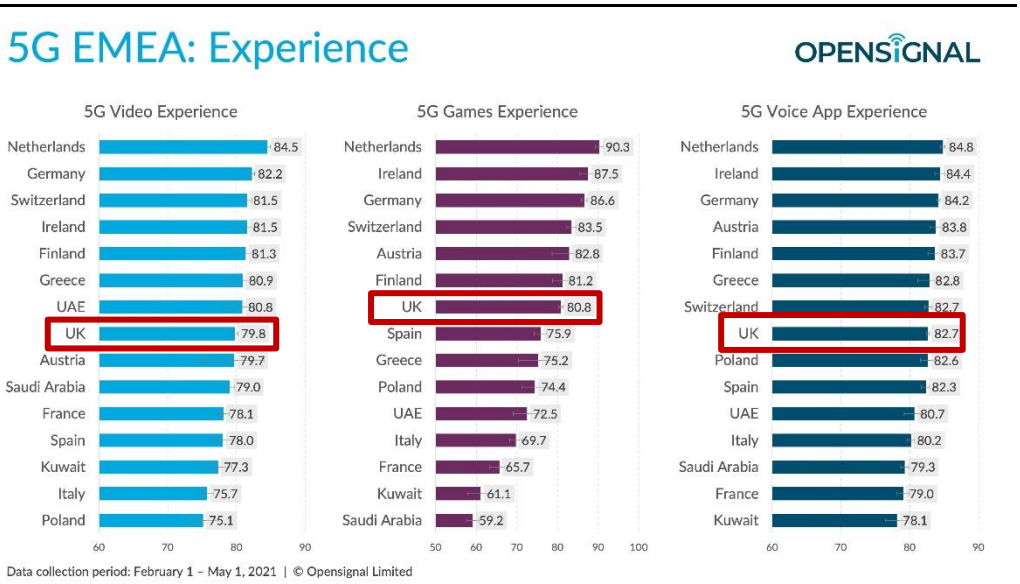
Mobility, a national MOCN joint venture which also covers 2G and has been extended to 5G). In Denmark, Telia and Telenor have a national MOCN sharing agreement across technologies.

[14] Opensignal State of Mobile Experience (May 2020), Tutela Global Mobile Experience (Sep 2020).

Source: OpenSignal State of Mobile Experience (May 2020), Tutela Global Mobile Experience (Sep 2020).

The UK fares only slightly better when it comes to 5G, ranking 7th and 8th amongst 12 European countries on the quality of the 5G experience in a 2021 study by OpenSignal. The same 3-MNO markets lead 5G experience in Europe – Netherlands, Germany, Switzerland, Austria and Finland – to which OpenSignal adds Ireland and Greece.

Figure 5: 3-MNO markets in Netherlands, Germany, Switzerland, and Austria (also Ireland) lead 5G experience in Europe



Source: OpenSignal: Benchmarking the 5G Experience – EMEA – June 2021

Similarly, London ranks 26th (out of 45 world capitals) in Ookla's recent study of world capitals with the best 5G speeds, based on locations with commercially available 5G during Q1-Q2 2021. The Ookla study sees median 5G download speeds of 167.50 Mbps in London, far behind the world's leading 5G cities. Oslo leads the race for fastest 5G performance with a median download speed of 526.74 Mbps.[15]

The results of these international studies are too consistent to be coincidental. One study after another, the same 3-MNO countries appear at (or towards) the top, with the UK faring comparatively poorly in Europe. We explore the reasons in Section 3.

[15] Oslo Tops the List of World Capitals with the Fastest 5G in Q1-Q2 2021 (speedtest.net)

The UK has average levels of 4G coverage in Europe – 3-MNO markets in Switzerland, Netherlands, Austria, and Germany are rolling out 5G faster than the UK (including in rural areas)

The consultation discusses that UK consumers enjoy widespread 4G coverage, with each MNO covering more than 99% of urban premises outside. Ofcom estimates 5G to be available from at least one MNO outside 42% to 57% of UK premises, but it does not attempt an international comparison of coverage metrics.

For an international comparison of coverage, we have relied on the EC's study 'Broadband Coverage in Europe 2020: Mapping progress towards the coverage objectives of the Digital Agenda'.[16] This study tracks three measures of coverage in the EU-27, UK, Norway, Iceland and Switzerland:

- **Overall 4G coverage** – 4G coverage by at least one MNO (taking into account overlapping network coverage of different MNOs).
- **Average 4G coverage** – across all MNOs in the country, which reflects the actual user experience more closely (as users only connect to one 4G network at a time).
- **5G coverage** – there are no official statistics yet, so the EC estimates this metric based on public information.

The EC study shows that 4G coverage is now ubiquitous in Europe, with 99% to 100% of households covered by at least one MNO in every country (overall 4G coverage), and average LTE coverage lower than 90% only in two countries (Bulgaria and Slovakia).

With 99.93% and 99.3%, the UK ranks 13th and 14th (out of 31 European countries) on these 4G coverage metrics respectively, but 4G coverage differences across countries are too small to be meaningful.

As regards 5G coverage, the EC study finds that (as of June 2020) the same 3-MNO markets that lead network quality in Europe also have the highest 5G coverage levels (overall and rural):

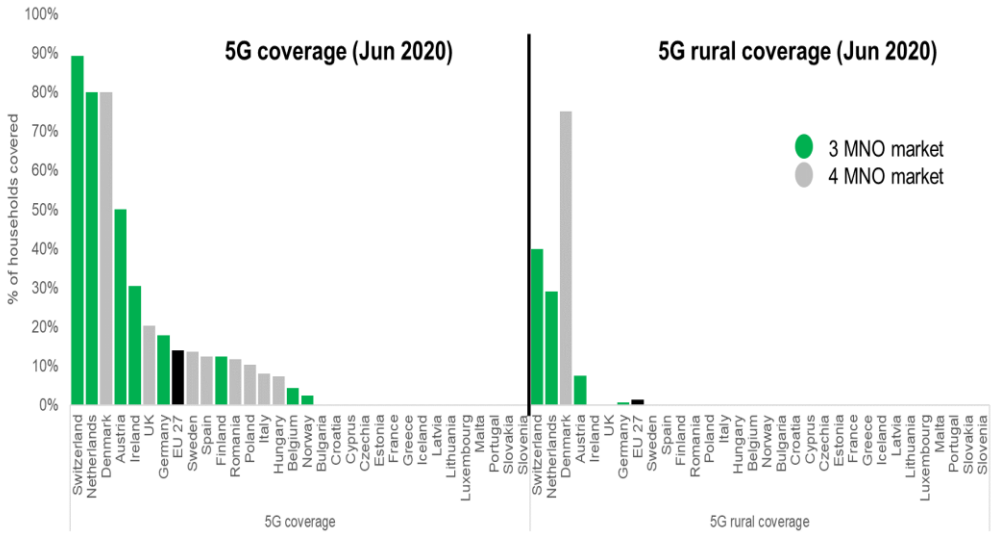
- **5G coverage overall** – Switzerland (89.2% of homes passed by 5G networks), Netherlands (80%), Austria (50%) and Ireland (30%) led 5G coverage in Europe at the time of the study. The only 4-MNO market to make it to the top five is Denmark (with 80.0% of

[16] DESI - Connectivity | Shaping Europe's digital future (europa.eu)

households covered) – which as discussed above is really a 3-MNO market. The UK ranks 6th with 20.4% 5G household coverage.

- **5G rural coverage** – the EC estimates that only 1.5% of rural EU households were covered by 5G networks by June 2020. 5G was available in rural areas in only five countries, including the usual 3-MNO markets (Switzerland, Netherlands, Austria, and Germany) and also a 4-MNO market (Denmark) which is really a 3-MNO country.

Figure 6: Switzerland, Netherlands, Denmark, Austria and Ireland led 5G coverage in Europe in June 2020

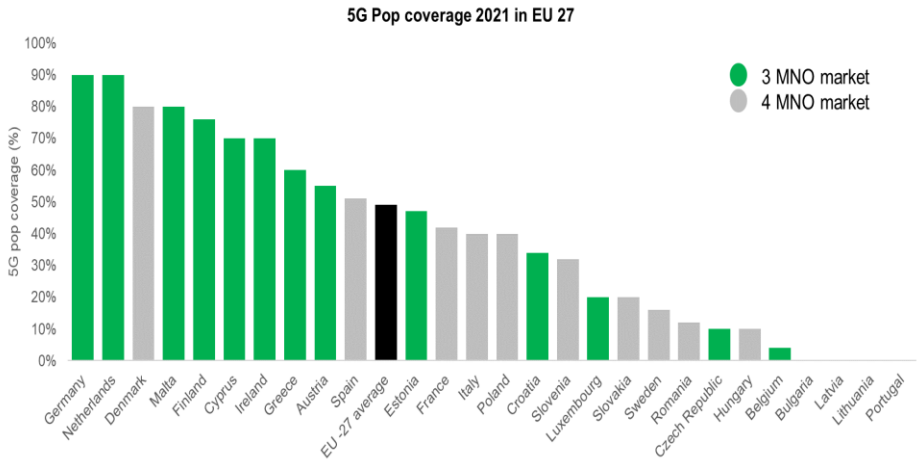


Source: European Commission: 'Broadband Coverage in Europe 2020. Mapping progress towards the coverage objectives of the Digital Agenda'

For a more recent study (which excludes the UK and Switzerland), the EC 5G Observatory reports that, as of January 2022, commercial 5G was available in all 27 EU Member States.[17] The EC estimates 5G population coverage in the EU-27 at the end of 2021 based on public announcements. Once again 3-MNO markets top the 5G coverage charts, with Germany and the Netherlands at the top.

[17] 5G-Obs-PhaseIII_Quarterly-report-14_FINAL-Clean-for-publication_16022022.pdf (5gobservatory.eu)

Figure 7: 3-MNO markets in Europe have higher 5G coverage



Source: European Commission 5G Observatory: Quarterly Report 14 Up to January 2022

We discuss in Section 3 that, with 5G rollouts now fully underway, the UK has 10k people per 5G base station, placing it 22nd out of 32 countries (including also the EU-27, South Korea, China, Japan and the US) according to data from the EC's 5G observatory. European countries with the least number of people per 5G site include Germany, Finland, Denmark, and the Netherlands (in addition to Malta and Cyprus), tracking closely 5G coverage metrics in Europe.

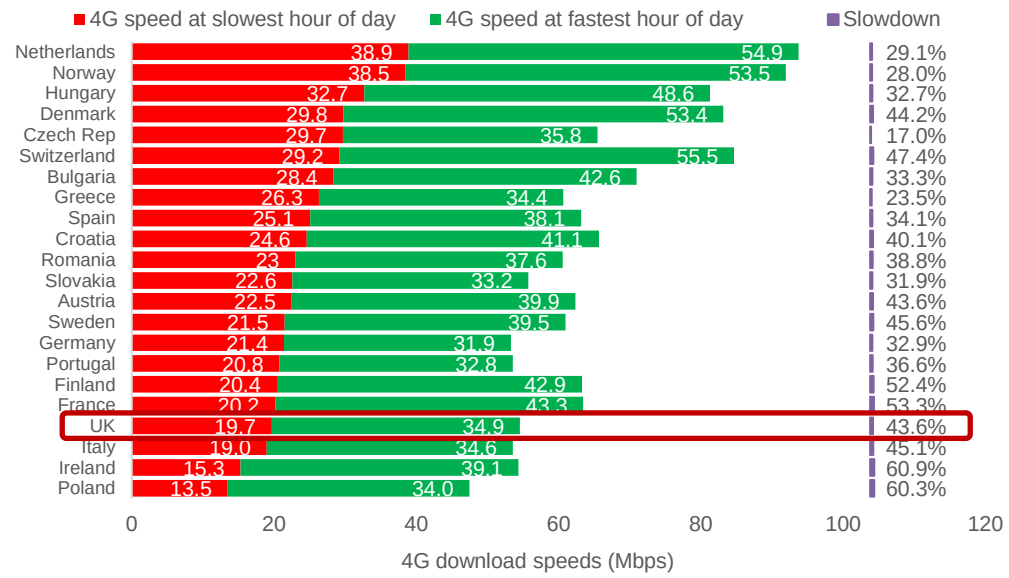
UK mobile networks are impacted by congestion, with London particularly affected across European capitals

A study by OpenSignal assesses congestion levels in 4G networks in 77 countries, including 22 European countries.[18] The study compares average 4G download speeds in the quietest and peak hours of the day in each country.

OpenSignal finds that the UK is particularly impacted by congestion amongst European countries. Most European countries are able to maintain a minimum level of service during peak hours, in terms of 4G download speeds averaging at least 20Mbps during busy times. The UK is one of four exceptions.

[18] See Countries Ranked by 4G Download Speed at Different Times of Day - ISPreview UK. The study is available here the_5g_opportunity_report_february_2019_0_0.pdf (opensignal.com)

Figure 8: UK 4G networks are being impacted by congestion.



Source: OpenSignal 'The 5G opportunity. How 5G will solve the congestion problem of today's 4G networks' (Feb 2019)

The Netherlands, Denmark, the Czech Republic and Switzerland (in addition to Norway and Hungary in this study) provide the best 4G speeds during peak hours.

The Czech Republic, Greece, Norway, and the Netherlands have the most consistent speeds in Europe throughout the day, with 4G speeds slowing down by less than 30% during peak hours. Consumers in these countries are less impacted by service degradation during the peak. The UK ranks 10th in terms of fluctuation in speeds, with download speeds slowing down by 44% in the peak hour.

OpenSignal analyses how major cities stack up in both average 4G download speeds and speed fluctuations during the day. The study reports 'wild swings' in 4G speeds across all European capitals, with London being particularly impacted (ranging from 17.5Mbps to 38.3Mbps). The only European city in the OpenSignal sample with more extreme speed fluctuations is Paris.

UK mobile prices sit in the lower to middle range in Europe – consolidated markets in Austria, Ireland and Germany are amongst the cheapest in Europe

One of the key benefits of the current market model has undoubtedly been good value for money. UK consumers have historically enjoyed very competitive pricing in comparison with other European countries.

In the consultation, Ofcom compares mobile prices in 2020 in the UK and five other countries (France, Germany, Italy, Spain, and the US). Ofcom concludes that the UK was the cheapest country across all connections analysed.

The EC's report 'Mobile and Fixed broadband prices in Europe 2020' allows a more comprehensive comparison across thirty European countries (the EU-27, the UK, Iceland, and Norway). This assesses the lowest-cost tariff available to residential customers that meets the requirements of 12 basket allowances in each country.[19]

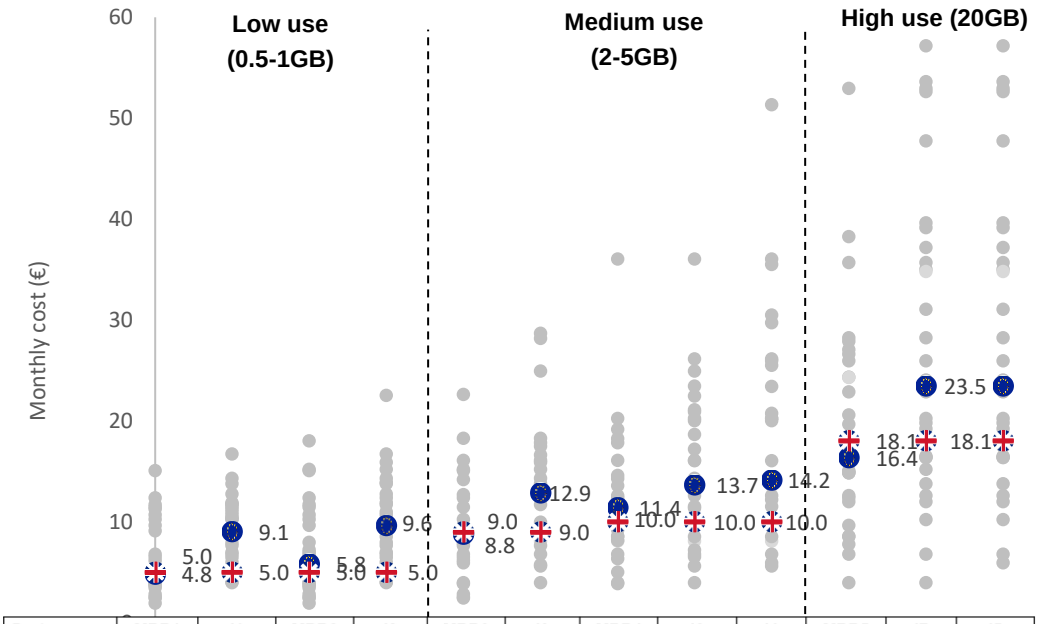
The baskets are meant to be representative of average use across all European countries, including:

- five mobile data-only baskets ('MBB' baskets for tablet / modem use); and
- seven handset-based baskets ('I baskets') with varying allowances.

Overall, UK prices generally sit in the lower to middle range of the thirty European countries assessed.

[19] 'Lowest available' refers to the lowest price a consumer could pay for a basket of services, using tariffs offered by MNOs. This assumes rational consumers who shop around to identify the best value tariff. In practice, few consumers will be on the lowest-cost tariff for their usage, but this assumption is needed for an effective international comparison. Prices are normalized (to take account of one-off fees, out of bundle charges, etc) and in Purchasing Power Parity terms (€ / PPP).

Figure 9: UK prices sit in the lower to middle range in Europe



Basket	MBB1	I1	MBB2	I2	MBB3	I3	MBB4	I6	I4	MBB5	I7	I5
Calls	-	30	-	30	-	100	-	30	300	-	100	300
Data (GB)	0.5	0.5	1	1	2	2	5	5	5	20	20	20
UK rank (of 30 countries)	17	4	14	4	16	9	13	10	9	17	11	11

Source: European Commission: 'Mobile and Fixed broadband prices in Europe at the end of 2020'

UK prices for the handset-based baskets are more competitive than for the data-only baskets:

- **Handset-based baskets (I1-I7)** – UK prices are below median European values (denoted by the EU flag in the graph) for all seven baskets. Pricing for the two low use baskets (I1 and I2) is competitive – the UK is 4th cheapest. Pricing of the five medium and high use baskets (I3-I7) is not particularly competitive – the UK ranks 9-11th cheapest.

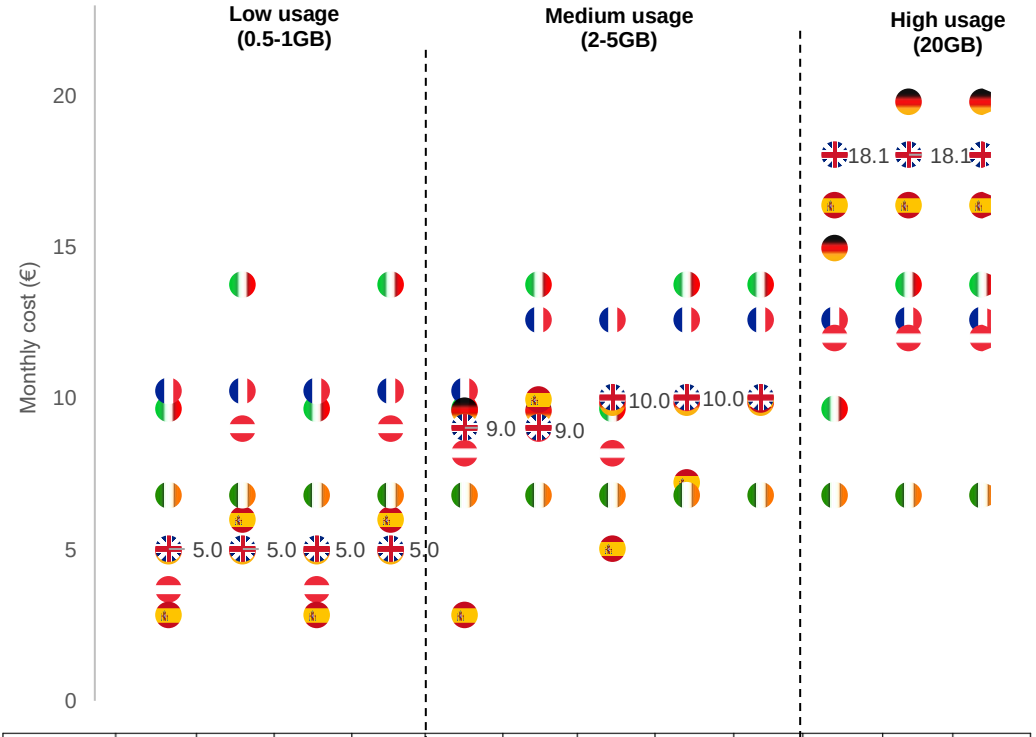
- **Data-only baskets (MBB1-MBB5)** – UK pricing is 'middle of the pack', with UK values above median EU values for three out the five baskets and the UK ranked 13th to 18th cheapest depending on the basket.

If the sample is restricted to seven European countries (Ofcom's chosen five plus Austria and Ireland, where Three's sister companies operate):

- UK prices are not cheapest for any of the twelve baskets. The UK ranks 2nd or 4th cheapest for low usage baskets, and 6th or last for the high usage ones (out of seven countries);

- Ireland and Austria (where Three's sister companies have merged) generally have more competitive pricing than the UK – they are cheaper than the UK for ten and eight of the twelve baskets respectively.

Figure 10: UK prices vs selected European countries

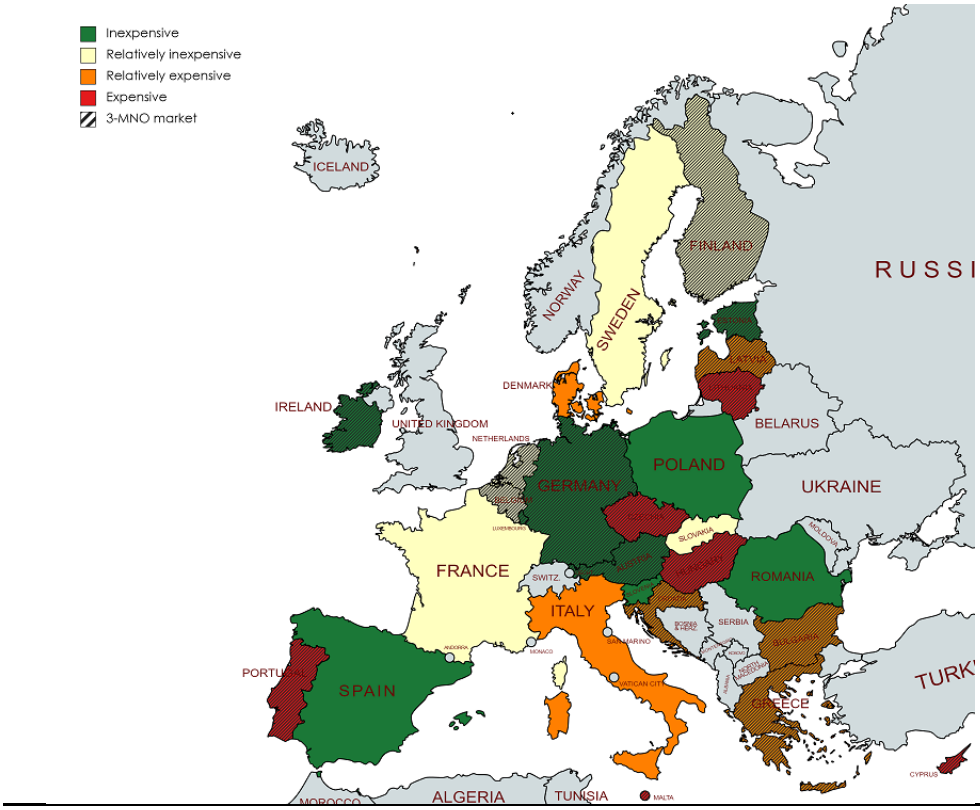


Basket	MBB1	I1	MBB2	I2	MBB3	I3	MBB4	I6	I4	MBB5	I7	I5
Calls	-	30	-	30	-	100	-	30	300	-	100	300
Data (GB)	0.5	0.5	1	1	2	2	5	5	5	20	20	20

Source: European Commission: 'Mobile and Fixed broadband prices in Europe at the end of 2020'

The EC report names nine 'inexpensive' countries in the EU-27. Five of them are three-MNO markets: Ireland, Austria, Germany (all of which have consolidated), Estonia and Luxembourg.

Figure 11: 3-MNO markets in Ireland, Austria and Germany (all of which have merged) are some of the cheapest in Europe



Source: European Commission: 'Mobile and Fixed broadband prices in Europe at the end of 2020'

According to the study Three's sister companies are the lowest cost provider in almost all European countries where it is present (the study does not include Three Sweden):

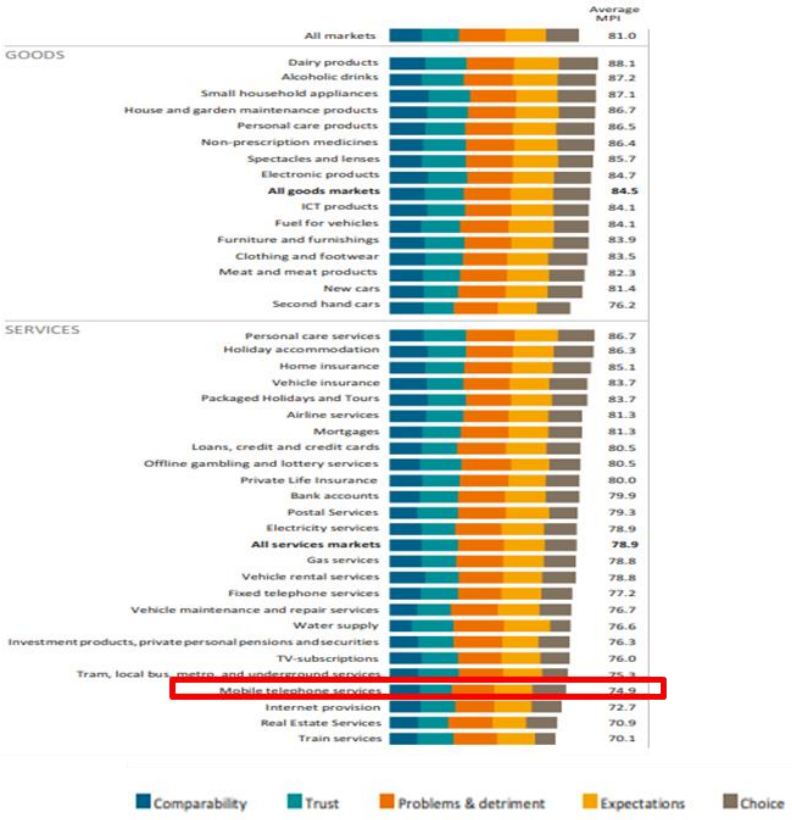
- UK, Ireland and Italy: *"Three provides all the least expensive offers across all* service *bundles on the market*";
- Austria: "*Three provides most of the least expensive offers across all* service *bundles on the market (10 of 12*)";
- Denmark: *"Three provides the least expensive offers across 5 of the 13 market bundles*".

The UK has some of the lowest levels of customer satisfaction with mobile in Europe

The consultation finds that 90% of mobile customers in the UK are satisfied with the overall service. However, official data from the CMA and the EC presents a less optimistic picture, particularly when customer satisfaction is compared against that in other European countries.

The CMA's report 'The State of UK Competition 2020' finds that mobile is the 4th worst performing sector of the UK economy according to UK consumers, ahead only of transport, real estate, and internet.[20]

Figure 12: The CMA reports that mobile is the 4th worst performing sector of the UK economy



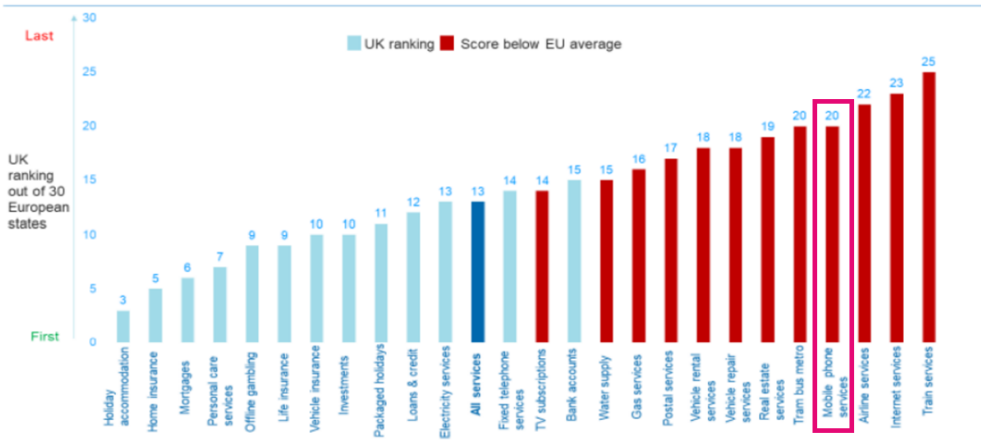
Source: Competition and Markets Authority: 'The State of UK Competition 2020'

[20] State of UK competition report 2020 - GOV.UK (www.gov.uk). This is based on the EC's Consumer Markets Scoreboard, which compares market performance across European countries based on a consumer survey of five elements: trust on suppliers, ease of comparing offers, problems experienced, whether expectations are met and range of choice. These attributes are aggregated to create a composite index out of 100 – the Market Performance Indicator (MPI).

The CMA report also compares consumer perceptions of each individual sector of the UK economy against the same sector in twenty-nine other European countries. Sectors which perform better than the EU-28 average are shown in blue, those with lower-than-average scores appear in red.

The CMA finds that the UK mobile market shows room for improvement, sitting in 20th place out of 30 European states in terms of consumer satisfaction with the market.

Figure 13: The UK mobile market sits in 20th place out of 30 European states in terms of consumer satisfaction



Source: Competition and Markets Authority: 'The State of UK Competition 2020', Annexes

The '4-MNO' model has delivered low returns on investment – and Ofcom should not assume that MNOs will continue to invest

Ofcom estimates Return on Capital Employed (ROCE) across the industry for 2017 to 2020 taking a simple average of MNOs' ROCEs to conclude that "*at an industry level, financial performance appears to support investment*".[21]

As discussed in more detail in Annex B, we do not think this conclusion is adequately supported:

[21] Para 1.22, Consultation

- It is individual MNOs that invest, not the industry as a whole – Three does not make investment decisions based on EE's or Virgin Media O2's profitability. Moreover, Ofcom takes a simplistic, binary view of whether or not MNOs have incentives to invest – rather than considering the strength of those incentives (we discuss this in Section 3).

- Ofcom's analysis shows that Three is earning returns below cost of capital, even on an economic ROCE basis – where spectrum prices are marked down (to market value) and goodwill is removed, both of which inflate returns.

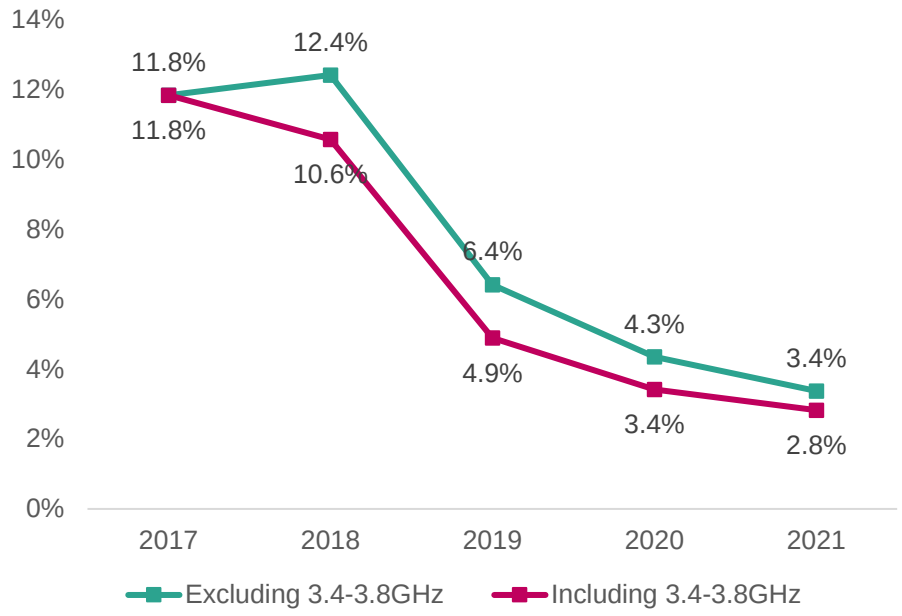
- Ofcom's economic ROCE is overstated – several spectrum bands have been excluded from Capital Employed (3.4-3.8GHz, 3.9GHz, 28GHz and 40GHz). Ofcom excludes the 3.4-3.8GHz spectrum on the basis that it does not expect it "*to have generated any meaningful profit*".[22]

- We do not agree with this exclusion: this spectrum has an opportunity cost. Our shareholder expects a return on spectrum investments, so it should be part of the capital base. Three has used the spectrum since 2017, initially to provide FWA and since 2019 for 5G mobile.

Figure 14 shows Ofcom's estimated economic ROCEs for Three over the period 2017 to 2020, excluding our 3.4-3.8GHz spectrum. We have replicated Ofcom's approach to estimate a 2021 ROCE of 3.4%.[23] We also show a ROCE estimate which includes the 3.4-3.8GHz spectrum from 2018.[24] With this approach, Three's economic ROCE for 2021 is only 2.8%.

[22] Footnote 69, Annexes to Consultation
[23] See Annex B
[24] We have valued our 3.4-3.8GHz spectrum at the 2018 auction price for our 2018-2020 ROCE estimates, and at the lower 2021 auction price for our 2021 ROCE estimate. We have also added the 700MHz spectrum from 2021, but his makes no material difference to the ROCE estimate.

Figure 14: Three's estimated economic ROCEs with and without 3.4-3.8GHz spectrum

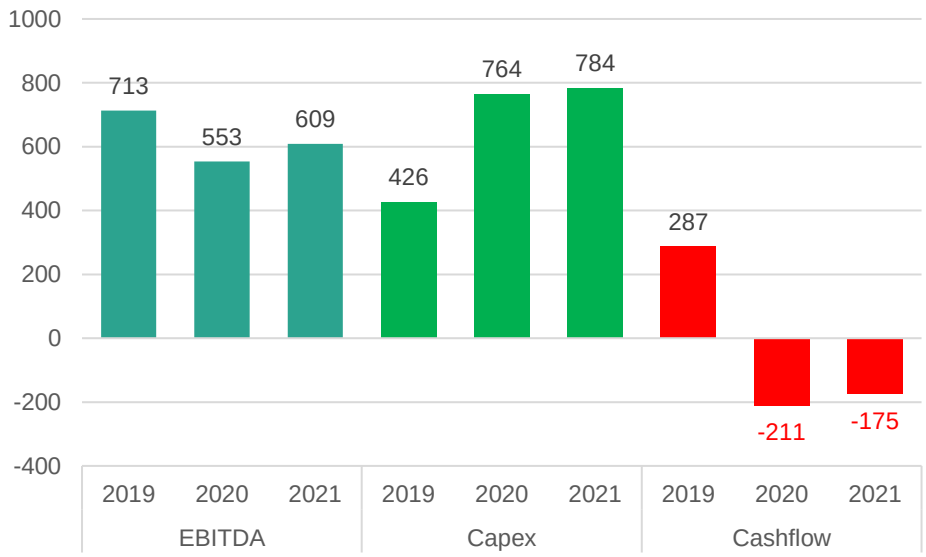


Source: Ofcom and Three

Three is not earning adequate returns on either basis. We consider these ROCE estimates to be a ceiling as Three's 3.9GHz, 28GHz and 40GHz spectrum are still excluded from Capital Employed.

As shown below in Figure 15, Three has been in negative cashflows since 2020 (even when our £280m purchase of 700MHz spectrum in 2021 is excluded from capex). We are investing £750-800m a year, [✂]

Figure 15: Three's EBITDA, capex (excluding spectrum) and operating cashflow (£m)



Source: Three

Ofcom nevertheless concludes that all MNOs will continue investing in their networks, even if some MNOs are not covering cost of capital. This is based on MNO business plans (which Ofcom has requested as part of the consultation).

We think that Ofcom is taking these plans too literally. In reality, an MNO cannot present a business plan to its shareholder with fewer customers and diminishing profits over time. In their business plans, all MNOs aim to grow (or at least maintain) customers and profitability, but in a saturated consumer market not all of them will.

If Ofcom puts together the four MNOs' business plans, it will discover that the aggregate plan for the industry exceeds the actual size and profitability of the market. That exercise would reveal that MNOs' business plans are not mutually consistent – they cannot all be simultaneously realised.

The point is that there will inevitably be winners and losers – some MNOs will fail to deliver targets agreed with their shareholder and will see their investment envelopes cut back. MNOs must balance their books. For instance, [✂]

Figure 16: [✂]

[✂]

Source: Three

[✂] It is therefore not safe for Ofcom to conclude that all MNOs will continue to invest just because their business plans include some investment figures.

Conclusion

Official data from the EC, the CMA and independent quality studies indicates that consumer outcomes in the UK have not been entirely satisfactory, particularly when UK outcomes are consistently compared against those in other European countries.

According to this data, competition between four MNOs in the UK has delivered good value for money, but also poor-quality networks (including significant levels of 4G congestion) and poor industry returns. We explore potential reasons in the next section.

3. The UK mobile market needs to consolidate to become a global 5G leader

Government wants the UK to become a global 5G leader, with the majority of the population covered by a 5G signal by 2027.[25] Ofcom shares the Government's commitment to world-class digital infrastructure for the UK.[26] The UK mobile market needs to consolidate to achieve this ambition.

The single most important challenge MNOs face today is how to address explosive growth in traffic and deploy 5G cost-effectively. The capacity required to meet traffic demands of UK mobile users is doubling every two years, but mobile revenues are in long-term decline. We know from experience that 5G will only exacerbate this problem.

These market pressures – and financial exhaustion of some MNOs – have brought about consolidation in Australia, the US and many European markets. Out of this experience, an understanding is gradually emerging that the four-MNO model is not well-suited to meet the 5G challenge.

In the UK, traffic growth and 5G investment needs are putting [✂] networks and profits under huge pressure. Three is not covering its cost of capital and is seeing cashflows diminish. In this investment environment, the UK has no real chance of becoming a global 5G leader with world-class connectivity. In summary:

- Courts and regulators are taking a more welcoming stance towards mobile consolidation.
- Traffic growth and 5G investment needs are putting [✂] MNOs in the UK under huge pressure.
- UK MNOs are allowing some sites to congest and focusing their 5G rollouts on alleviating 4G congestion in the busiest areas.
- The UK mobile market needs to consolidate to become a global 5G leader with world-class infrastructure and bring 5G to underserved rural areas.
- Under current industry economics, the UK will not realise the full potential of 5G.

[25] Future Telecoms Infrastructure Review (publishing.service.gov.uk)
[26] Statement: Ofcom's plan of work 2022/23

Courts and regulators are taking a more welcoming stance towards mobile consolidation

Several mobile markets have consolidated in the past decade. One after another, MNOs in the US, Australia, and many European markets have merged. Our shareholder (CK Hutchison), Deutsche Telekom, and Telefonica have been the most active in M&A. In Q1 2022, MasMovil and Orange have entered exclusive talks to join mobile operations in Spain, and Iliad made a bid for Vodafone in Italy.

Table 4: Mobile mergers in Australia, US and Europe since 2011

Country	Year	MNO 1	MNO 2	Type	Outcome
US	2011	T-Mobile	AT&T	4 to 3	Abandoned (FCC opposition)
Austria	2013	Three	Orange	4 to 3	MVNO access remedy
US	2014	Sprint	T-Mobile	4 to 3	Abandoned (FCC opposition)
Ireland	2014	Three	O2	4 to 3	MVNO capacity remedy
Germany	2014	O2	E-plus	4 to 3	MVNO capacity remedy
Denmark	2015	Telia	Telenor	4 to 3	Abandoned (EC opposition)
UK	2016	Three	O2	4 to 3	Blocked by the EC (annulled by the ECJ in 2020)
Italy	2016	Three	Wind	4 to 4	New 4th MNO remedy
Netherlands	2018	Tele 2	T-Mobile	4 to 3	Unconditional clearance
US	2019	Sprint	T-Mobile	4 to 4	New 4th MNO remedy
Australia	2020	TPG	VHA	4 to 3	Unconditional clearance

Source: Three

Most approved mergers reduced the number of national MNOs from four to three. Since 2011, the EC has referred all seven mergers in Europe for in-depth Phase II investigation. Having approved three mergers in Austria, Ireland, and Germany subject to MVNO access or capacity remedies, the EC hardened its stance from 2015 by making approval conditional on divestments to enable entry by a new fourth MNO.

The new stance by the EC led to the abandonment of the Telia / Telenor merger in Denmark and the blocking of Three's acquisition of O2 in the UK, despite the extensive structural remedy that Three had offered to secure clearance.

The EC subsequently cleared two mergers: i) in 2016, the Three Wind merger in Italy (subject to divestments to enable a new entrant); in 2018, the T-Mobile/Tele 2 merger in the Netherlands, which was cleared unconditionally as the fourth MNO in the country did not provide an effective competitive constraint on the other MNOs.

As seen in Table 4, more recently courts and regulators have taken a more welcoming stance towards mobile consolidation. An understanding is gradually emerging that the four-MNO model is not well-suited to meet the 5G challenge:

- In 2019 the US Federal Communications Commission (FCC) and US Department of Justice abandoned their long-held opposition to mergers – approving the T-Mobile US / Sprint merger (which had previously been abandoned due to opposition by regulators), subject to divestments to allow entry of satellite player Dish as a fourth MNO;

- In 2020 Europe's General Court upheld the appeal brought by Three's shareholder (CK Hutchison) against the EC's prohibition of the Three/O2 merger in the UK[27] (which is under appeal by the EC) – this decision clarified that the EC's hardened stance was not legally or factually justified in relation to the specific market conditions and reminded the EC that merger efficiencies must be considered in a proper merger assessment.

- In 2020, the Federal Court of Australia overturned the prohibition decision by the Australian Competition and Consumer Commission – allowing the Vodafone Hutchison Australia (VHA) / TPG merger to proceed. In July 2020, VHA and TPG completed their merger to establish a fully integrated telecommunications operator in Australia.

These events have reopened the consolidation debate in Europe and the UK. What these recent decisions have in common is a greater understanding of the importance of merger synergies, network quality, scale economies, investment incentives and the potential consumer benefits from mobile mergers. For instance:

- FCC's order in T-Mobile US / Sprint merger:[28]

  "We agree with the Applicants that the proposed transaction will significantly increase New T-Mobile's coverage, speed, and capacity, which should increase competition in quality. Moreover, the network

[27] in Case T-399/16, CK Telecoms v Commission
[28] Memorandum opinion and order, declaratory ruling and order of proposed modification (2019)

benefits are likely to engender competitive responses from AT&T and Verizon Wireless that are not fully accounted for in a static merger simulation."

- Federal Court of Australia judgement, Vodafone Hutchison Australia Pty Limited v Australian Competition and Consumer Commission (2020)

"In the end, the merger parties submitted that the acquisition would substantially increase the competitiveness of MergeCo relative to a standalone Vodafone and TPG for the following four key reasons:

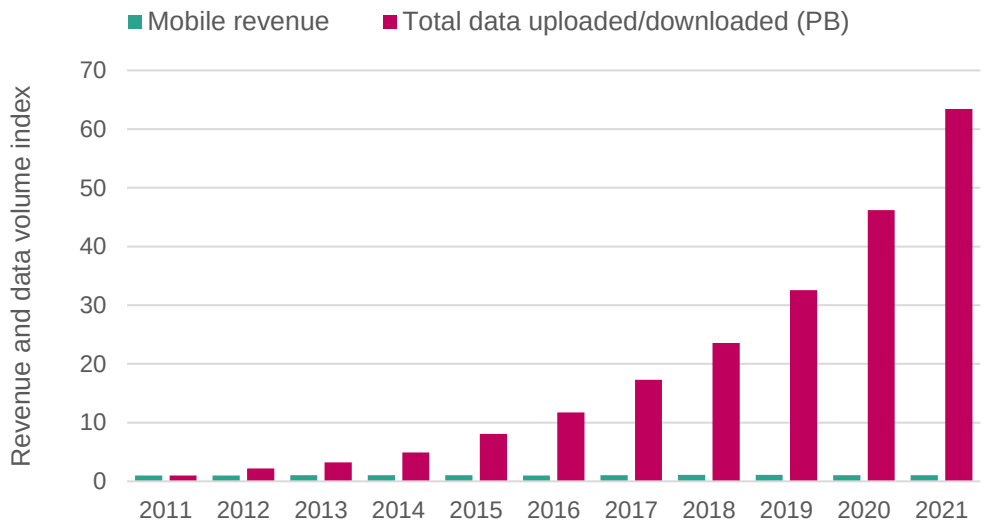
(1) the complementary spectrum holdings of MergeCo would increase MergeCo's network capacity and ability to compete with Telstra and Optus;
(2) …
(3) the ability of MergeCo to fund investment in network capacity will be increased, because MergeCo will benefit from an improved balance sheet (which increases its debt and equity fundraising capacity), cost synergies and the benefits of economies of scale; and
(4) MergeCo would be able to roll-out 5G faster, which lowers the risk of it being competitively disadvantaged as a 5G latecomer relative to Telstra and Optus.

On the basis of the evidence, I accept each of these submissions, although in each case it is a matter of degree to the extent the competitiveness is increased by each of the four factors. However, I am left in no doubt that a combination of those factors will increase the competitiveness of MergeCo relative to a standalone Vodafone and TPG".

Traffic growth and 5G investment needs are putting [✂] MNOs under huge pressure

What is driving MNOs to consolidate in so many different markets? The single most important challenge MNOs face today is how to address explosive growth in traffic and invest in 5G cost-effectively. In the UK, mobile traffic has grown by a factor of 64 (51% year-on-year) since 2011, while mobile revenues are in long-term decline.

Figure 17: UK mobile revenues and data traffic indexed to 2011 (basis: 1 in 2011)



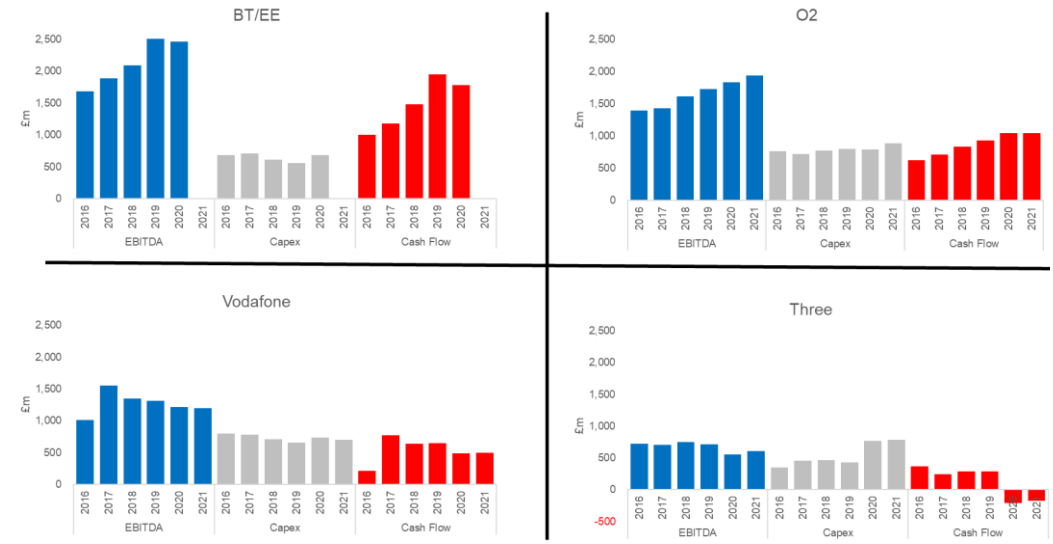
Source: Enders (mobile revenues), Ofcom Connected Nations Report (data traffic)

At current growth rates, the capacity required to meet UK traffic demands doubles every two years. We know from our experience with 4G that demand for data will only accelerate with 5G.[29] Ofcom projects that, by 2030, UK mobile traffic could be between 7.5 times (low growth scenario) and 52 times (high growth scenario) higher than in 2021.[30]

An MNO needs scale to be able to invest to address this challenge. This situation is putting [✂]

[29] 5G releases more bandwidth, which leads to application and content players developing new bandwidth-hungry services, which in turn triggers a further increase in consumer demand for data, and so on.
[30] Discussion paper: Meeting future demand for mobile data (ofcom.org.uk)

Figure 18: [✂] EBITDA, Capex and Free Cashflow (FCF) [31]



Source: Company accounts, Enders Analysis: 'What's to become of H3G'

With similar-sized networks, retail states and IT systems, all MNOs are investing similar amounts (£700-£800m pa in capex, in our case only since 2020). With a fraction of their customer base, however, Three has much less EBITDA to play with. Matching investment by market leaders (as Three has done in 2020 and 2021) has immediately put Three in negative cashflow territory.

UK MNOs are allowing some sites to congest and focusing their 5G rollout on alleviating 4G congestion in busiest areas

In this investment environment, the UK has no real chance of becoming a global 5G leader. The UK has too many networks, some too small to exploit all available economies of scale in expanding capacity, deploying 5G outside dense urban areas, and in investing in the full potential of 5G.

Today, UK MNOs have three main options to address the challenge of traffic growth: i) capping data consumption (which is not commercially viable as the market moves to unlimited with 5G); ii) allowing the 4G network to congest during busy hours; and iii) expanding network capacity with 5G.

[31] BT/EE had not published financial results for 2021 at the time of this assessment.

The cost of expanding capacity through 5G deployment is very high. Under current industry economics:

- MNOs are allowing 4G congestion during peak hours.
- 5G rollouts focus on alleviating congestion in the busiest areas.
- The UK's 5G rollouts will not deliver a global 5G leader with world-class infrastructure, even if the objective of bringing 5G to the majority of the UK by 2027 will be met.

We discuss these issues in turn.

MNOs in the UK are allowing 4G congestion during peak hours

As discussed in Section 2, the UK does not fare well in international comparisons of network quality. One of the reasons is likely to be existing levels of congestion in the UK's 4G networks. A study by OpenSignal shows that the UK is one of only four countries in Europe unable to maintain a minimum level of service (i.e. 20Mbps average download speeds) during peak hours.[32]

The problem is most acute in densely populated cities like London, Manchester, or Birmingham. The OpenSignal study notes that London displays 'wild swings' in 4G speeds between quiet and busy hours, with only Paris having more extreme speed fluctuations in Europe.

Mobile networks are designed to provide a minimum level of service during peak hours. The capacity of a base station on any given sector is limited. As utilisation increases, average speeds reduce. At high levels of utilisation, the sector becomes congested and service is degraded.

As 4G data traffic keeps growing, peak hour traffic increases and more sites become congested in the 4G layer. Under current industry economics, some MNOs cannot upgrade thousands of sites to 5G as quickly as required to address 4G congestion.

[✂].

A study by Tutela shows that all 4G networks in the UK are congested to some extent.[33] Three's network suffers the most, slowing down by 36%

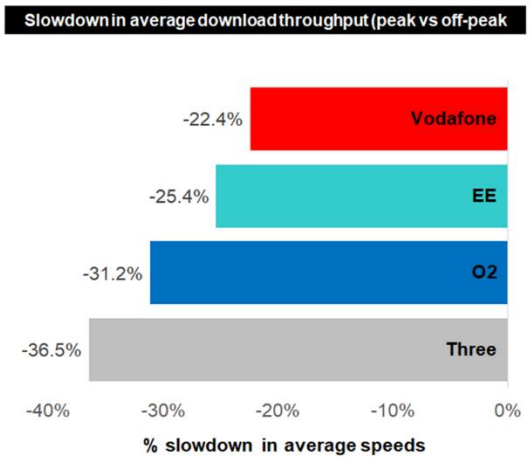
[32] Countries Ranked by 4G Download Speed at Different Times of Day - ISPreview UK. The study is available here the_5g_opportunity_report_february_2019_0_0.pdf (opensignal.com)
[33] Examining the effect of congestion on Three's network performance in the UK (tutela.com)

during peak hours and delivering less than 1.5Mbps on average on 10% of tests.

O2's network slows down by 31% during peak hours too. Vodafone's network has the highest proportion of tests where upload is faster than download – another sign of congestion – and slows down by 22% during peak hours.

Figure 19: 4G networks in the UK are showing signs of congestion.

[✂]



Source: Three, Tutela 'Examining the effect of congestion on Three's network performance'

We explain below that UK MNOs are not addressing 4G congestion efficiently because they are not able to leverage economies of scale from capacity expansion.

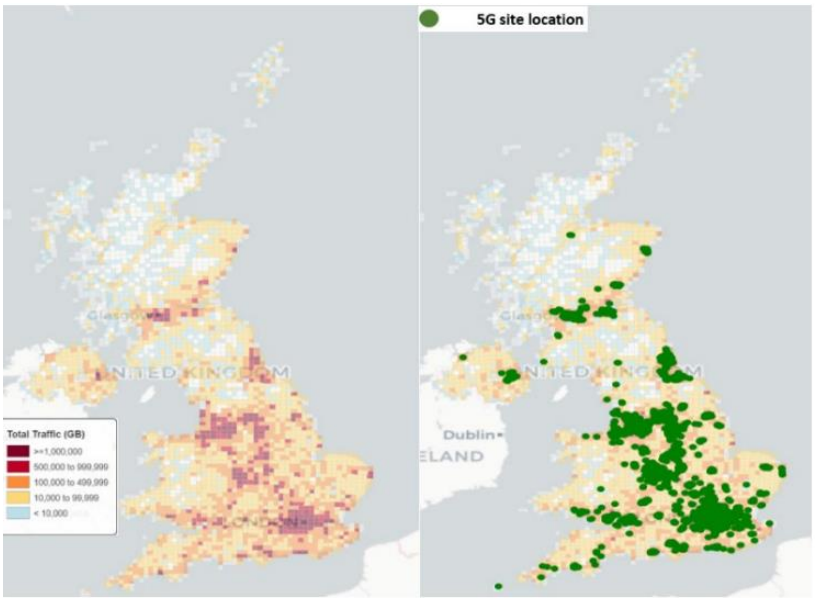
5G rollouts in the UK focus on alleviating congestion in the busiest areas

MNOs have another option to deal with explosive traffic growth – expanding capacity through 5G deployment. This is the option that delivers the greatest benefits to UK consumers, but it is very costly.

5G rollout is a major civil engineering project that requires a huge investment across all network domains: spectrum, the RAN, fibre, and the core network. In the RAN alone, initial 5G rollouts involve upgrading tens of thousands of sites to 5G (i.e. strengthening or replacing masts and installing new antennas and equipment on every site). Section 2 shows that UK MNOs invested £330m in the 5G RAN in 2020 (£175m in 2019).

Initial 5G rollouts in the UK are capacity-driven and focus on alleviating 4G congestion in urban and suburban areas. This is not unique to the UK – MNOs in other countries are initially deploying 5G in dense urban areas too. MNOs focus on this use case – 5G mobile for the mass consumer market – because it is well-understood and has a positive business case based on protecting existing 4G revenues from churn.

Figure 20: UK mobile traffic (left) vs 5G deployments (right)



Source: Ofcom Connected Nations 2021

5G rollouts in the UK follow the same pattern as the earlier 4G rollout:

- **A 'cities-first' approach** – we expect MNOs to deploy new 5G equipment using mid-band spectrum (initially, 3.4-3.8GHz) on [✂] existing macro sites (depending on budget), mostly in urban and suburban areas where 4G congestion is most acute.

- **Focus on existing macro sites** – we expect the vast majority of 5G requirements to be met by upgrading existing macro sites to 5G. Other than our rollout of [✂] new monopoles (see below), MNOs are not expected to deploy new 5G macro sites to any large extent. Similarly, we expect localised small cell deployments in high footfall areas, not mass deployment of tens of thousands of small cells.

- **Rural areas last** – there is virtually no 5G in rural areas of the UK. Most 5G sites are in England (87%), with only 8% in Scotland, 3% in Wales and 2% Northern Ireland.[34] In each of the nations, 5G sites are mostly in urban areas.

The UK is very unlikely to deliver world-class infrastructure, even if the objective of bringing 5G to the majority of the UK by 2027 will be met

In the consultation, Ofcom seems satisfied that the objective of having the majority of the population connected to a 5G signal by 2027 is on track. This is not an ambitious goal – Ofcom reports that 42%-57% of the UK population already has a 5G signal from at least one MNO.[35]

We had understood that Government and Ofcom want the UK to become 'a global 5G leader with world-class infrastructure'. This requires comprehensive, timely deployment of high-quality 5G networks.

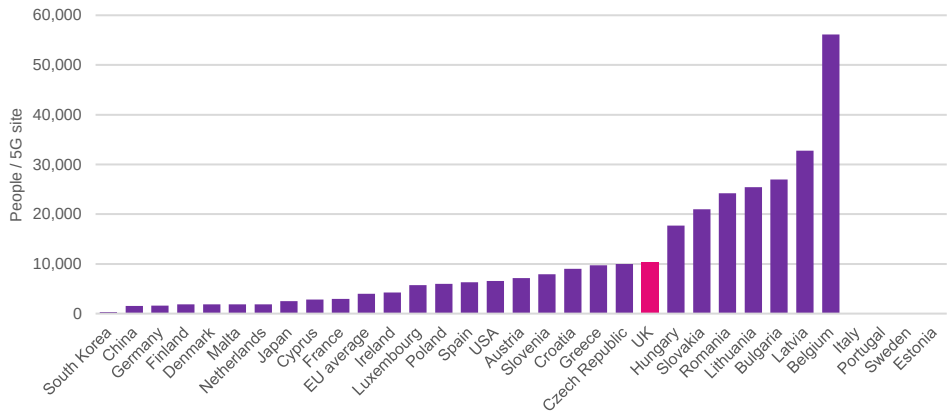
With the current market structure, we see no real chance of the UK realising this ambition. The UK has too many networks, limiting MNOs' ability to leverage all available scale economies in expanding network capacity to address congestion, deploying 5G outside urban areas, and in investing in 'full-fledged' 5G.

With 5G rollouts now fully underway, as of Sep 2021 the UK mobile industry has deployed 5G on 6.5k sites (16% of c40k macro sites in the UK), with 1k of those sites using Dynamic Spectrum Sharing (DSS).[36]

Based on the UK's population, this equates to 10k people per 5G base station, placing the UK 22nd out of 32 countries, well behind the EU-27 average and also South Korea, China, Japan and the US according to data from the EC's 5G observatory.[37] European countries with the least number of people per 5G site include Germany, Finland, Denmark and the Netherlands (in addition to Malta and Cyprus).

[34] Connected Nations 2021: UK report (ofcom.org.uk)
[35] Connected Nations 2021
[36] Ofcom notes that DSS deployments represent on average c16% of 5G enabled sites. Connected Nations 2021: UK report (ofcom.org.uk)
[37] 5G-Obs-PhaseIII_Quarterly-report-14_FINAL-Clean-for-publication_16022022.pdf (5gobservatory.eu). There is no data available for Italy, Portugal, Sweden and Estonia.

Figure 21: People per 5G site in EU-27 and selected nations.



Source: Ofcom and European Commission, '5G Observatory Quarterly Report (Up to Jan 2022)'

The pace of 5G rollout and equipment choices to date suggest that some UK MNOs may be unwilling to increase their cost base significantly with 5G. We expect 5G rollouts to deliver similar outcomes to the earlier 4G rollout:

- **High capacity 5G mid-band (initially 3.4-3.8GHz) in high traffic areas** – 5G leadership requires extensive massive MIMO (mMIMO) deployments using mid-band spectrum (e.g. 3.4-3.8GHz). By spreading many antennas across a single device, mMIMO provides higher coverage and capacity (and better spectral efficiency) than cheaper kit configurations.

- However, Ofcom reports that 56% of 5G deployments in the UK to date use cheaper equipment such as 8T8R (45%, featuring only eight transmitters and receivers per unit) and lower configurations like 2T2R (11%). Less than half (44%) of 5G deployments are mMIMO (32T32R or 64T64R).[38] Table 6 compares the relative capacity and coverage outcomes of these 5G equipment choices.[39]

[38] Connected Nations 2021: UK report (ofcom.org.uk), footnote 66.
[39] Ibid, footnote 66 8T8R use eight transmit and eight receive antenna elements. In contrast, 64T64R massive MIMO radios have 128 antenna elements, offering up to ten times more capacity per radio than more traditional radios.

Table 6: Capacity, coverage of different 5G options (8T8R = 1)

	Capacity gain [40]	Coverage gain (m^2)[41]
5G 8T8R	1.00	1.00
5G 32T32R	2.04	2.50
5G 64T64R	2.92	3.00

Source: Three

- **A thin 5G coverage layer in semi-rural areas** (enabled by low band 5G or DSS) – this service will not be substantially different from 4G due to the limited bandwidth available. c16% of 5G-enabled sites (c1k) to date use DSS, which offers a quick route to 5G with just a software upgrade (no strengthening of masts or new kit needed).[42] However, DSS offers no real gain in capacity as it re-uses existing 4G spectrum. DSS is being used to 'colour the map' (i.e. put a 5G icon on coverage maps) with no real improvement over a 4G service.

- **No 5G in the more remote parts of the UK** – MNOs are unlikely to find it cost-effective to deploy 5G in rural areas in the next five to ten years. There is already broad 4G coverage and the Shared Rural Network (SRN) will take 4G to the remaining not spots.[43]

In summary, the current investment climate makes it very unlikely that the UK can become a global 5G leader. As discussed in Section 2, we know of no 5G study that places the UK in a position of 5G leadership on any metric. The UK comes 7th or 8th out of 12 European countries on the quality of the 5G experience in a 2021 study by OpenSignal. There is virtually no 5G in rural parts of the UK – unlike in Switzerland, Netherlands, Austria, and Germany.

In the latest study by Ookla, the UK ranks 12th and 10th out of 21 European countries on 5G speeds and 5G availability respectively. Similarly, London ranks 26th (out of 45 world capitals) in Ookla's study of world capitals with the best 5G speeds.

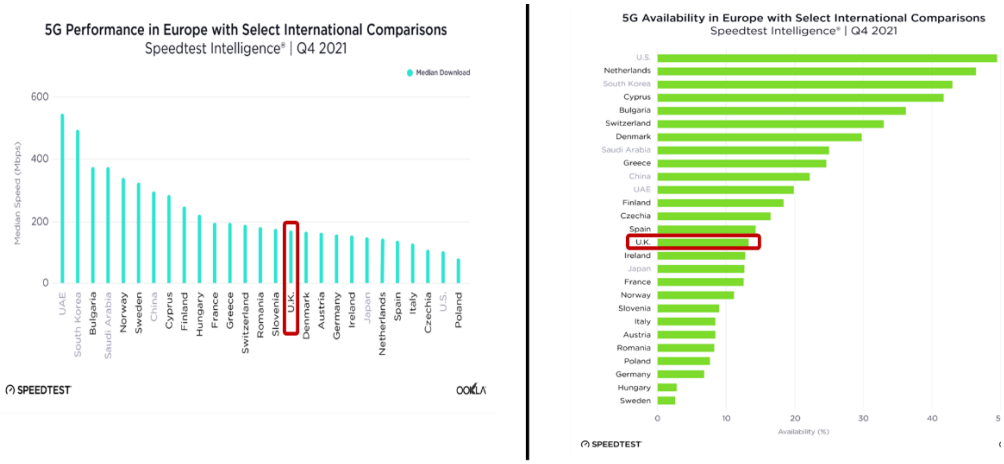
[40] Massive MIMO enables advanced beamforming (BF) features that send data to multiple users simultaneously and at the same frequency resource blocks, up to 8x users, enhancing spectral efficiency and increasing spectrum capacity. In 8T8R, only one user (maximum two users) can utilise the frequency resource blocks at any given time.

[41] Massive MIMO beams are sharper toward the users than 8T8R beams, which increases signal range outdoor and indoors and enhances signal SINR (signal to interference and noise ratio), thereby enhancing the coverage.

[42] DSS allows the same spectrum to be used for both 4G and 5G simultaneously, switching between the two technologies dynamically based on demand

[43] The Shared Rural Network will only deliver 4G coverage with a download speed of at least 2 Mbps, which allows browsing the internet; using social media and SD video streaming

Figure 22: The UK is far from leading 5G in Europe



Source: Ookla: '5G in Europe: Reflecting on the Progress So Far and Mapping the Future'

Furthermore, achieving the full potential of 5G requires delivering significantly better performance than 4G, along with the enhanced functionality to support a much broader range of uses beyond the familiar consumer mobile broadband use. We discuss this at the end of the section.

The UK mobile market needs to consolidate to become a global 5G leader with world-class infrastructure and bring 5G to underserved rural areas

The 4-MNO model is disappearing in many markets. Market pressures – and financial exhaustion of MNOs – have brought about consolidation in Australia, the US and many European markets. Out of this experience, an understanding is gradually emerging that the four-MNO model is not well-suited to meet the 5G challenge detailed above.

MNOs are merging to address explosive traffic growth and invest in 5G cost-effectively. Competition tends to concentrate production in the most efficient firms (i.e. those with lowest costs and higher quality). In the presence of economies of scale, this process invariably drives out smaller players and puts fewer, stronger operators in their place.

Regulators have long recognized that competition between multiple RANs can be inefficient – as networks are duplicated and economies of scale not fully exploited – but the benefits of competition are seen to outweigh this.

The explosion in mobile traffic and the heavy 5G investment required have put the spotlight back on these trade-offs and inefficiencies. With capacity needs in the UK doubling every two years, the social cost of having duplicative networks is now much higher.

The 5G rollout is a chance for the UK to start again and become a global leader in 5G. A newly merged MNO can exploit all available economies of scale to expand capacity and provide better coverage and quality of service at lower cost than two smaller MNOs can achieve on their own, namely:

- **Economies of scale from capacity expansion** – combining spectrum, sites and equipment increases network capacity more than proportionally, enabling an MNO to address 4G congestion and invest in 5G at lower cost than two separate MNOs can achieve on their own.

- **Economies of scale from coverage** – combining sites and customer bases allows a merged MNO to deploy 5G more quickly and extensively (including in rural areas) than two standalone MNOs can do independently.

- **Network sharing is not a realistic alternative and does not deliver comparable economies of scale to mobile mergers.**

We discuss each of these in turn.

MNOs must leverage economies of scale from capacity expansion to meet traffic growth and invest in 5G cost-effectively

The need to rapidly increase network capacity has yielded new economies of scale in mobile. These arise when a doubling of output (e.g. mobile traffic) does not require a doubling of every input (e.g. sites, spectrum and equipment in an area).

A mobile merger promotes competition by enabling a merged MNO to achieve network-based economies of scale that increase capacity – and reduce 4G congestion – at lower incremental cost than two standalone MNOs can achieve independently.

Capacity measures a network's ability to supply traffic at a specified level of quality. Capacity determines both the number of users that can be served in an area and the average speeds they will receive. Mobile network capacity is determined by three network assets:

- The number of mobile cell sites deployed in an area.
- The amount of spectrum deployed on those sites (MHz).
- Spectral efficiency (ie the amount of data carried per MHz of spectrum, Mbps/MHz) – which is a function of the equipment technology deployed (4G, 5G, etc).

MNOs can expand capacity by adding more sites to the network, deploying more spectrum on existing sites, or rolling out more efficient technology. The basic network capacity formula is:

Figure 23: Network capacity is determined by sites, spectrum and spectral efficiency

$$Capacity = Number\ of\ cell\ sites \times Spectrum\ deployed\ per\ site \times Spectral\ efficiency$$

Source: Three

This means that capacity increases linearly with each of i) the number of sites in an area, and ii) with the amount of spectrum deployed. Combining both assets has a multiplicative effect on network capacity. For a given technology (i.e spectral efficiency), simultaneously increasing spectrum and sites in an area increases capacity more than proportionately.

Once two separate networks have been integrated, a merged MNO gets a boost in capacity from the combination of complementary assets in a single network, namely:

- **A denser site grid** – the merged entity has access to a superior site grid with more sites (even after removal of duplicate sites) and better locations than either MNO can achieve on its own. The higher site density boosts the level of traffic that can be carried in any given area.
- **More spectrum deployed across those sites** – a merged entity can also deploy more spectrum on each site, and leverage spectrum complementarities to achieve a more balanced spectrum mix on every site (e.g. than a network that is short of mid-band or has no mmWave spectrum).

- **Greater spectral efficiency** – a merged entity can repurpose 4G spectrum more quickly to 5G (which has greater spectral efficiency than 4G) than two separate networks can do on their own.[44]

From a quality perspective, the capacity of the merged network will be greater than the sum of the standalone capacities, with associated improvements in user throughput, reliability and experience. This gives the merged MNO a much stronger 5G offering than either company could ever achieve on its own.

The merged entity can use this capacity boost to address congestion at lower cost than two standalone networks can do in isolation. Outside heavily congested areas, the greater capacity results in faster speeds and a better user experience. The MNO can also 'carrier aggregate' more blocks of spectrum to offer higher average and headline speeds.

From a cost perspective, a 5G network built for higher levels of traffic has lower unit costs than two smaller networks, each supplying a portion of the market. Larger 5G networks are cheaper to deploy and maintain because they require fewer inputs (i.e. spectrum and sites) in relation to output (i.e. traffic). Doubling capacity does not double the cost.

A merged network can also expand capacity at lower marginal cost than two standalone networks. It costs less for a merged MNO to add a given level of capacity to its network – as it needs to build fewer sites and deploy less spectrum to do so – than for two standalone MNOs to separately provide it. A merged MNO gets more capacity out of every new site (as it can deploy more spectrum on it) and also out of each new MHz (as the new frequencies can be deployed on many more sites).

Regulators have taken the view that merger synergies are unlikely to be passed on to consumers through lower prices, as they amount to 'fixed' cost savings. This is a misunderstanding as these scale economies have nothing to do with the 'spreading of fixed costs' (see next section).

These scale economies reduce the marginal cost of expanding capacity so they should be considered variable (not fixed) cost savings. The capacity addition allows the merged MNO to expand output (i.e. traffic) beyond the sum of the output levels that would be achieved if the two MNOs continued to operate independently.

[44] Since a larger spectrum portfolio may mean that the merged entity can use spectrum more efficiently. Each operator needs to reserve a small amount of their spectrum for technologies with lower efficiency (e.g. 2G, 3G and 4G). This allocation of spectrum to old technologies is duplicated by standalone operators. A merged firm can instead retain some spectrum for 2G/3G/4G while refarming some spectrum that would otherwise be used by a standalone operator for legacy use to the more efficient 5G technology.

A merged MNO has more capacity to serve the same number of customers as the standalone MNOs had before the merger. The MNO has every incentive to put this capacity into use, as the investment will have been incurred and would otherwise be wasted. Fresh surplus capacity puts downward pressure on prices.

In these circumstances, 5G investments are wastefully duplicated if undertaken by too many networks, some too small to take full advantage of the available economies of scale. 5G requires a heavy investment in capacity sufficient to meet (peak) traffic demands, and this is most efficiently provided by fewer networks.

Today, mobile investment in the UK is thinly spread across too many networks. As long as the marginal cost of expanding capacity declines with traffic, it is more efficient for 5G investment to be delivered by a single MNO than by two smaller MNOs, each supplying part of the market.

The judgement of Europe's General Court in the Three/O2 merger appeal[45] reminds regulators that a proper merger assessment must account for these scale economies. Regulators should oppose mergers that result in a reduction in output and higher prices, not those which expand output, improve quality and lower prices (compared to the levels that would prevail absent the merger).

Merged operators can leverage economies of scale from coverage to roll out 5G more quickly and extensively in rural areas.

A mobile merger can also help 'level up' the UK by improving the economic case for 5G rollout across the country.

Combining customer bases and reducing the costs of 5G upgrades can make faster, wider 5G coverage profitable which may not be economic for two MNOs operating independently. Today, demand is fragmented across too many MNOs, limiting their ability to leverage scale economies in deploying 5G outside high traffic areas.

This benefit is related to economies of scale in another part of a mobile business: the 'coverage layer'.[46] An MNO needs a base grid of thousands

[45] Case T-399/16, *CK Telecoms v Commission*

[46] For a discussion of these economies of coverage and how they differ from economies of scale from capacity, see Three's response to Ofcom's consultation on the PSSR Auction

of sites (and spectrum) across the UK to serve customers on demand – at the tap of a smartphone key – even if the network is empty.[47]

These investments provide a base level of coverage throughout the UK, but they also create a base layer of capacity that can be spread over additional customers and traffic volumes as demand increases over time.

The cost of the associated site leases, base stations, spectrum, backhaul, etc. is an inescapable and indivisible burden of installing a base level of coverage and capacity. Even in the long run, the cost of this base network can only be eliminated by discontinuing service altogether.

What creates these economies of scale is that the cost of these indivisible outlays is largely fixed (within the limits of the capacity deployed) and the same sites can be used to provide additional capacity by supplementary investments and variable expenses, such as those of upgrading the sites to 5G.

These economies arise from the 'spreading of fixed costs' and should not be confused with scale economies from capacity expansion. As Ofcom has found, these economies of scale mean that – all else the same – an MNO with a smaller subscriber base will face a unit cost disadvantage in competition with a smaller MNO.

Back in 2007, MNOs agreed to share RANs to exploit these economies. Three and T-Mobile created MBNL in 2007 to manage a shared site grid. Initially, we also shared 3G equipment, but this is now limited to rural areas. Three and EE have rolled out 4G and 5G kit independently. In 2012, Vodafone and O2 created CTIL to own and operate a single grid.[48]

The UK has derived enormous benefits from these economies of scale. Large savings in upfront costs (in sites and base stations) and in the expenses of operating the shared infrastructure have allowed faster and more extensive 3G and 4G rollouts than would have been possible with separate networks. Many rural areas of the UK only receive a mobile signal today because of these site sharing agreements.

Today, competitive pressures are pushing MNOs to exploit these economies further. As the industry expands, it pays to set up specialist providers who can take fuller advantage of scale economies by sharing passive assets between a greater number of MNOs:

[47] This base coverage network is supplemented with capacity sites in high traffic areas.
[48] They also share active kit (2G/3G/4G/5G) across c14.2k sites, with each MNO responsible for the network in half of the UK. Vodafone and O2 have rolled back active sharing in London and twenty-three other large cities (25% of the total number of sites).

- **Moving to Towerco and neutral host models** – MNOs are divesting underutilised towers (or outsourcing management) to specialist providers who can increase co-location. Some MNOs set up a separate towerco to retain ownership while others divest their towers to a neutral host. The CMA has recently approved the sale of CKHN's UK towers to Cellnex (subject to a divestment by Cellnex of c1k macro sites).[49] In January 2021, Vodafone and O2 agreed to commercialise 14.2k UK mast and tower sites owned by CTIL.

- **Shared Rural Network (SRN)** – in March 2020 MNOs agreed to share sites in a shared network in rural areas funded by industry and Government. The industry will deploy c1.2k new sites to take 4G coverage to partial and total not spots. [50]

Even with these initiatives, a merged MNO will have a better business case to deploy 5G more quickly and extensively, including in rural areas:

- On the revenue side, a merged MNOs has a greater customer base over which to monetise its investment in 5G coverage.

- On the cost side, the merged MNO will save on site upgrade costs – once the separate grids have been integrated (and duplicate sites removed), the MNO will only need one engineer visit, one set of equipment, one backhaul upgrade etc. per site.

For instance, a merged MNO may find it profitable to deploy 5G on the 1.2k SRN sites in partial and total not spots, and deeper in other rural areas. Under current industry economics, this is unlikely as revenues do not cover incremental costs. Getting the SRN off the ground has required site sharing between more MNOs (three or four) and public funding, but this will only make 4G (not 5G) available.[51]

Customers of the combined network would also receive a boost in 5G coverage, as they will benefit from coverage that was previously only available to customers of the other network – i.e. in areas where one, but not both, of the standalone networks was present.

[49] Final report (publishing.service.gov.uk)
[50] Each MNO will reach 88% of the UK landmass by June 2024 (90% by January 2027).
[51] Licence obligations supporting SRN commitments are technology neutral and Ofcom will assess compliance based on a 4G service. Public funding in Total not Spots does not cover 5G equipment.

Network sharing does not deliver comparable economies of scale to mobile mergers

In recent merger assessments, competition authorities have dismissed 4 to 3 merger efficiencies on the basis that they are not-merger specific (i.e. can be achieved through network sharing).[52] This is a misunderstanding which confuses different types of scale economies in mobile networks.

Network sharing can take several forms, with each type progressively delivering greater economies of scale:

- **Passive sharing /Towerco / Neutral Host** – where passive non-electronic infrastructure (sites, masts, passive antennas, cabinets, power, etc.) are shared. [53] This is the prevalent type of sharing in the UK. As discussed above, MBNL is now largely a passive sharing agreement and Three has sold its tower interests to Cellnex (a neutral host operator). Vodafone and O2 share a site grid of 14.2k sites owned by CTIL, which is now commercialised as a Towerco.

- **Active sharing** – this also involves sharing equipment and active antennas.[54] In MBNL, this is limited to 3G in rural areas. In CTIL, active sharing occurs only outside large cities (Vodafone and O2 rolled it back in London and twenty-three other cities).[55] As Ofcom notes, MBNL and CTIL have evolved from active towards passive sharing, as economies of scale from sharing equipment are exhausted when the kit reaches capacity on a site.

- **Spectrum sharing** – for instance, with Multi Operator Core Network (MOCN) passive infrastructure and active equipment are shared, and spectrum is also shared (but core networks remain separate).

- **Full merger** – all network elements are integrated into a single network (including core networks), with a single strategy. IT systems, retail state, brands, head office functions, etc. from the two standalone MNOs are also integrated. This greater level of

[52] For an example, see Ofcom comment on the proposed merger of Three and O2 - Ofcom
[53] Passive elements are those which are not able to process or convert telecommunication signals.
[54] Active elements are able to generate, process, amplify and control signals.
[55] Vodafone and O2 finalise 5G network agreement in the UK

integration delivers additional economies in retail distribution;[56] IT,[57] marketing and head office functions.[58]

Figure 24: economies of scale from network sharing and mergers

Key assets	Passive / Towerco / Neutral host		Active		Spectrum sharing		Full sharing (ie merger)
Site	Shared		Shared		Shared		Shared
Base station	A	B	Shared		Shared		Shared
Spectrum	A	B	A	B	Shared		Shared
Core network	A	B	A	B	A	B	Shared
IT, retail & other assets	A	B	A	B	A	B	Shared
Incremental economies of scale	Spread fixed cost of coverage layer		Spread 'lumpy' kit costs		Expand capacity at lower cost		Merged core, IT, retail, head office & other synergies
Benefits to MNOs	Extend coverage / upgrade sites at lower cost		Share kit costs (until capacity is reached)		Boost capacity at lower cost		Reduce costs, improve efficiency
MBNL	Most of our [✂] shared sites		3G in few rural areas only		-		-
CTIL	c5k sites in large cities		C14.2k sites elsewhere		-		-

Source: Three

Network sharing cannot plausibly match the scale economies and efficiencies of a mobile merger. This is for four main reasons:

- **Network sharing does not generate the same economies of scale as mergers** – taking full advantage of network-based economies of scale from capacity requires sharing spectrum and other assets in a fully integrated network, with a single network strategy and no room for misaligned priorities. Moreover, network sharing does not deliver non-network efficiencies. These synergies imply that the merged MNO can deliver the same (or better) consumer outcomes with lower investment (and lower opex) per subscriber, other things being equal.

- **Network sharing is not a realistic alternative to mergers in the UK** – both MBNL and CTIL have gradually unwound active sharing and fallen back to passive sharing [✂].[59] [✂].

[56] MNOs need a minimum number of retail stores (between 200 and 250) to cover the main UK population centres.
[57] The incremental cost of IT over and above the set up and maintenance for a small number of customers is small. Similarly, the bulk of Three's investment in its website is to set up and maintain an initial presence. Thereafter, the marginal cost of incremental volume or traffic is negligible.
[58] A large part of marketing costs are fixed and are driven by brand building instead of being volume-driven. The costs of head office functions, including property costs, finance costs, legal costs and supporting HR function costs are largely fixed irrespective of an MNO's number of customers
[59] [✂]

- **Sharing 5G networks is unlikely to be feasible** – [✂]. MNOs have very different positions in the market for 5G and would derive very unequal returns from joint investments in new 5G services (such as network slicing, mobile edge computing, private 5G networks, etc).

- **Regulators discourage active and spectrum sharing where network competition is feasible –** BEREC's position on network sharing discourages active and spectrum sharing where infrastructure-based competition is feasible, as sharing is seen to reduce network competition.[60] But this is exactly the reason why regulators oppose mergers. The most extreme form of sharing (spectrum sharing) and mergers have similar impacts on network competition, but mergers are much more effective in delivering customer benefits (as there is a single network strategy and no scope for misalignment).

Under current industry economics, the UK will not realise the full potential of 5G

All MNOs are initially deploying non-standalone 5G (5G NSA), as this sits on top of the existing 4G RAN and 4G core to minimise time to market and deploy fresh capacity quicky.

Fulfilling 5G's potential requires transitioning to 5G standalone (5G SA) networks. 5G SA opens up new markets for MNOs, as it is designed to support a much broader range of uses (beyond the familiar consumer mobile broadband use).

5G will be essential for a wide range of innovative applications which have the potential to transform many sectors of the UK economy. These other uses are usually grouped under:

- **Massive machine type communications (mMTC)** – 5G will connect many more devices in the Internet of Things (IoT), creating a massive web of interconnected devices spanning everything from smartphones to kitchen appliances.

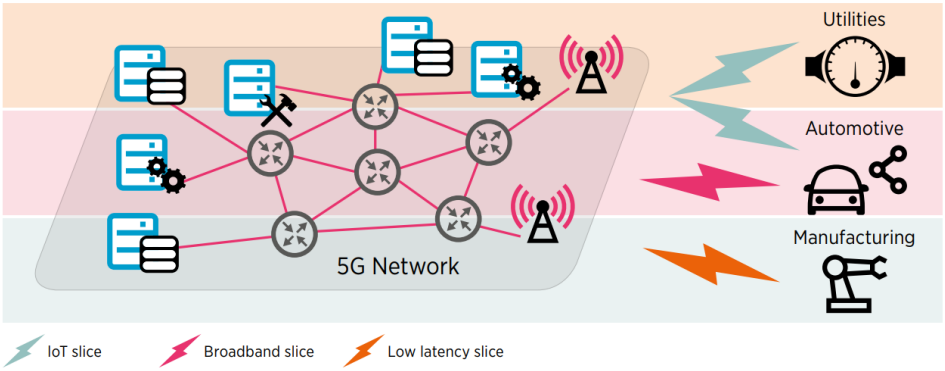
- **Ultra-reliable low latency communications (URLLC)** – 5G will provide universal ultra-high reliability and low latency connectivity for industrial users (e.g. automotive, health, transport and energy).

[60] BEREC Common position on infrastructure sharing (europa.eu)

5G is designed to meet the diverse needs of these applications. Network slicing enables 5G services to be delivered over the same infrastructure but tailored to their individual requirements. Different users will share a common infrastructure, but the network is partitioned so that each user is served through its own dedicated 'slice' tailored to its individual needs. A slice could span across the network (e.g. access, core and transport).

For instance, one customer may require an ultra-reliable service slice, whereas another user needs a slice guaranteeing ultra-high-bandwidth communication or extremely low latency. In essence, MNOs will operate multiple dedicated networks with different service level requirements on a shared physical infrastructure.

Figure 25: Network slicing allows MNOs to supply diverse needs over a common network infrastructure



Source: GSMA 'An introduction to network slicing'

Achieving the full potential of 5G requires a step change in investment. MNOs need to roll out a completely new network architecture to transition to standalone 5G deployments (5G SA), a new 5G cloud core and associated infrastructure to meet these diverse requirements:

- Uses requiring high capacity and speeds (e.g. FWA, mobile hot spots, on-site solutions for industrial campuses and live events) will need investment in an ultra-dense network of small cells leveraging large bandwidths in the mmWave range, as well as a dense fibre network for backhaul – Ofcom has estimated that, in a medium growth scenario, an MNO may need 30-50k small cells by 2035.[61]

- Other uses will require very low latency, high bandwidth and high reliability (e.g. industry verticals that need to process and store large

[61] Discussion paper: Meeting future demand for mobile data (ofcom.org.uk)

amounts of data locally). [62] To meet these needs, an MNO needs to invest in Edge Cloud infrastructure, including a highly distributed network of data centres and nodes that sit far closer to the sources of the data (i.e. the enterprises) than today. This requires a much denser distribution of computing resources than can be achieved with a traditional and centralised cloud architecture today.

- Some uses require nationwide coverage and high data rates (such as in-vehicle infotainment).[63] To supply this, an MNO needs to invest in deploying enough capacity outside high traffic areas. For other uses (e.g. Industry 4.0) a local area must be covered (e.g. a factory or hospital). In other cases, a thin layer of widespread coverage at low data rates suffices (e.g. smart grid, smart meters, waste management).

Smaller MNOs lack the scale needed to build all of the required infrastructure. [✂]

A merged MNO will have a better economic case to invest in 'full-fledged 5G' than two standalone MNOs will have on their own. The business case for this investment depends on incremental revenues from all of these sectors, including consumer applications (e.g. mobile, FWA), industry 'verticals' and the public sector.

The upfront investment in a common network infrastructure with network slicing is only economic if it can be leveraged across multiple adjacent 5G use cases and markets (beyond consumer mobile). Broadening the 5G use cases that can be supported brings new economies of scope within grasp, giving a merged MNO a wider set of 5G services and users over which to recover the upfront investment.

The costs incurred in supplying one 5G use (e.g. FWA) can then be shared with other uses (e.g. traditional consumer mobile) sharing the same infrastructure (e.g. a macro site and small cell network), improving the business case and making investment profitable where it may not be so for two standalone MNOs.

Another source of economies of scope with 5G arises due to the diversity of 5G user requirements. Mobile networks are designed to meet 'peak' requirements, as traffic varies between time of day and also between

[62] For instance, Felixstowe Port uses a 5G standalone network, IoT sensors and AI to operate quay cranes remotely and determine when cranes should be taken out of service

[63] E.g. music, movies, live TV streaming, audio/video conference streaming (office-in-car), online gaming, web browsing.

services. For instance, mobile traffic on Three's network remains largely constant between [✂] pm, whereas FWA traffic peaks at [✂] pm.

This variability in peak demands makes it more efficient to supply many new 5G use cases than few. 5G creates new economies of scope based on the diversity of uses and 5G markets served.

The more diverse the set of 5G uses, the more likely that variations in their separate traffic demands cancel each other out, and the greater the chance that peak usage for some uses will fall at different times from peak usage by other 5G services.

A single MNO must invest in enough 5G capacity to meet the sum of total demands from all uses during the network peak. By contrast, two separate MNOs serving a narrower set of 5G uses need enough capacity to meet peak traffic of its own set of customers. The sum of those non-coincidental demands requires greater capacity that if all these 5G cases can be served by a merged MNO.

In consequence, a merged MNO with greater scale to attract a broader set of 5G uses has a better relationship between investment costs (as determined by peak demand) and revenues, and hence lower unit costs than two standalone firms, each supplying a portion of the 5G market.

4. Mobile mergers of Three sister companies in Austria and Ireland have delivered large benefits for consumers

In December 2020, Ofcom published a discussion paper on mobile market consolidation, finding that investment and speeds are lower in markets where consolidation has occurred. We have commissioned Frontier Economics to review Ofcom's paper. Frontier's report is found in Annex A.

Frontier finds that Ofcom's results are not robust due to questionable modelling assumptions, including that:

- Ofcom's model conflates entry and exit effects, meaning that it does not reliably find an impact of mobile mergers on investment and network quality.
- The positive relationship between mergers and investment disappears once investment per subscriber (rather than investment per capita) is used.

Frontier concludes that statistical models find it challenging to reliably assess the impact of mobile mergers, even when the correct assumptions are made. This is for three reasons:

- There are too few instances of mobile mergers in Europe in recent times to make reliable statistical inferences about the 'average effect' of market consolidation.
- There are factors which affect the impact of mergers (e.g. degree of network sharing, planning restrictions) which cannot be systematically controlled for in a statistical analysis.
- Each merger is unique with different impacts on consumer outcomes which take different amounts of time to materialise – this exacerbates the difficulty in finding an 'average effect' of mergers.

For these reasons, Frontier has developed case studies of mobile mergers in Austria and Ireland, where Three sister companies merged. Frontier finds that both mergers have delivered significant consumer benefits in terms of higher investment, better average download speeds and improved coverage.

We have complemented Frontier's work by assessing the impact of the Irish and Austrian mergers on prices. [64] We find that price competition remains strong in Austria and Ireland post-merger: both countries are

[64] Assessing pricing outcomes was outside of Frontier's remit for the Irish and Austrian case studies.

among the cheapest for mobile services in Europe with Three as the lowest-cost MNO in each country.

Ofcom's results disappear once the correct investment measure (investment per subscriber) is used

Ofcom's December 2020 paper found a negative relationship between the number of MNOs and investment per capita at the industry level. Because Ofcom also found a positive relationship between investment per capita and quality (proxied by average download speeds), it concluded that there is a negative 'indirect' relationship between the number of MNOs and average download speeds.

These findings contrast with the existing literature which either finds a positive relationship or no statistically significant relationship between consolidation and investment. Frontier finds that, taken in the round, mergers can in principle lead to improved consumer outcomes and the question of whether they do is an empirical one.

Frontier provides a comprehensive critique of Ofcom's paper, explaining why its results cannot be relied upon. The two main issues with Ofcom's analysis are:

- Ofcom's measure of concentration includes market entry inappropriately.
- Ofcom's findings appear to be driven by an erroneous investment measure.

Firstly, the discussion paper assumes the average impact of entry on investment is symmetrical to the average impact of a merger (i.e. a merger in one country and an entry in another will have the same sized impact but in opposite directions).

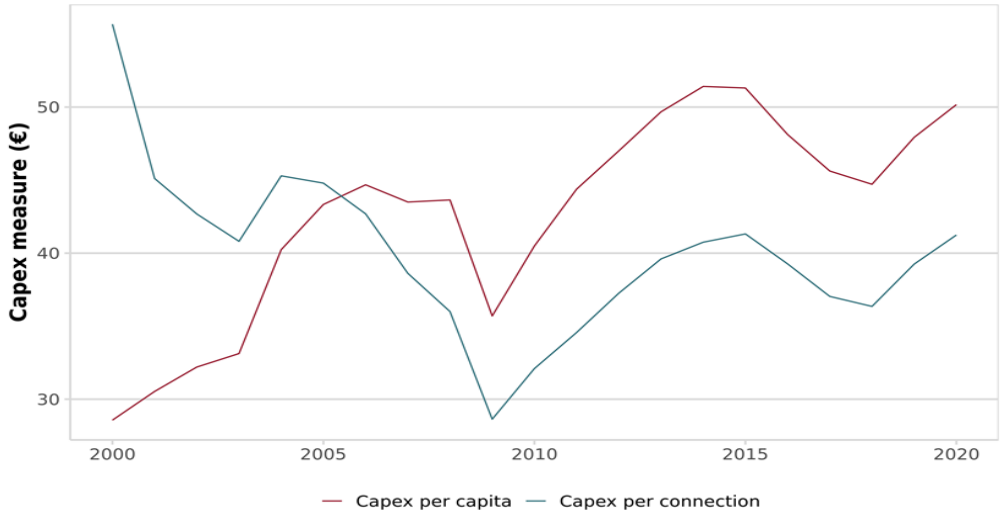
Frontier finds that this assumption is not justified in principle and is unsupported by the evidence. This implies that the estimated effect of a merger will be influenced by the strength of any effect of entry.

The second issue is the measure of investment chosen by Ofcom. The discussion paper uses investment per capita at the industry level, rather than investment per connection. This is not the right measure to use. MNOs invest in their networks to support the expected number of subscribers and traffic, not based on expected population growth in a country.

As the sample used by Ofcom covers the early 2000s (when mobile adoption was growing rapidly), the difference between the two measures

of investment between 2000 and 2009 is significant. From 2009 onwards, once mobile market penetration had stabilised, the relationship between the two are measures are broadly similar.

Figure 26: Investment per capita vs investment per connection (across 30 European countries in Ofcom's sample)[65]



Source: Frontier Economics: THE IMPACT OF MOBILE MARKET CONSOLIDATION ON QUALITY. A report for Three UK (Dec 2021)

Investment per connection reflects more accurately the investment that impacts mobile subscribers, especially during the period when the market was growing (i.e. when the number of subscribers was different from the size of the population).

Ofcom's finding of a positive relationship between the number of MNOs and investment per capita simply reflects the fact that, during the early 2000s, investment per capita was rapidly rising due to increased mobile adoption, and there was also a wave of MNO entry into the market.

Using (substantially) the same data set, Frontier has been able to replicate Ofcom's findings when measuring investment on a per capita basis. Frontier finds no impact of consolidation on investment when the correct measure of investment (i.e. capex per connection) is used.

[65] Graphs are weighted averages of investment per capita and investment per connection for the 30 countries in the GSMAi dataset. Countries are weighted according to the number of connections in each country

This shows that Ofcom's results are driven by its choice of investment measure (which is uniquely used by Ofcom and is not used elsewhere in the literature).

Moreover, our view is that Ofcom has erroneously studied investment at the industry level. It would be more informative to estimate the impact of mergers on operator-level investment since this is what drives network quality and consumer outcomes.[66,67] Frontier corrects for this in its own analysis by using capex per connection at the operator level.

In relation to speeds, Ofcom's paper finds a positive relationship between investment and speeds, but no direct relationship between market structure and speeds. It follows, based on the above analysis, that consolidation should not be expected to have a negative impact on speeds (as it has none on investment).

Frontier finds no statistically significant relationship between merger and investment per connection or speeds

Frontier has built on Ofcom's analysis using econometric techniques to estimate two relationships: i) the relationship between market structure and investment per mobile connection at the operator level; and ii) the relationship between market structure and average download speeds.[68]

This analysis controls for the influence of factors other than market structure, such as the rollout of 4G and dynamics of investment. Frontier finds no statistically significant relationship (positive or negative) between mergers and investment per mobile connection, or between mergers and download speeds.

Frontier concludes that these results are not surprising given that:

- The absence of a positive or negative effect is consistent with the theory, especially for the type of mergers / entries in Frontier's sample (4-to-3 and 3-to-4).

- There are effectively only three countries in the sample which can provide insights into the impacts of mergers on investment and speeds.

[66] The download speeds that Three offers its customers are not impacted by how much money Vodafone, EE and Virgin Media/O2 choose to invest in their networks.
[67] Ofcom rejects studying operator-level investment on the basis that mergers lead to larger firms which naturally invest more. This can simply be remedied by studying investment per connection.
[68] The statistical analysis effectively compares the outcomes in markets where there have been mergers and in markets where the number of operators has not changed.

- Some factors are hard to control for in a systematic way, e.g. the degree of network sharing (no/limited network sharing vs. passive vs. active), how many players share networks and coverage obligations. These make it more difficult to identify the impact of mergers on investment per connection and average download speeds accurately.

- If quality is impacted over varying timeframes in different markets that have undergone consolidation, it may be challenging to identify a universal relationship between mergers and quality, especially if the data only covers a relatively short period of time after the mergers took place.

This should not be interpreted as meaning there is no positive relationship between mergers and investment. Instead, they are more likely to reflect the challenges in finding an 'average merger effect' in statistical studies.

Even if we were to take it on face value, the finding of no material impact on capex per connection is consistent with the merging parties re-investing some of the capex savings resulting from the merger. This would suggest that subscribers of the merging parties could expect to see an improvement in quality of service.

Mergers of Three sister companies in Austria and Ireland have materially improved consumer outcomes

Given the limitations of statistical studies, Frontier has undertaken a detailed assessment of the two 4-to-3 mergers involving Three companies in Europe: Austria and Ireland.[69]

Once network integration had been completed, consumer outcomes have improved significantly in both Ireland and Austria. Table 7 provides a high-level summary of key post-merger outcomes we've identified.

[69] Frontier Economics did not study Italy as this is a 4 to 4 merger and the results would be affected by the entry of Iliad as a merger remedy.

Table 7: Summary of post-merger outcomes for Three sister companies in Austria and Ireland

	Capex	5G speeds	5G coverage	Prices
Austria	+32%	Fastest 5G network	Joint 5G coverage leader	7th cheapest (of 33) in EC study
Ireland	+23%	Fastest 5G network	Joint 5G coverage leader	5th cheapest (of 33) in EC study

Source: Three

This section sets out the conclusions of Frontier's case studies:

- The Three / O2 merger in Ireland has delivered significant benefits to consumers – particularly after both networks were integrated in 2019.
- In Austria, consumer outcomes improved within two years of the Three-Orange merger.
- Quality improvements in Ireland and Austria would not have materialised absent those mergers.

We also present our own assessment of how prices in Austria and Ireland have remained competitive post-merger.

The Three / O2 merger in Ireland has delivered significant benefits to consumers

As the most recent entrant to the Irish market, at the time of the merger Three had a scale disadvantage (with only 12% market share) and relied on a roaming agreement with Vodafone for 2G coverage.

Three had extensive 3G coverage, but its 4G rollout was limited (30% population coverage) compared to market leaders Vodafone and Eir (57% and 58% respectively). Meanwhile, O2 had invested in 4G spectrum but it had not invested significantly in rolling out a 4G network.

The merger reduced the number of MNOs from four to three. Immediately after the merger, Vodafone remained the largest network (42% market share), while Three became the second-largest network (37%) with Eir in third place (21%).

Integration of the Three and O2 networks took 4 to 5 years to complete due to existing network sharing agreements,[70] merger remedies[71] and differences in equipment used by Three and O2. While the integration was substantially completed in 2019, [✂].[72] This is one of the reasons why a statistical cross-country analysis is likely to be misleading.[73]

Impact on investment

Scale has enabled Three Ireland to make large network investments post-merger (ie the 'Big Upgrade'). The merged entity ramped up investment following the merger in 2014, investing significantly greater sums than Three and O2 had previously invested on a standalone basis.

Figure 27: Three/O2 ramped up investment in Ireland following the merger

[✂]

Source: Three Ireland

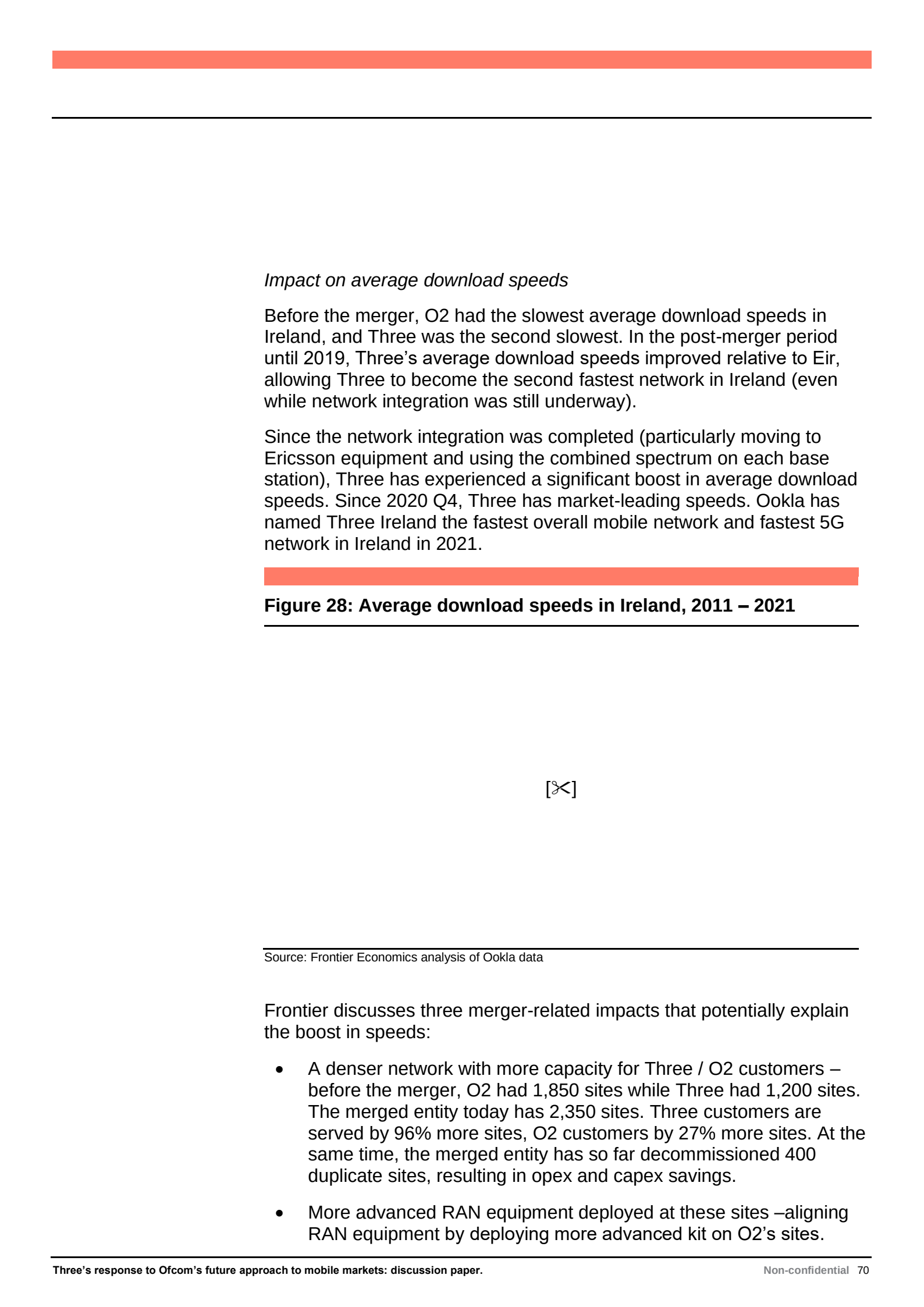
[70] O2 previously shared the passive infrastructure on its network with Eir.
[71] As a condition of clearing the merger, Three was required to share its network with Eir.
[72] [✂]
[73] Econometric techniques aim to pick up an 'average' effect of the studied relationship. When the impact of different mergers is experienced after different amounts of time post-merger, it is difficult for statistical techniques to pick up an average effect (particularly when there is only a small treatment sample).

Impact on average download speeds

Before the merger, O2 had the slowest average download speeds in Ireland, and Three was the second slowest. In the post-merger period until 2019, Three's average download speeds improved relative to Eir, allowing Three to become the second fastest network in Ireland (even while network integration was still underway).

Since the network integration was completed (particularly moving to Ericsson equipment and using the combined spectrum on each base station), Three has experienced a significant boost in average download speeds. Since 2020 Q4, Three has market-leading speeds. Ookla has named Three Ireland the fastest overall mobile network and fastest 5G network in Ireland in 2021.

Figure 28: Average download speeds in Ireland, 2011 – 2021



Source: Frontier Economics analysis of Ookla data

Frontier discusses three merger-related impacts that potentially explain the boost in speeds:

- A denser network with more capacity for Three / O2 customers – before the merger, O2 had 1,850 sites while Three had 1,200 sites. The merged entity today has 2,350 sites. Three customers are served by 96% more sites, O2 customers by 27% more sites. At the same time, the merged entity has so far decommissioned 400 duplicate sites, resulting in opex and capex savings.
- More advanced RAN equipment deployed at these sites –aligning RAN equipment by deploying more advanced kit on O2's sites.

- More efficient use of spectrum – pre-merger Three had no 800MHz spectrum (critical for 4G coverage). Post-merger Three customers had access to O2's 2x10 MHz of 800MHz. Three and O2 were able to pool their respective 900MHz (2x5 MHz and 2x10 MHz respectively) to serve both customer bases, and to re-farm it more efficiently for 3G and 4G.

Impact on coverage

The Three O2 merger in Ireland had the following impacts on coverage.

Table 8: Coverage outcomes of Three's merger in Ireland

	Pre-merger	Post-merger
2G	• Three: no 2G network • O2: 86.3% pop coverage (indoors)	• Three / O2: 99.7% pop coverage (indoors) • Three customers gained access to O2's 2G network
3G	• Three: 66% pop coverage (indoors) • O2: 66% pop coverage (indoors)	• Three / O2: 99% pop coverage (indoors)
4G	• Three: 43.1% pop coverage (indoors) • O2: no 4G rollout	• Three / O2: 97.6% pop coverage (indoors) • O2's customer gained access to (what has become) a nationwide 4G network

Source: Frontier report

Scale has enabled Three Ireland to make large network investments and provide nationwide coverage with its own network, without national roaming or a network sharing agreement with Vodafone (which was terminated following the merger).

As a result, Three Ireland is now a market leader in 5G coverage. OpenSignal estimates that Three customers spent 10.3% of their time connected to 5G in Ireland in May-August 2021, compared to 7.8% and 4.8% for Eir and Vodafone's customers respectively.[74] In a recent survey, Three has reliable 5G coverage in over 2,400 square km areas across Ireland, compared to 1,000 sq. km for Eir and 800 sq. km for Vodafone.[75]

[74] https://www.opensignal.com/reports/2021/09/ireland/mobile-network-experience-5g
[75] Source: Systemics-PAB, Benchmark Measurements of 5G coverage in Ireland.

It is likely that absent the merger Three and O2 would have had lower coverage, as they both had fewer coverage sites and less sub-1GHz spectrum. This is particularly the case for Three, given it only had 2x5 MHz of 900MHz spectrum before the merger. Moreover, Three's and O2's incentives to increase coverage would have been limited due to their smaller scale.

Impact on prices

Our assessment shows that Three Ireland has continued to compete aggressively on prices following the merger, dispelling the myth that mobile mergers are simply a means to reduce competition and raise prices at the expense of consumers.

After Three achieved greater network parity, other MNOs started competing on price and offering larger data allowances. In Ireland, Vodafone and Eir now offer unlimited data (which only Three offered pre-merger).

Irish MNOs have launched low-cost sub-brands offering unlimited data at low prices. These sub-brands (Vodafone's X and Clear Mobile, Eir's Gomo and Three's 48), did not exist under the previous four-MNO market structure.

As discussed in Section 2, the EC's report on mobile prices in 2020 in Europe finds the following:

- Ireland is one of the nine 'inexpensive' countries out of 33 European countries – the 5th least expensive country in Europe.

- Three Ireland provides the least expensive offers across all 12 service baskets in the Irish market.

In Austria, consumer outcomes improved within two years of the Three-Orange merger

Before the merger, Three (13% market share) and Orange (17%) lagged A1 Telekom (40%) and Magenta Telekom (30%) in terms of market share. As the joint-newest entrant in the Austrian market (alongside tele.ring – now a Magenta Telekom subsidiary), Three was disadvantaged due to its limited 3G-only spectrum holdings.

The merger completed in early 2013, reducing the number of operators from four to three. While the merger meant that Three's active subscriber

base more than doubled from 1.3 million to 2.8 million, Three remained the smallest of the MNOs.

Impact on investment

Before the merger, Three planned to invest €[✂] m on a standalone basis between 2013 and 2016, and Orange planned to invest €[✂] m. In combination, both MNOs would have invested €[✂] m absent the merger. Following the merger the combined entity invested €[✂] over the period – [✂] % more than the sum of the standalone entities – to build a high-quality network.

Table 9: Network capex, Three Austria and Orange (€m)

MNO	2013	2014	2015	2016	2013-2016
Three standalone Business Plan					
Orange standalone Business Plan					
Sum of standalone Business Plans					
Merged entity actuals			[✂]		

Source: Three Austria

Impact on average download speeds

The integration of the Three and Orange networks completed by February 2014, only fourteen months after the merger. Figure 29 shows average download speeds for Austrian MNOs between 2011 and 2019. The vertical dashed line represents the merger between Three and Orange.

Figure 29: Average download speeds in Austria, 2011 – 2019

Source: Frontier Economics analysis of Ookla data

Before the merger, Three and Orange had the slowest speeds among Austrian MNOs. By mid-2014, shortly after network integration was completed, Three's average download speeds jumped from 4Mbps to 21Mbps (an increase of 425 percent).

This followed completion of Three's 4G rollout ahead of rivals. Three became the speed leader in the Austrian market, triggering a competitive response from rivals and driving a substantial increase in download speeds across the market.

More recent Ookla data since 2019 indicates that Three is now the market leader in Austria in terms of average download speeds. Three won Ookla's 2021 Speedtest award for fastest 5G mobile network in Austria: Three's median 5G download speed was 183 Mbps compared to 145 Mbps and 111 Mbps for Magenta Telekom and A1 respectively.

Frontier discusses two network improvements that led to this outcome:

- The merged entity was able to make more efficient use of its spectrum holdings – before the merger, Orange used its 1800MHz spectrum for 2G. Following the merger, Three re-farmed some of this spectrum to 4G.

- Three was able to combine 1800MHz spectrum dedicated to 4G with its 2600MHz 4G spectrum using carrier aggregation – giving a performance boost that would not have been possible for either of the networks on a standalone basis.

Impact on coverage

Before the merger, Three had extensive 3G coverage while Orange had a limited 3G network footprint (35% of the population). At the time of the merger, Three's 4G coverage was similar to A1 Telekom's (31% and 30% population coverage outdoors respectively). Orange had an extremely limited 4G footprint.

Before the merger, Three had [✂] 3G sites. By the end of 2013, Three's 3G network had grown to [✂] sites – [✂] % more than its standalone network. Following the merger, Three had by far the highest number of 4G sites ([✂]).

In around three years, the merged entity reached 98% 4G population coverage (outdoors) by August 2015, compared with Three's standalone plan of [✂] % (and Orange with [✂]). Three Austria became the 4G coverage leader, as A1 provided 87% and T-Mobile 75% 4G population coverage.

Table 10: Three Austria, population coverage (%)

	Three stand-alone forecasts			Three / Orange actuals		
	2G	3G	4G	2G	3G	4G
2013	[✂]			99%	96%	26%
2014				99%	96%	65%
2015				99%	98%	98%

Source: Three Austria

Impact on prices

The EC authorised the Austrian merger in December 2012 subject to remedies, including a reference offer for up to 16 MVNOs to have wholesale access to Three's network. The MVNO sector has grown to approximately 12% of the market following large scale entry by MVNOs.

Austrian consumers now enjoy low prices and aggressive price competition from low-cost MVNOs, such as HoT (owned by Hofer, the Austrian arm of supermarket Aldi) and Spusu (an MVNO on Three's

network), which have achieved 7.1% and 2.4% market share respectively.

As discussed in Section 2, the EC's report on mobile prices in 2020 in Europe finds the following:

- Like Ireland, Austria is one of the nine 'inexpensive' countries out of 33 European countries – the 7th least expensive country in Europe.

- Three Austria is the lowest cost provider in Austria, providing the least expensive offers across 10 out of 12 service baskets in the market.

Quality improvements in Ireland and Austria would not have materialised absent those mergers.

The analysis presented above compares outcomes before and after the Austrian and Irish merger (a 'before and after' analysis), linking observed improvements in Three's quality to specific outcomes of mergers in Ireland and Austria.

An alternative approach is a 'with-and-without' analysis. This asks: would the observed improvements have materialised had Three not merged? This analysis compares observed outcomes with and without the merger – which requires constructing a 'counterfactual' of the likely situation absent the merger.

For these purposes, Frontier compares observed outcomes (i.e. average download speeds) in Austria and Ireland against those in a 'control group' – i.e. typical 3rd and 4th MNOs in European four-player markets – which serve as the counterfactual. These are calculated by aggregating data on the 3rd and 4th MNOs (according to market share) in seven European markets served by four MNOs.

Figure 30: Three's speeds in Austria and Ireland vs average speeds for the typical 3rd and 4th MNO in four-player markets.[76]

Source: Three Austria

Frontier finds three important conclusions from this analysis:

- Average download speeds of the typical 3rd MNO in four-player markets grow faster than those of the typical 4th MNO in the same markets. This implies a positive link between scale (relative to the size of the market) and growth in average download speeds.

- Shortly after the merger in Austria, Three Austria's speeds improved much more quickly than those of the typical 4th and 3rd MNOs. It is possible that, had Three not merged with Orange in Austria, Three Austria's speed improvement would have been closer to the improvement of the typical 4th MNO.

- After the Irish merger, Three Ireland's speed broadly tracked those of the typical 4th MNO until 2019, when the network integration was completed. After that, the speed improvement achieved by Three Ireland far exceeds that the typical 4th MNO. Had the merger not gone ahead in Ireland, Three Ireland's speed boost may have been closer to that of the typical 4th MNO).

[76] Dashed lines denote projections based on 2018 to 2019 growth rates. The typical fourth operator and typical third operator is calculated using data on the third and fourth largest MNO (based on current market share) in Denmark, Poland, Romania, Slovenia, Spain, Sweden and the United Kingdom. Data on the relevant MNO from each country is weighted according to the number of speed tests recorded for that operator.

Frontier concludes from these case studies and comparisons to ‘typical’ MNOs indicate that consolidation has a beneficial impact on consumer outcomes, but these impacts can take time and be realised in different ways over different periods.

5. The mobile value chain has evolved, so future mobile regulation should no longer focus on the MNO

As discussed in Section, 1, the MNO has been the focus of mobile regulation in the UK. The original justification for this policy was that the MNO plays a central position in the mobile value chain by virtue of its control of the RAN and spectrum.

We welcome Ofcom's acknowledgment that, increasingly, mobile networks are just part of the range of different wireless technologies people use to meet their needs.

As Ofcom has found, 5G creates an opportunity for an expansion of the market. New types of firms – with different business models – are expected to enter the market to provide mobile networks and sell mobile services to UK consumers.

In consequence, the focus of mobile regulation on a particular type of player (the MNO) operating at a specific level of the mobile value chain (the RAN) is no longer appropriate. Future mobile policy should not seek to maintain network competition between four MNOs, but rather promote innovation and investment by all market players – MNOs and others.

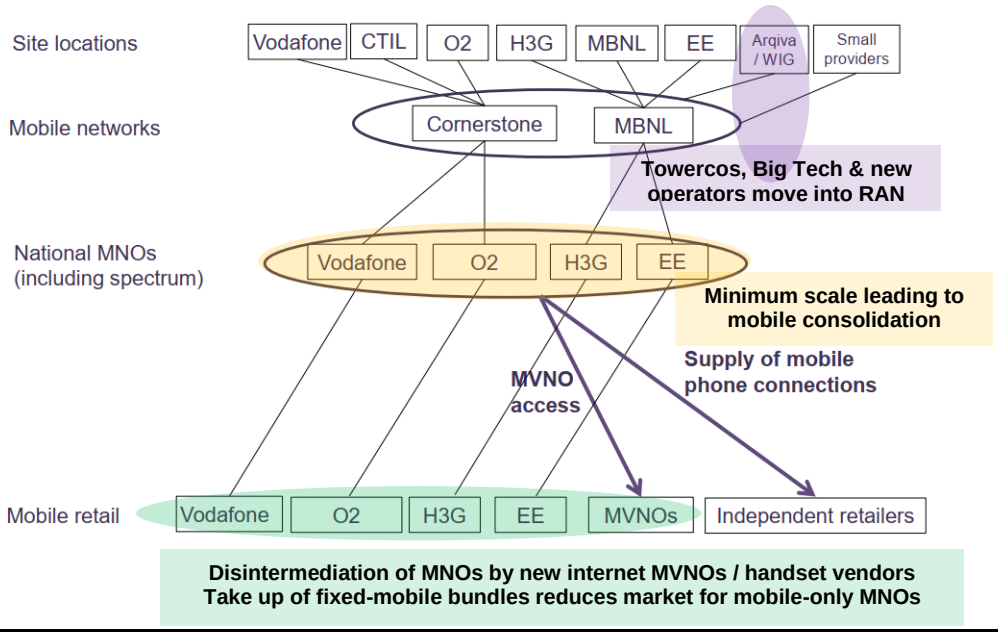
Fundamental changes in consumer behaviour, and in the way telecoms services are delivered are impacting the economics of mobile connectivity. These changes threaten the role and viability of the national MNO model in the value chain, [✂]. The key market trends are:

- At the wholesale level, the emergence of new RAN operators and providers of mobile connectivity (ie Towercos, Big Tech and local private 5G network providers) competing with the MNO.

- At the retail level, key changes in the way mobile services are purchased – such as the potential for increased take-up of fixed-mobile bundles and disintermediation of the MNO role (facilitated by eSIM).

These changes to the UK mobile value chain are illustrated in Figure 31.

Figure 31: Key changes to the mobile value chain in next decade



Source: Three

We discuss each of these market trends in turn.

New network providers are emerging to compete with MNOs at the RAN level (Towercos, Big Tech, neutral hosts and private network providers)

As Ofcom has found, MNOs have traditionally played a central role in the provision of mobile networks – particularly the RAN. This is changing, however. 5G opens the mobile market to new RAN operators and will also require significant changes in how mobile networks are configured.

Towercos and neutral host models are entering the macro-RAN

National MNOs are seeing some of their traditional functions taken over by Towercos or 'neutral host' providers. Under this model, an independent infrastructure provider with no retail mobile operation owns elements of the network. MNOs then pay to access this infrastructure, sharing masts and avoiding the upfront cost of installing it.

Traditionally, MNOs rent access to sites and other passive infrastructure from independent towercos (such as Cellnex or WIG in the UK). As discussed in Section 3, this part of the mobile value chain is rapidly evolving as MNOs divest RAN assets (or outsource management to specialised Towercos). The assets typically involve passive elements

(sites, masts, and associated infrastructure),[77] not active equipment or backhaul (which remain the responsibility of the MNOs).

Here in the UK, the CMA has recently approved the proposed acquisition by Cellnex of the wireless telecoms infrastructure business of the CK Hutchison Group in the UK (subject to a site divestment remedy). Vodafone and Telefónica have made public their intention to commercialise CTIL to create a leading tower infrastructure company in the UK.[78]

Vodafone has transferred its 50% equity stake in CTIL to Vantage Towers (its European tower business). Telefónica has agreed to sell its controlling stake in Telxius (which operates Telefónica's passive infrastructure assets in Germany, Spain and Latin America) to American Tower, a third party towerco.[79]

In effect, some MNOs are giving up control of passive elements of the RAN to an independent Towerco, which can then lower barriers as that infrastructure is made available on a wholesale basis to multiple operators.

These transactions reflect a global trend towards vertical dis-integration of the mobile value chain. RAN assets and activities previously carried out by the MNO are being transferred to an auxiliary industry of specialised tower operators. This further mirrors market trends in the US, where independent tower operators are now the norm.

Vertical dis-integration is one of the industry's responses to declining mobile revenues and escalating costs. MNOs seek to exploit economies of scale, unlock the value of their passive assets (to finance the rollout of 5G networks), make 5G rollout more efficient and reduce RAN costs through the sharing of passive infrastructure (as independent towercos make those assets available to new operators).

The towerco / neutral host model may naturally evolve to one where the towerco owns the active kit – not just the passive infrastructure – to provide an integrated RAN solution to MNOs, including access to site space and wholesale capacity. MNOs would share kit on a shared site

[77] Shelters, power supply equipment, fences, lightning protection systems, aircraft warning lights and cooling systems

[78] See https://www.cornerstone.network/media/vodafone-and-telefonica-commercialise-cornerstone. See also sections 15.4.10 and 16.4.6 of the Vantage Towers prospectus, available here: https://www.vantagetowers.com/sites/tower-co-v2/files/vantage-towers-prospectus-v3.pdf.

[79] See https://www.telefonica.com/en/web/press-office/-/telefonica-sells-telxius-tower-division-to-american-towers-corporation-at-record-multiples-for-7-7-billion-euros.

and transmit using their own separate frequencies. There is increased interest in the mobile industry in this model.

As a recent example, Cellnex has reached an agreement with Cyfrowy Polsat in Poland to acquire passive assets (c.7,000 towers and sites) and active infrastructure and backhaul (including c.37,000 radio carriers, 11,300 km of fibre backhaul, and a national network of microwave links).[80]

Cellnex views its expansion into active infrastructure as one which *"evolves the traditional tower operator model towards an integrated telecommunications infrastructure management model, combining the operation of passive elements (towers) and active elements such as transmission equipment, radio links and fibre-to-the-tower".*

This evolution of the value chain has important implications for mobile regulation. First, the rise of the passive infrastructure towerco lowers barriers to entry into the RAN, as the towerco can quickly and easily expand into active equipment and become a RAN operator in its own right (as evidenced by Cellnex' move in Poland).

Second, a model where MNOs rent both active equipment and passive infrastructure from a neutral host towerco could fundamentally change the competitive landscape in mobile. In this model, responsibility for buying and deploying active equipment (and backhaul) transfers to the towerco.

This effectively turns towercos into national RAN operators. As discussed in Section 3, competition is pushing MNOs to pool network assets (spectrum, equipment, and sites) in order to leverage economies of scale.

This model provides an alternative route to exploit these scale economies and may ultimately lead to consolidation of networks between MNOs. The MNO would effectively become an MVNO, with its role limited to contributing spectrum (via leasing, trade, etc.) and renting wholesale capacity from the towerco.

Big Tech as new suppliers of mobile connectivity

In parallel, Big Tech is looking to leverage cloud capabilities to enter the traditional domain of the MNO. Cloud providers like Amazon Web Services, Microsoft Azure and Google Cloud are already providing public

[80] 20210226-Cellnex-to-acquire-Polkomtel-Infrastruktura_EN-2.pdf (cellnextelecom.com)

cloud core services to MNOs – i.e. storing and processing data close to the core of the network.

These players want to take centre stage in the re-architecture of the RAN needed to provide 5G 'edge cloud' services. This entails storing and processing data closer to the edge of the network (i.e. the RAN) to enable new 5G uses that require low latency, high bandwidth, etc.

Different MNOs are at different stages along the path of 'cloudification':

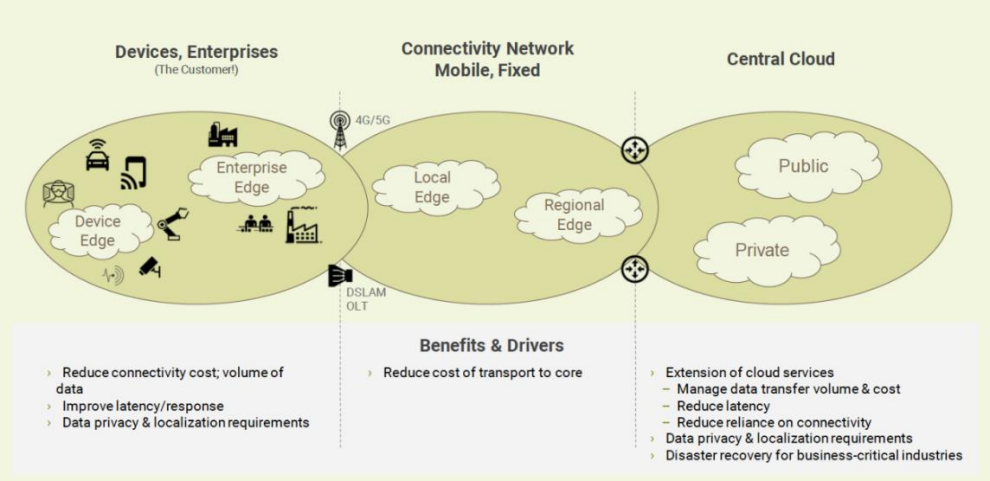
- Some MNOs have deployed a virtualized core in the private cloud and are moving IT functions to the public cloud – for instance, Three has a virtualised core network in 20 of our data centres and has moved IT workloads to Microsoft Azure.

- Other MNOs are moving the core network (plus IT functions and some operation and business support systems) to the public cloud – e.g. AT&T with Microsoft Azure. This is important as the core network is the key enabler of network slicing and other 5G functions.

- Some MNOs (particularly newer ones) are deploying and operating their 5G RAN network in the public cloud ('Cloud RAN') – to provide 5G network slicing and edge computing to industry verticals / enterprises / private networks and the public sector (eg Dish, Rakuten, Drillisch).

The end game for cloud players is not hosting core and IT functions for MNOs – instead, they want a stake in hosting 5G edge computing applications and enterprise wireless networks (i.e. the left hand side of Figure 32).

Figure 32: Ecosystem and drivers of the Edge Cloud



Source: Axon Partners

To do so, cloud players are vertically integrating by moving downstream in the value chain, from the provision of data centres and long-distance cables to the edge – i.e. the RAN, where MNOs provide connectivity to end users. Big Tech wants a stake in the growing market for eMBB, URLLC and IoT 5G services and is developing network functions themselves or acquiring network function vendors for this purpose.[81]

Cloud players seem particularly interested in entering the enterprise market for private 5G networks, either in collaboration with MNOs (i.e. the MNO manages the private network and the cloud provider provides computing and edge applications) or in competition them (i.e. where the cloud provider hosts network functions and edge applications directly for the enterprises, bypassing the MNO).

In this model, Big Tech assumes responsibility for edge platforms and applications, and possibly for much of the network infrastructure too. The MNO role is limited to providing wholesale connectivity only or is taken out of the equation altogether.

[81] Microsoft has acquired Affirmed Networks (a developer of EPC/5G core) and Metaswitch (IMS). This makes Microsoft a competitor of equipment vendors like Cisco, Ericsson or Nokia.

New neutral host providers of small cell connectivity

Beyond the traditional macro model, 5G requires small cells connected to a power source and installed on street furniture like lampposts, CCTV columns and bus shelters, as well as on the side of buildings.

The prevailing model in the UK is one where this infrastructure is operated by a neutral host. Typically, a neutral host first acquires access rights to assets on which small cells can be placed by winning concessions from the asset owners, such as Local Authorities or Tfl in London. The host then markets the small cells to MNOs in specific locations (and in some cases shares some of the revenues with the owner of the assets).

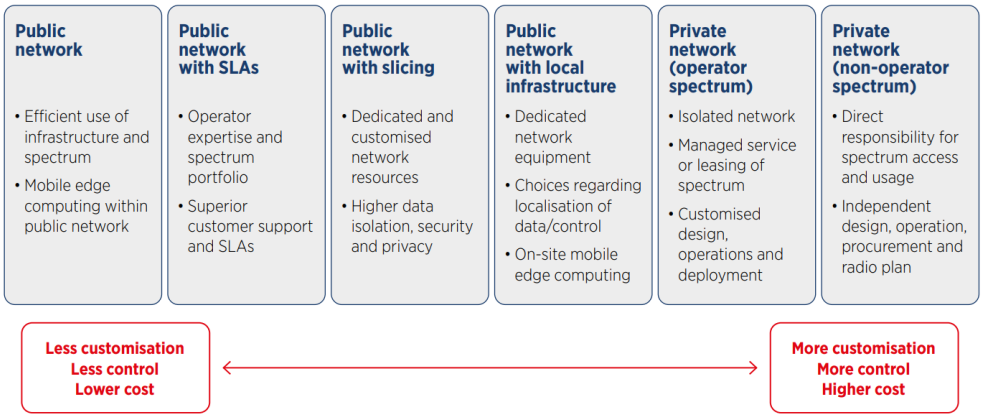
For instance, BAI has just won a Tfl concession to provide mobile coverage at stations and in tunnels in the London Underground, including the commercialisation of 80k streetscape assets (street lighting columns and bus shelters) which can be marketed for small cell deployment.

New providers of private networks

Finally, 5G opens up new opportunities for new connectivity providers to supply private 5G networks in competition with MNOs. Private networks allow enterprises to have greater control over their connectivity needs, with services tailored to their individual requirements (e.g. in terms of coverage, latency, security, etc).

As Ofcom notes, the industry expects significant growth in this area. Different models are emerging with varying levels of MNO involvement.

Figure 33: Private network models



Source: GSMA 'Mobile Economy 2021'

An MNO's involvement in these models ranges from:

- Providing its public network to serve an industry vertical (with mobile edge computing applications sitting within the public network) – with or without Service Level Agreements.
- Providing a network slice – i.e. a dedicated portion of the network with service levels tailored to the specific needs of the enterprise.
- Providing spectrum only – i.e. via a leasing agreement with the enterprise.
- Having no involvement at all – e.g. where a cloud player or equipment vendor or system integrator provides private networks and edge computing services directly to industry, without MNO intermediation, using shared 5G spectrum from Ofcom (e.g. 3.8-4.2GHz).

As discussed above, cloud players and equipment vendors have entered the private network market, sometimes in collaboration with MNOs, sometimes replacing the MNO function altogether (as in the last model above).

Disintermediation of the MNO and fixed mobile convergence threaten the viability of the MNO model at the retail level

As Ofcom highlights, buying patterns of UK consumers are evolving. The UK retail market is moving towards unlimited offers with 5G. SIM-only offers now constitute approximately 70% of the industry's weekly contract sales (ie. handset and SIM-only).

Contracts separating out the device from the airtime are very popular, and customers increasingly buy their devices outside the traditional MNO channels – i.e. online or directly from the manufacturer.

Against that background, the retail market is ripe for significant changes in terms of how mobile connectivity is purchased, including potential disruption by Big Tech. Key changes involve increased take-up of fixed-mobile bundles and potential disintermediation of the MNO role (facilitated by eSIM).

Fixed-mobile convergence and the future size of the market for mobile-only MNOs

Fixed operators and MNOs are merging. Here in the UK, BT/EE and Virgin/O2 have combined separate fixed and mobile operations to create a converged player. With this move, both players seek greater scale and cost and revenue synergies from fixed/mobile convergence.

If consumer take-up of these bundles picks up, the size of the market for mobile-only MNOs (such as Three UK) will correspondingly diminish. BT/EE and Virgin/O2 are betting on a future where mobile and fixed connectivity are purchased in a bundle (possibly with content, hardware, accessories, and related services), as is increasingly the case in other European countries.

Bundles of fixed services (broadband, landline or Pay TV) are already prevalent amongst UK consumers: 80% of UK households buy two or more bundled services from the same provider as part of a bundle. Dual-play (landline and fixed broadband) and triple-play bundles (landline, fixed broadband and pay TV) are the most popular bundles today.[82]

Take-up of fixed/mobile bundles is at an earlier stage of development: only 11% of UK households buy mobile as part of a bundle from the same provider (compared with 8% in 2016). Most commonly, this includes quad-play bundles including landline, broadband, pay TV and mobile.

Both BT/EE and Virgin/O2 intend to accelerate uptake of fixed/mobile bundles in the UK. As the two largest telecoms providers in the UK, they are well-placed to achieve this aim. EE and O2 have a combined 57% share of retail mobile subscribers in the UK.[83] BT and Virgin together account for 55% of retail fixed broadband connections in the UK market.[84]

These developments create obvious challenges for mobile-only players, such as Three UK. BT/EE and Virgin/O2 dwarf most other industry players in terms of customers, revenue, and profitability.

These players can accelerate take-up of fixed/mobile bundles in the UK by pricing aggressively on the mobile side of the bundle, as Telefonica did

[82] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/189112/pricing-trends-communication-services-report.pdf
[83] Figure A3.6 https://www.ofcom.org.uk/__data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf
[84] Sky, TalkTalk and smaller providers (Gigaclear, Hyperoptic and Vodafone) account for the remaining share of broadband connections. See Table 2.2 of Ofcom's Wholesale Fixed Telecoms Market Review 2021-26. https://www.ofcom.org.uk/__data/assets/pdf_file/0029/188822/wftmr-volume-2-market-assessment.pdf

successfully with Movistar Fusion in Spain. This could include giving free SIMs as part of the bundle, as Virgin is already doing with its top tier bundles.

The risk of MNO disintermediation by Big Tech

Big Tech is not only encroaching on the mobile RAN at the wholesale connectivity level – there is a clear risk it will do so at the retail level as well. As Ofcom highlights, the advent of eSIM could pave the way for Big Tech to enter the retail mobile market. Two models are possible:

- Apple and Google may become gatekeepers to mobile airtime subscriptions – i.e. by using their mobile operating systems as a platform from which customers can choose operator.

- Big Tech (and other providers like handset vendors) may launch internet MVNOs selling connectivity directly to UK consumers – like the Google Fi model in the US.

The first model is one where Apple and Google become gatekeepers to mobile airtime subscriptions. As Ofcom is aware, these players have an effective duopoly in mobile operating systems and application stores. Apple and Google sell handsets to UK consumers directly as well.

These players can leverage their dominance of the Android and iOS operating systems (OSs) to insert themselves between the customer and the MNO, acting as a mobile reseller.

The OS controls which applications can run on a phone. With this model, the handset would display multiple MNOs on the screen. The OS becomes a digital platform from which customers can choose MNO, directing customers to one operator or another based on commission.

As suppliers of the two key mobile OS in the UK, Apple and Google can decide which MNOs would appear on the phone. In this model, MNOs would have to pay Apple and Google to secure a good position on the screen, and also for every sale secured.

This follows a similar model to the one Apple and Google use with Google Play and Apple's App Store. These players decide which applications are allowed on their stores, how prominently they feature, and how they are discovered. Both Apple and Google charge commissions (up to 30%) on app developers' revenues from in-app transactions.

The second model entails entry into the retail market by new internet MVNOs, which could result in the 'disintermediation of the MNO'. The

MNO would lose the customer relationship and would be relegated to the role of wholesale connectivity provider (the so-called 'dumb pipe'). The more disruptive versions of the internet MVNO model could lead to the commoditisation of mobile connectivity.

This risk has been 'in the air' for over a decade, but the key ingredients for it to materialize are now present. The UK retail mobile market is shifting from airtime and device contracts purchased at an MNO's high street store to SIM-only contracts bought online.[85] Only around a third of UK handsets are now purchased directly from MNOs, and most of them are purchased online.[86]

The rise of e-SIM could bring about radical changes to the position of the MNO in the mobile value chain. Today, UK consumers sign a contract with an MNO and must insert the MNO's SIM into their device to connect to the network. To switch MNO, the consumer must swap out the SIMs. This effectively ties the handset to the MNO's network.

An embedded SIM ('eSIM') effectively decouples the device from the network. The eSIM is soldered in the device to accommodate multiple SIM profiles. The customer then signs a contract with the MNO and provisions the SIM remotely (e.g. by scanning a QR code).

With eSIM, a customer only needs to download new profiles in order to change MNO or add new MNOs. The handset will display multiple MNO networks on the screen, and the user can easily switch between them in real time or based on pre-defined parameters.

In the UK, EE, O2 and Vodafone already support eSIM. Three [✂]. Most major flagship handsets (e.g. from Apple, Google, and Samsung) and other devices (e.g. iPad and Apple Watch Series) already have eSIM installed.

The combination of eSIM and the internet MVNO can fundamentally alter the competitive landscape in the UK. eSIM lowers the cost of entry and expansion into the retail market by making it easier for customers to choose internet MVNOs with no physical retail presence and for MVNOs

[85] Ofcom data shows that bundled handset and airtime contracts accounted for 46% of the overall pay-monthly market in January 2019, compared to 74% in 2014. In turn, pay-monthly subscriptions represented 74% of overall mobile subscriptions in 2019. Over the same period, the proportion of SIM-only contracts (where customers pay monthly for the airtime and either purchase a handset separately or use a handset they already own) has nearly doubled from 21% to 38%. Ofcom expects this trend to continue. Para 1.16, https://www.ofcom.org.uk/__data/assets/pdf_file/0037/157699/statement-and-consultation-mobile-handsets.pdf

[86] https://www2.deloitte.com/uk/en/pages/technology-media-and-telecommunications/articles/digital-consumer-trends-mobile-operator-stores.html

(and their customers) to switch between MNOs at the tap of a key. If the internet MVNO model gains traction the MNO would effectively leave the retail mobile layer of the value chain.

Nokia has launched an internet MVNO in the UK (HMD Global). Customers can buy a Nokia smartphone and mobile connectivity (on EE's network) directly from Nokia.com and download an HMD Mobile app to manage their account.[87]

An even more disruptive model is the Google Fi model in the US. Google Fi has non-exclusive MVNO agreements with multiple MNOs. Google Fi devices 'multi home' on several networks, switching between them based on parameters determined by Google (such as cost, congestion or signal strength).

Players like Google, Amazon or Apple can use their bargaining power to impose non-exclusive MVNO agreements on UK MNOs. Customers would then switch MNO networks dynamically based on the best signal strength, or speeds, or coverage in the area at the time. [88] This service would be superior to what any individual MNO could provide on its own.

Both of these models – gatekeeper or internet MVNO – threaten the position of the MNO in the value chain and risk commoditising mobile connectivity, with on-screen comparisons focused on price, MNOs bidding to secure prominent positions and the customer relationship managed by Big Tech.

Conclusion

The focus of mobile regulation on a particular type of player (the MNO) operating at a specific level of the mobile value chain (the RAN) is no longer appropriate.

As Ofcom has found, 5G creates an opportunity for an expansion of the market. New types of firms – with different business models – are expected to enter the market to provide mobile networks and sell mobile services to UK consumers.

Market entry by new players means that future mobile policy should focus not on the number of MNOs, but rather on the strength of competition and

[87] HMD Mobile – a new mobile network to simplify the way people manage their mobile connection — HMD Global - The home of Nokia Phones
[88] Scenario 1: choosing the best mobile network operator – Open APIs in the Telecoms Industry (projectsbyif.com)

the ability of all players – MNOs and others – to invest and innovate for the benefit of UK consumers.

Annex A Frontier Economics report for Three UK: The Impact of Mobile Market Consolidation on quality.

Annex B Comments on Ofcom's profitability analysis.

Executive Summary

Ofcom estimates Return on Capital Employed (ROCE) for each UK MNO over the period 2017 to 2020. Ofcom takes a simple average of MNOs' ROCE and finds that "*at an industry level, financial performance appears to support investment*".[89]

In this Annex, we explain our view that Ofcom has not adequately supported its findings. Firstly, it is not appropriate for Ofcom to take an average ROCE across MNOs to make conclusions about investment incentives. It is individual MNOs that invest, not an 'average MNO' or the industry as a whole. Three does not make investment decisions based on EE's or Virgin Media O2's profitability.

Furthermore, we believe there are several other errors in Ofcom's analysis:

- Ofcom understates the real-world importance of historic accounting ROCEs (including goodwill and historic prices paid for spectrum) as a driver of investment, which Ofcom estimates to be below the cost of capital at 5.6% from 2017 to 2020;

- Even using Ofcom's approach to estimate economic ROCEs (where goodwill is excluded and spectrum is marked down to current values), it is clear that from 2017 to 2020 Three earned insufficient returns. We use Ofcom's approach to estimate a 2021 economic ROCE for Three, which is even lower than for 2020; and

- Ofcom's economic ROCE estimates are overstated because several 5G spectrum bands have been excluded from Capital Employed (3.4-3.8GHz, 3.9GHz, 28GHz and 40GHz).

We discuss these issues in more detail below.

Ofcom understates the real-world importance of accounting ROCE, which is below the cost of capital, as a driver of investment

Ofcom explains that economic ROCE is its preferred measure of returns, which it estimates by excluding goodwill from MNOs' balance sheets and marking down the value of MNOs' spectrum to current prices. Ofcom also discusses accounting ROCE and notes that:

[89] Para 1.22, Consultation

- "*some MNOs report accounting ROCE in their financial statements as a measure of financial performance*";[90] and

- 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*".[91]

Ofcom explains that while investment decisions should be based on expected future returns, "*historical performance can give an indication on how well existing investments have performed to date, which could impact market sentiment and act as a sense check on future expected performance*".[92]

We agree with this and believe that accounting ROCEs are heavily relied upon by investors. In normal circumstances, past returns offer a good guide to future levels of profitability, so historical performance (and accounting returns) is very important as an indicator of the likelihood that profit forecasts will be achieved.

When assessing historic performance, it is appropriate to consider the sums paid for spectrum, e.g. £22.5bn paid for 2100MHz spectrum in a 2000 auction, instead of Ofcom's estimated current value of £1.25bn. In the 2018 and 2021 auctions, MNOs invested in 700MHz and 3.4-3.8GHz spectrum with a view of generating returns, and when assessing the actual return it would be irrelevant if the value of the spectrum had changed since acquiring it.

Ofcom's analysis suggests that, including goodwill and historic prices paid for spectrum, accounting ROCEs over the period 2017 to 2020 were 5.6% (significantly below the cost of capital) on an industry basis, with only EE and Virgin Media O2 earning sufficient returns.

Even using Ofcom's approach to estimate economic ROCEs, it is clear that Three is earning insufficient returns

Ofcom accepts that "*not all MNOs have covered their cost of capital on a continuous basis*"[93] and that "*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*".[94]

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[90] Page 59, Consultation
[91] Para 6.15, Consultation
[92] Para 6.12, Consultation
[93] Para 1.22, Consultation
[94] Para 6.16, Consultation

To estimate economic ROCEs, Ofcom excludes goodwill from MNOs' balance sheets and marks down spectrum to its estimated current value. Ofcom's analysis from 2017 to 2020 shows that Three's economic ROCE was below the cost of capital.

We have used Ofcom's approach to estimate a 2021 economic ROCE for Three. Ofcom used Three's statutory accounts for its analysis of the period 2017 to 2020, but the 2021 statutory accounts are not yet available. In Table 11 below, we show how we have estimated Three's 2021 economic ROCE and compare this to Ofcom's calculation for 2020.

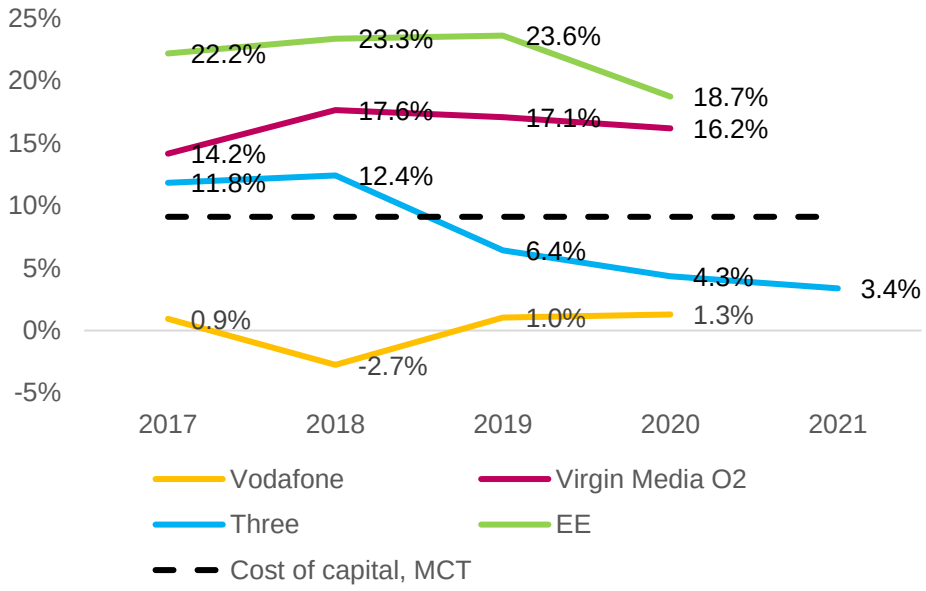
Table 11: Economic ROCE for 2021 using Ofcom's approach

		2020 (Ofcom)	2021 (Three)
EBIT		**£176m** (operating profit from statutory accounts)	[✂] (operating profit, not yet published)
Capital Employed	Fixed assets	£2,795m (average of 2019 and 2020 from statutory accounts)[95]	[✂] (average of 2020 figure and our estimate for 2021)[96]
	Spectrum (at current prices)	£1,248m (Ofcom's model)	[✂]
	Total Capital Employed	**£4,043m**	[✂]
ROCE		**4.3%**	**3.4%**

In Figure 34 below, we combine Ofcom's estimates for 2017 to 2020 (for each MNO) and add our estimated 2021 economic ROCE for Three. Even using Ofcom's approach, i.e. excluding Three's 700MHz, 3.4-3.8GHz, 3.9GHz, 28GHz and 40GHz spectrum, the picture of Three's insufficient returns is even clearer.

[95] Ofcom takes an average of 2019 (£2,640m) and 2020 (£2,950m).
[96] [✂]

Figure 34: Economic ROCEs using Ofcom's approach



Source: 2017 to 2020 figures from Figure 6.2 of Ofcom's Consultation. 2021 estimate for Three provided by Three as described above

Ofcom's economic ROCE estimates are overstated because it has excluded several spectrum bands

To estimate economic ROCEs, Ofcom excludes all MNOs' 3.4-3.8GHz spectrum and also excludes Three's 3.9GHz, 28GHz and 40GHz spectrum. These exclusions serve to artificially decrease Capital Employed and therefore inflate the economic ROCEs, which we do not believe to be appropriate.

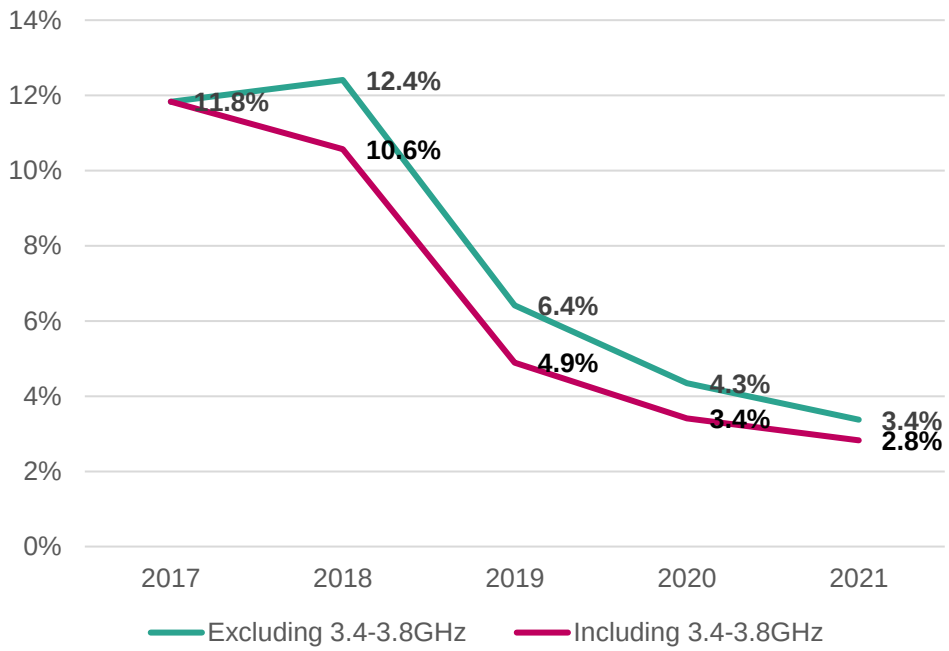
Ofcom excludes the 3.4-3.8GHz spectrum on the basis that it does not expect the spectrum "*to have generated any meaningful profit over our analysis period*".[97] This 5G spectrum has an opportunity cost (i.e. the value an MNO foregoes by not selling it, as Ofcom explained in its Statement on 3.4GHz and 3.6GHz ALFs) and our shareholder expects a return on that investment, so it should be included in the capital base. Further, Three has used this spectrum since it was acquired in 2017, initially to provide FWA services and since 2019 also for 5G mobile.

[97] Footnote 69, Consultation Annex 6

We understand that Ofcom may have excluded Three's 3.9GHz, 28GHz and 40GHz spectrum due to a lack of reliable information on its current value, but we note that this serves to further underestimate Three's Capital Employed and therefore overestimate Three's economic ROCE.

In Figure 35 below we show Ofcom's estimated economic ROCEs for Three, along with an additional set of estimates which include Three's 3.4-3.8GHz spectrum. We have also included 2021 ROCEs for Three, both using Ofcom's approach and using our approach where the 3.4-3.8GHz spectrum is included.[98] We consider these ROCEs to be upper limits given that Three's 3.9GHz, 28GHz and 40GHz spectrum are excluded.

Figure 35: Three's economic ROCE



Source: 2017 to 2020 estimates excluding 3.4-3.8GHz spectrum from Ofcom's model. All other estimates are provided by Three as described above.

[98] We have valued all of Three's 3.4-3.8GHz spectrum based on the 2018 auction price (for 2018 to 2020) and the 2021 auction price (for 2021).