Three's response to Ofcom's consultation on the PSSR Auction.

Non-Confidential

Date 6/02/17

Executive Summary.

Three welcomes the opportunity to respond to Ofcom's consultation on the competition issues pertaining to the Public Sector Spectrum Release (PSSR) of 2.3GHz and 3.4GHz spectrum.

In its consultation Ofcom sets out two key policy objectives for the PSSR: i) making spectrum available in a timely fashion; and ii) ensuring that the UK continues to benefit from a competitive mobile market.

It is through these policy objectives that Ofcom sees itself as fulfilling its duties to further the interests of citizens in relation to communication markets, to further the interest of consumers, where appropriate by promoting competition and to secure the optimal use of spectrum.

Ofcom's provisional conclusion is to cap immediately usable spectrum (IUS), where the level of the cap would only allow BTEE to obtain 2.3GHz spectrum if it sells some of its spectrum in advance. On the other hand, Ofcom proposes no restrictions on 3.4GHz spectrum, which represents 80% of the spectrum on sale.

In our response, we focus on Ofcom's primary objectives and explain why we believe a different set of proposals are needed in order to meet these objectives. Spectrum allocation is a key determinant of the future structure of the mobile market and of the intensity of competition within it. Ofcom can only achieve its policy objectives if its approach to the PSSR auction does not undermine the viability of a four-player market in the UK.

The need to protect competition was the key argument that Ofcom relied upon to oppose Three's acquisition of O2. Ofcom has also taken the view that competition drives both investment and coverage. It is extremely important for the confidence of the industry and investors that Ofcom pursues this logic to its conclusion.

It is our view that the current proposals will not meet Ofcom's objectives. We base this view on a detailed understanding of the market and how it has changed, on the significance and unusually extreme nature of the current UK spectrum imbalances, on the risk of strategic behaviour and scale advantage, and finally on the asymmetric nature of policy risk in this context.

If Ofcom does not intervene now to ensure the viability of a competitive four-player market, subsequent intervention will need to be far more drastic, much less proportionate and will carry far greater risk of regulatory failure.

The UK market has evolved to a data-centric market where an MNO needs between 20% and 30% spectrum to remain credible

Consumer preferences have now shifted. The UK mobile market has rapidly evolved from a voice-centric to a data-centric market. Traffic carried over UK mobile networks increased approximately eight-fold between 2011 and 2015, outstripping all expectations. In the month of October 2016 alone Three carried more traffic than [✂].

In a data-centric market capacity and speeds are increasingly important to consumers given the high quality they expect from the applications they want to use (particularly video streaming, web browsing and file downloads). Independent studies confirm the vital importance of speeds if an MNO is to remain competitive. It is essential that Ofcom's competition assessment takes into account this changing reality.

Furthermore, in a data-centric market economies of scale related to capacity are now crucial for competition. MNOs need to be able to expand their capacity significantly at lower cost if they are to remain credible. These economies of scale are going to make a four-player market structure increasingly difficult to sustain, particularly in the presence of large disparities in spectrum holdings between MNOs.

This is because MNOs need both spectrum and sites in sufficient quantity and quality to be competitive. Increasing both simultaneously in an area increases capacity more than proportionately and reduces the (long run) cost per unit of capacity. This means that MNOs with more spectrum will also find it profitable to deploy more sites than smaller MNOs. Because the cost of adding capacity falls in line with an MNO's holdings of spectrum and sites, the larger MNOs are only going to get larger.

This was one of the key reasons why Three attempted to acquire O2. It is also a key reason why MNOs are merging in large numbers, in Europe and elsewhere.

MNOs cannot address a spectrum shortage through network investment as Ofcom has suggested. As we discuss in detail in our response, this is neither feasible nor economical. MNOs need to keep sites and spectrum in balance. Expanding capacity solely through network investment (with a given spectrum portfolio) yields rapidly diminishing returns.

Independent studies, from Real Wireless and Qualcomm commissioned for this response, confirm that it is not possible to match additional spectrum with network deployment. The benefits of site densification decrease rapidly as densification increases. Even in the most heavily

loaded sites, where sites can technically substitute for spectrum, finding sites can literally take years. The cost and practicalities of finding large numbers of sites make this an infeasible option.

Given the above considerations, spectrum concentration creates fundamental competition concerns in the presence of economies of scale related to capacity. [✂-Three's views on the relationship between size of spectrum holdings and competitiveness.]

It is therefore critical to keep spectrum asymmetries at a sustainable level to maintain a market structure with four MNOs. Our analysis suggests that this requires MNOs' spectrum shares to be between a 20% floor and a 30% ceiling. [✂-Severe spectrum imbalances are damaging to competition.]

Ofcom has seriously underestimated the scale and likelihood of the competition concerns

In the Consultation, Ofcom finds that the mobile market is currently working well despite the current spectrum asymmetry. Ofcom recognizes that there could however be a competition problem in the transitional period if the asymmetry (of immediately usable spectrum) worsened following the auction, but that the problem is limited to the ability of Three and O2 to compete for the high-data usage segment of the market and does not affect the overall credibility of any MNO.

In our view this assessment seriously underestimates both the scale and likelihood of the competition concerns.

In relation to the scale of the concerns, UK consumers are already suffering the consequences of the current spectrum imbalance. Furthermore, the full extent of the competition problem will only become apparent in the next few years because BTEE and Vodafone are only using a fraction of their usable spectrum now.

Firstly, *retail mobile prices have significantly increased in 2015 and 2016 after a decade of continuous price decreases*. We provide independent evidence on this and it is also evident in several Ofcom reports (such as the International Communications Market Report for 2015).

Secondly, *Ofcom has expressed serious concerns itself about the intensity of competition in the wholesale market*. Ofcom told the European Commission (EC) that MVNOs are becoming increasingly less relevant because they are unable to compete for customers with high data use due to the pricing structures offered by MNOs.

Thirdly, *UK consumers are receiving diminished benefits from the spectrum held by the industry*. Spectrum hoarding by BTEE and Vodafone is demonstrably not an efficient use of a highly valuable public resource. Ofcom has a duty to promote the optimal use of spectrum. The failure to use existing spectrum, which could be used by other MNOs, has a direct impact on competition – this is the strategic advantage from hoarding.

If this unused spectrum were to be reallocated evenly between Three and O2, Three's customers would benefit from an increase in average download speeds [✂]. The competitive benefits are clear, [✂-and yet others suffer from not having enough spectrum].

As regards the likelihood of further concerns arising, Three believes that Ofcom has seriously underestimated the incumbency advantage affecting Three's ability to secure spectrum, with consequential competition concerns that are central to Ofcom's own policy objectives.

Ofcom recognises this risk in relation to 2.3GHz but it thinks it is unlikely to arise for 3.4GHz (given the amount of 3.4GHz on sale, the future availability of 700MHz and 3.6 to 3.8GHz and the uncertainty around the incremental value consumers may place).

Three has commissioned one of the leading auction theorists in the world, Professor Larry Ausubel, to assess likely outcomes in the PSSR award based on illustrative MNO values provided by Analysys Mason. Figure 1 shows the auction outcome that Professor Ausubel considers most likely under Ofcom's preferred option. [✂-Professor Ausubel's predicted auction outcome.]

Figure 1: [✂]

[✂-Figure 1 redacted – shows spectrum holdings if Professor Ausubel's prediction proves to be correct.]

Source: [✂]

[✂-Explanation of why Professor Ausubel's predictions make sense to Three.]

In essence, the combination of changes in consumer behaviour, the existing significant spectrum imbalances and the incentive for strategic behaviour mean that the risk to effective competition is extremely serious. It is no longer sufficient to try to prevent spectrum imbalances from deteriorating further. Ofcom should act now to actively reduce spectrum concentration.

Failure to intervene now, to ensure the viability of competitive four-player market, will require much more drastic and riskier intervention later

There are two further important considerations. Firstly, Three has always been determined to help itself and to use its own resources to address the challenges it faces, and it will continue to do so in the future. Appealing for regulatory support is not our default position. We only seek such support when we believe it is essential to support wider competition objectives and where the alternative (Three's proposed acquisition of O2) has been prohibited.

Secondly, the risk from intervention at this point is highly asymmetric. Ofcom will find it difficult to intervene later if an even more extreme spectrum imbalance arises now. The likely timing of the availability of 700MHz and 3.6GHz (which is later than Ofcom has assumed) combined with the proven ability of players to delay awards through legal challenge, make it highly unlikely that Ofcom would be able to act promptly to make substitutable spectrum available.

A failure to intervene in a proportionate form in the PSSR auction is likely to require a far bigger, far riskier and far less proportionate intervention in the future - or alternatively will simply risk rendering competition ineffective and thereby fundamentally undermine Ofcom's central policy objective. The consequences for UK consumers and businesses will be highly negative and will be visible in the near term.

On the other hand, a proportionate intervention can realistically be expected to enhance competition and to deliver significant benefits to the wider economy. We note that delivering competition and wider economic benefits are a primary objective for Ofcom.

Ofcom is more likely to achieve its policy objectives by implementing a spectrum reservation and a 30% cap in the PSSR auction

Taking the argument in the round, and taking all relevant factors into account, Ofcom is significantly more likely to achieve its policy objectives if it addresses the current spectrum asymmetries by intervening at this stage of market development. The most appropriate and proportionate way of doing this would be to:

- Introduce a spectrum reservation of 20MHz of 2.3GHz and 40MHz of 3.4GHz spectrum for Three (and new entrants); and

- Set an overall 30% cap (255MHz) on spectrum holdings post auction – a cap set at that level would exclude BTEE from the auction unless it relinquishes spectrum, particularly unused 2.6GHz, to the benefit of consumers. Vodafone would be limited to 75MHz out of the 190MHz on sale, but could also bid for more by divesting some of its unused 2.6GHz.

This combination of measures would give the UK the best chance of securing effective competition through a credible four-player market, while minimising the risk of acting disproportionately in the auction process.

This would be entirely logical and consistent with Ofcom and the CMA's position on the recent merger process as well as the repeatedly stated preference for an effective four-player market.

Post- script – Three's proposed acquisition of UK Broadband

On 6th February 2017, Hutchison 3G UK Limited ("Three") entered into an agreement (the "Agreement") with PCCW Limited ("PCCW") and its indirect subsidiaries Seamless Industries Limited ("Seller") and UK Broadband Limited ("UKB").

Pursuant to the Agreement Three will obtain full control of UKB. UKB provides a range of broadband services in London under the brand name Relish. These include Broadband internet services (fixed and mobile) for homes and SMEs and a Dedicated Business Internet service.

[✂-Further information on the deal and Three's expectations on timing for completion.]

UKB has a number of spectrum licences [✂], including 40MHz in the 3.4GHz band, 84MHz in the 3.6GHz band, a concurrent licence at 1800MHz as well as spectrum [✂-suitable for particular uses] in the 3.9GHz, 28GHz and 40GHz bands.

Annex A to this response sets out the detail of the Agreement and its implications for Three's response to the Consultation. In summary, [✂-Three's plans for some of UKB's spectrum]. Three accepts that, if the transaction completes, this will lessen the case for Ofcom to intervene to ensure that Three has access to 3.4GHz spectrum.

Even if the transaction proceeds, however, Ofcom should still take steps to promote competition in the transitional period by reserving 20MHz of 2.3GHz for Three (and new entrants), and also implementing a 30% cap on overall spectrum holdings post-auction.

[✂-Why Three considers that a reservation is necessary.]

Contents.

1. Ofcom's proposals for the auction should not undermine the viability of a competitive four-player market

Executive Summary

In May 2016 the European Commission (EC) decided to prohibit Three's proposed acquisition of O2. The EC agreed with Ofcom's advice that the transaction created significant competition concerns that could not be resolved without the creation of a fourth MNO in the UK.

The need to protect competition was the key argument that Ofcom relied upon to oppose Three's acquisition of O2. It is extremely important for the confidence of the industry and investors that Ofcom's proposals for the PSSR auction do not undermine now the viability of a four-player market.

UK consumers should enjoy the benefits of a competitive market in terms of lower prices, greater quality and innovation. Competition, however, is critically dependent upon the availability of sufficient spectrum to all MNOs. In summary:

- Ofcom has publicly committed to a competitive four-player market;
- Ofcom promised to the EC that it would regulate to avoid an auction outcome that would weaken Three's ability to compete;
- Ofcom has failed to take into account, or to give due weight to, relevant considerations that it has itself identified;
- Competition depends critically upon the availability of spectrum to all MNOs;
- The UK now has one of the worst levels of spectrum concentration in the developed world;
- Ofcom has previously relied on the future availability of spectrum to address spectrum concentration, but was eventually unable to do so;
- Other regulators have tackled spectrum concentration decisively.

Ofcom has publicly committed to maintaining a competitive four-player market

Ofcom strongly and publicly opposed Three's proposed acquisition of O2. Ofcom told the EC that "*four MNOs, rather than three, competing for*

customers is the only way to ensure that competition is effective, in terms of pricing, quality and innovation".[1]

Ofcom's view was that competition, not consolidation, drives investment and lowers prices. Ofcom was concerned that, once competition slips away, it is hard to re-establish because barriers to entry are high.[2]

Ofcom expressed serious concerns to the EC about the potential loss of Three as a 'key market disruptor' that was keeping industry margins in check. Ofcom estimated that prices are generally 17.2% to 20.5% lower in countries with four-player markets which include a disruptive firm. [3]

Ofcom has now reconfirmed its objective of maintaining a four player market in its PSSR consultation. In Three's view, there is a fundamental tension between this objective and Ofcom's proposals for the auction. [✂-Quoting the views of a third party.][4]

Ofcom promised to the EC that it would regulate to avoid an auction outcome that would weaken Three's ability to compete

Ofcom has indicated to the EC that it would regulate to ensure that all four UK MNOs have access to the necessary spectrum in the future:

> *"Ofcom previously secured this outcome by reserving spectrum for a fourth MNO in the 2013 4G auction to ensure that it had at least the minimum spectrum requirements to allow it to be an effective competitor so that UK consumers continued to benefit from a competitive market. Ofcom anticipates that it will continue regulating to secure this policy objective in the future.*
>
> *An outcome which results in a weakening of an MNO's ability to compete effectively, if it were to prevail, would be inconsistent with this policy objective. The assumption that Ofcom will not impose competition measures in the PSSR award, on which Three's submissions appear to be based, is not correct.* To reiterate, our position is that there should be four MNOs in the UK and we will continue to regulate to achieve that*"* (emphasis added)

[1] Letter from Philip Marnick of Ofcom to Michele Piergiovanni of the European Commission, 10 March 2016.
[2] https://www.ofcom.org.uk/about-ofcom/latest/media/speeches/2015/consumers_and_consolidation
[3] OFCOM Phase I Submission to EC, paragraphs 2.26, 2.50. Ofcom's comments on the effect of the Three/O2 merger on prices. Strategic Review of Digital Telecommunications, discussion document (paragraph 4.26).
https://www.ofcom.org.uk/__data/assets/pdf_file/0021/63444/digital-comms-review.pdf
A cross country econometric analysis of the effect of disruptive firms.
https://www.ofcom.org.uk/__data/assets/pdf_file/0019/74107/research_document.pdf.
[4] [✂]

The EC relied on these commitments in its decision to prohibit the Three/O2 transaction (the Decision). The EC found that Three drove competition in the industry in the period 2007-2012 [✂-Reference to findings in the confidential version of the European Commission's decision.] The Decision concludes that it is largely due to Three that the price of data remained very competitive in the UK in the last six years.[5]

Three expects Ofcom to honour the commitments very recently provided to the EC. However, as discussed in this response Ofcom has seriously under-estimated the scale and likelihood of the competition issues in the auction. Hence, its proposal regarding the spectrum auction is insufficient to meet its regulatory commitment in this area.

Ofcom has failed to take into account or give due weight to relevant considerations that it has itself identified

As discussed above, in its representations to the EC in respect of Three's proposed merger with O2 Ofcom took the view that it was critically important to preserve competition. In multiple submissions Ofcom characterised Three as a *"key market disruptor*" that has increased competition and created significant benefits for consumers. Ofcom even estimated that mobile prices are between 10.7% and 12.4% lower in countries with a disruptive player.[6]

These clearly constitute relevant considerations for the purposes of the Consultation, but Ofcom does not appear to have given due weight to its goal of preserving competition, or to have taken into account Three's "*key market disruptor"* role at all.

The Consultation reiterates Ofcom's goal *"to ensure that consumers and businesses continue to benefit from a competitive market in the provision of mobile services*".[7] However, when Ofcom considers potential options to address the competition concerns it has identified in Section 5, it puts efficiency (i.e. allowing the bidder with the highest intrinsic value to win the spectrum) ahead of competition.

For instance, Ofcom explicitly acknowledges that Option B (which would prevent Vodafone from bidding for 2.3GHz) may be more effective than its preferred option A at promoting competition in the transitional period, which is Ofcom's main competition concern. However, Ofcom discards Option B on the basis that, inter alia, preventing Vodafone from bidding for 2.3GHz may lead to an inefficient distribution of spectrum.[8]

[5] Decision, paragraph 577
[6] https://www.ofcom.org.uk/__data/assets/pdf_file/0019/74107/research_document.pdf
[7] Paragraph 1.3
[8] Page 75

Similarly, Ofcom recognises that Option C (which prevents BTEE from bidding for 2.3GHz and more than 85MHz of 3.4GHz) is as effective in promoting competition in the transitional period and more effective beyond that period than its preferred Option A if 3.6-3.8 GHz spectrum were usable significantly later than 3.4GHz.[9]

However, Ofcom prefers Option A because Option C is "more interventionist", even though Ofcom recognises that 3.6GHz may not be available at the same time as 3.4GHz to mitigate a very asymmetric distribution of 3.4GHz in the future.[10] Likewise, Ofcom does not want to prevent BTEE from acquiring less than 85MHz of 3.4GHz because BTEE might have the highest value for that spectrum.

Moreover, Ofcom's position fails to properly take into account the fact that the bidder with the highest intrinsic value will not necessarily be the bidder who would provide the greatest benefit to consumers if it won that spectrum.

Ofcom is rightly concerned about a very asymmetric distribution of spectrum due to differences in intrinsic values between MNOs (even absent strategic bidding).[11] The reason is, of course, that an MNO's intrinsic value for spectrum may not fully reflect the benefits that consumers derive from its participation in the market (a *"competition externality").*

[✂]

If Three's *"key market disruptor*" role was deemed a relevant consideration when Ofcom intervened in the EC's review of the proposed merger, it remains a relevant consideration now. If it is not properly taken into account, Ofcom's final decision will be legally flawed as irrational and there is a real danger that the benefits received by consumers will be materially diminished.

Ofcom's final decision should address these issues and, in doing so, explicitly consider (i) the extent to which Three's role as a *"key market disruptor*" would be harmed by further spectrum asymmetry and (ii) the consequent potential loss of benefit for consumers.

Further explanation and an illustrative example of the potential loss of benefit for consumers on Ofcom's own case is set out in Section 8.

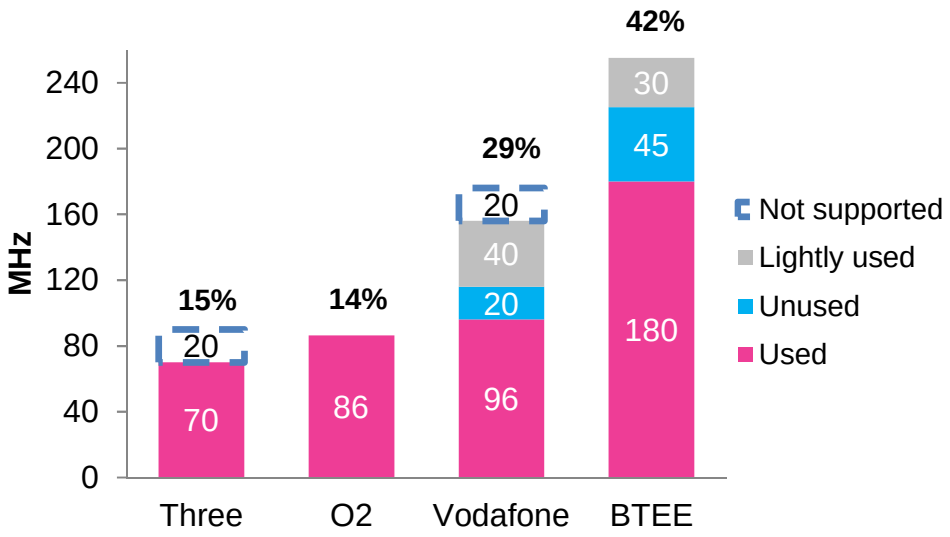
[9] Paragraphs 5.83-5.84
[10] Paragraph 5.74, 5.84, 5.92
[11] Paragraphs 1.26, 4.168

Competition depends critically upon the availability of enough spectrum to all MNOs

UK consumers should be able to enjoy the benefits of a competitive mobile market in terms of lower prices, better quality and greater choice and innovation. Competition, however, is critically dependent upon the availability of sufficient spectrum to all operators.

Today, the UK has an extreme spectrum imbalance. As shown in Figure 2, BTEE and Vodafone now control 71% of the UK's airwaves (including both useable spectrum and 1400MHz spectrum not currently supported by handsets).[12]

Figure 2: Mobile spectrum in the UK is disproportionately concentrated in the hands of BTEE and Vodafone



Both BTEE and Vodafone are hoarding large amounts of 2.6GHz spectrum purchased in the 4G auction nearly four years ago (section 5). Sub 1GHz spectrum, which is critical to the provision of good quality coverage, has also been historically concentrated.

At the other end of the market, Three (and O2) are both within the 10-15% range that Ofcom considered in 2012 to be the minimum share of

[12] See Figure 3.1 of the Consultation.

spectrum necessary for an MNO to be credible. BTEE has almost three times as much spectrum as Three, and Vodafone almost twice as much. Three carries 37% of UK mobile data on just 20% of the combined spectrum held by BTEE and Vodafone (89MHz compared with 431MHz).

The UK now has one of the worst levels of spectrum concentration in the developed world

The Consultation includes an analysis of spectrum shares in different four-player markets in Western Europe.[13] Ofcom has found that the UK has the second most asymmetric distribution (after Slovenia) in those countries.[14] However, as Ofcom notes, the smallest MNO is Slovenia has filed for bankruptcy.

Three has extended Ofcom's analysis to all countries for which spectrum records exist, not just four-player markets in Western Europe. This is in Annex 1. Like Ofcom, Three has measured the degree of inequality in the distribution of spectrum using the Gini Index.[15]

Table 1 presents the main results of this analysis, with details in Annex 1. In summary, the UK has the third largest spectrum imbalance amongst the 50 largest economies by GDP, the worst spectrum asymmetry of all countries in the G20, and the second largest imbalance in Western Europe (after Iceland, a tiny country with c.300k inhabitants).

Table 1: The UK has one of the worst distributions of spectrum in the developed world

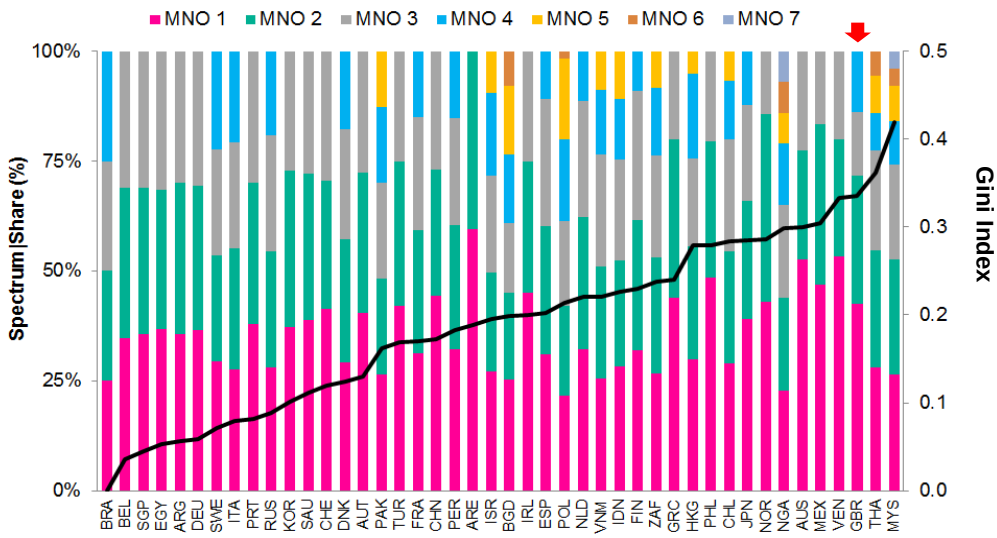
Group of countries	Number of countries	UK ranking (from best to worst)	Countries with larger spectrum imbalance than UK
Top 50 world economies (by GDP)	50	48th	Thailand, Malaysia
G20	20	20th	-
Western Europe	20	19th	Iceland

Source: Annex 1

[13] Annex 6
[14] Or Netherlands, if measured by the degree of concentration of spectrum per subscriber. See Annex 6
[15] Gini coefficients were calculated using the relative mean absolute difference method.

To illustrate, Figure 3 shows the share of spectrum held by MNOs in each of the top 50 economies by GDP. The black line is the Gini measure of the inequality in spectrum distribution.[16] The UK's index of 0.34 is the third highest behind Thailand (Gini of 0.36, a country with six MNOs) and Malaysia (Gini of 0.42, a country with seven MNOs).

Figure 3: The UK has the 3rd largest spectrum imbalance of the world's 50 largest economies.

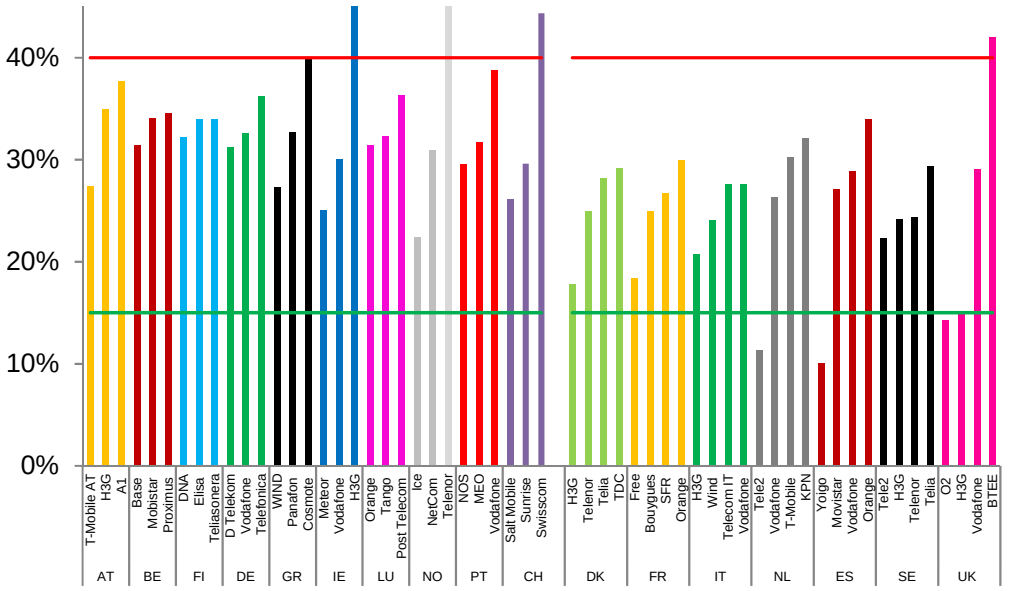


Source: Three

Similarly, Figure 4 shows the shares of mobile spectrum held by all fifty-eight MNOs in Western Europe. This includes MNOs in both three-player markets (to the left) and four-player markets (to the right).

[16] Because we have calculated the Gini Index as half of the relative mean absolute difference of operators' spectrum holdings, the index ranges from zero (spectrum is equally distributed between MNOs) to a maximum of (n-1)/n (where every individual except one has a size of zero). See Annex 1.

Figure 4: Only four MNOs in Western Europe have a spectrum share at or below 15%



Source: Three

Only four MNOs in Western Europe have 15% of spectrum or less: Tele 2 in the Netherlands, Yoigo in Spain and Three and O2 in the UK. However, Ofcom does not consider Yoigo (which was recently sold and has stalled at 6% market share) a credible MNO,[17] and Tele 2 was until recently an MVNO and has only recently launched its 4G service (in November 2015, see Section 4).

At the other end, BTEE has a much greater share of spectrum than any other MNO in a four-player market. The UK is the only country in Western Europe where one MNO has more than 35% (Orange Spain has 34% compared to BTEE's 42% share).

In fact, BTEE's share of spectrum is only comparable to that of the largest MNOs in three-player markets (Three Ireland, Telenor Norway, Swisscom in Switzerland and Cosmote in Greece).

The Consultation discusses other ways of comparing spectrum distribution, such as the ratio of spectrum shares to subscriber shares.

[17] Paragraph 4.131

Ofcom finds that, on that measure, O2 has the lowest ratio of all European MNOs in its set, whereas Three fares relatively well.

However, the ratio of spectrum share to subscriber share says very little about MNOs' relative capacity constraints if average customer usage varies greatly between MNOs (as discussed in Section 2). For instance, Three carries 37% of the industry's traffic on just 15% of the spectrum (or 12% of immediately usable spectrum).

The more meaningful measure is the ratio of spectrum share to traffic share, which Ofcom has been unable to calculate.[18] Three has been able to do so. This evidence shows that Three has the lowest ratio of spectrum to traffic of all European MNOs in the sample.[19]

Figure 5: Three has the lowest share of spectrum to share of data traffic in Ofcom's sample of countries.

Source: Three

[18] Paragraph A6.52

[19] This provides a snapshot of spectrum share per share of traffic in Q2 2016. The analysis was conducted by FTI Consulting. FTI sourced spectrum data from own sources, Three UK, spectrummonitoring.com, EC Communications Office Frequency Information System and regulatory web sites. FTI sourced traffic data from own sources, Enders Analysis, tefficient.com, GSMA Intelligence, and regulatory websites. Where data was not available for all operators, FTI used market share to normalise traffic figures. FTI only included countries where data was complete for at least three operators

Ofcom has previously relied of the future availability of spectrum to address spectrum concentration

Ofcom suggests that an asymmetric auction outcome now could be remedied in future auctions of 700MHz and 3.6GHz, if necessary by implementing competition measures.[20] There is a useful precedent in 900MHz liberalization, when Ofcom also relied on the future availability of 800MHz to address spectrum concentration at 900MHz.

Until the 2013 4G auction sub-1GHz spectrum was concentrated in the hands of Vodafone and O2. It is well-established that low frequency spectrum provides superior coverage over large areas at lower cost. Sub 1GHz spectrum has a direct impact on competition between MNOs, as it determines an MNO's ability to compete on coverage, particularly in rural areas.

Ofcom considered this problem when it liberalized 900MHz spectrum from 2G to 3G services. The Amended GSM Directive required Ofcom to address potential competitive distortions from 900MHz liberalization. However, Ofcom took a different approach to other European regulators (see below):

- Ofcom initially proposed to take back three 900MHz blocks (2x15MHz in total) from Vodafone and O2 to make them available to other MNOs.[21] Ofcom found that consumers would benefit from greater intensity of competition if all MNOs could compete strongly on coverage. Vodafone and O2 could not bid in the auction for the released 900MHz, and no participant could buy more than one 2x5MHz block. This would have ensured that all other MNOs (Orange, T-Mobile and Three) had access to sub 1GHz;

- In February 2009 Ofcom proposed to require Vodafone and O2 to give up a single 2x5MHz block between them, to allow a third MNO only to have access to 900MHz;[22]

- Then in February 2011 Ofcom just liberalized the spectrum in the hands of Vodafone and O2.[23]

As in the Consultation, Ofcom recognized the potential for a competitive

[20] Paragraphs 1.28 and 4.46
[21] https://www.ofcom.org.uk/__data/assets/pdf_file/0019/53632/liberalisation.pdf
[22] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/46218/spectrumlib.pdf
[23] https://www.ofcom.org.uk/consultations-and-statements/category-1/spectrumlib/advice-to-government

distortion in three to five years' time, but suggested that substitutable spectrum at 800MHz would be available in the 4G auction to balance the benefit of 900MHz.[24]

The 4G auction then included 2x30MHz of 800MHz. Ofcom initially sought to ensure that all four MNOs (following the Orange/T-Mobile merger that created EE) had access to sub 1GHz spectrum. Its proposed spectrum floors would have ensured that both Three and EE would each win at least 2x5MHz of 800MHz.

Ofcom was initially concerned that, without measures, only three or even two MNOs might have sub 1GHz spectrum to compete in the provision of high quality services, including reliable indoor coverage.[25] This, it said, would lower the intensity of competition compared to what would be possible if all MNOs could provide reliable indoor coverage.[26]

But in July 2012, following threats of litigation from Vodafone and O2, Ofcom decided not to guarantee 800MHz to both Three and EE. [27] Ofcom found that it was not necessary for all MNOs to be able to provide high quality services or compete strongly for all customer segments, provided all MNOs could provide a minimum quality of service to remain credible.[28]

In consequence, only some of the reserved portfolios for Three (and new entrants) included 800MHz. Ofcom implemented a cap that prevented Vodafone and O2 from buying more than 2x10MHz of 800MHz each, leaving at least 2x10MHz for EE, Three and new entrants.

Ultimately, as was widely expected Vodafone and O2 won 2x10MHz of 800MHz each. Against the market expectation, however, EE only won 2x5MHz of 800MHz. EE preferred to win large amounts of 2.6GHz spectrum instead of a second 2x5MHz block.[29] Three (unexpectedly) won 2x5MHz of 800MHz as its reserved spectrum portfolio.[30]

It is only as a result of EE's bidding decision that Three has been able to agree to cover 90% of the UK geography by December 2017. Ofcom is currently proposing to take a similar risk and to adopt a 'wait-and-see' and 'intervene later' approach. Based on the precedent from 900MHz liberalization, Ofcom may not be able to auction substitutable spectrum

[24] http://www.publications.parliament.uk/pa/cm201012/cmselect/cmcumeds/uc1258-iii/uc125801.htm
[25] Ibid, paragraph 5.110
[26] Ibid, paragraph 5.104
[27] 4G Auction Statement, Annex A3.118
[28] 4G Auction Statement, Annex A3.118
[29] EE consistently bid large marginal values for additional 2.6GHz spectrum on top of 2x5MHz of 800MHz, and bid much less aggressively for a second 2x5MHz block at 800MHz
[30] Financial Times, Mobile operators face bartering over 4G (14 March 2013)

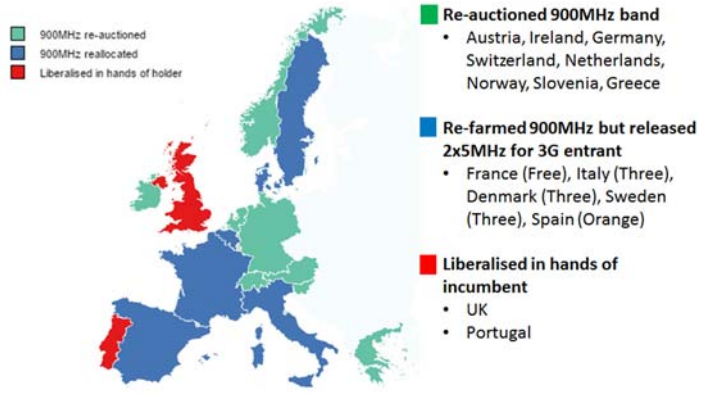
promptly, or rely on the future availability of substitutable spectrum to address an extreme spectrum imbalance following the PSSR award.

Other regulators have tackled spectrum concentration decisively

Ofcom operates with a bias against intervention. This has historically resulted in a bias towards "*under-intervention*" in circumstances where decisive action was needed to protect the general interest.

In this context, it is useful to compare Ofcom's approach to spectrum concentration to that taken by other regulators. For instance, when liberalizing 900MHz for 3G every Western European regulator except those in Portugal and the UK re-auctioned 900MHz or re-allocated some of it to a new 3G entrant.

Figure 6: Almost every other Western European regulator re-auctioned or reallocated 900MHz.



Source: Three

The US Federal Communications Commission (FCC) is now auctioning 600MHz in the US Incentive Auction. Verizon and AT&T control 73% of sub 1GHz spectrum (35% and 38% respectively).[31] Sprint only holds 10% and T-Mobile holds 5%. Other licensees hold the remaining 12%.[32]

The FCC has put rules in place to prevent excessive concentration of that

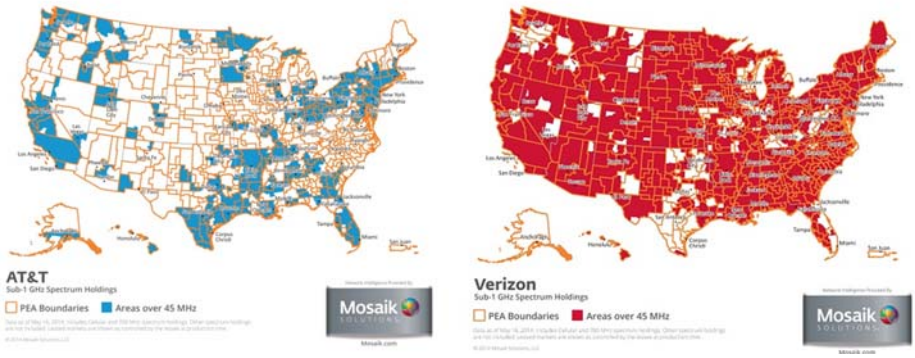
[31] Figure 3.2 of the Consultation
[32] FCC. Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services, September 2016

spectrum, even though all four MNOs already hold some.[33] The FCC has reserved up to 30MHz in each area for operators that do not currently hold a significant amount of sub 1GHz spectrum.[34]

All operators can bid initially for 600MHz but after the auction price reaches a certain threshold only operators with less than one-third of sub 1GHz in the area (mostly T-Mobile and the regional operators, as Sprint has not participated) can bid for the reserved spectrum. The unreserved spectrum remains open to all bidders.

This effectively bars Verizon from bidding on reserved 600MHz in most of the US. AT&T faces restrictions in many parts of the US. Rules prevent one carrier (e.g. T-Mobile) from acquiring all of the reserved 30MHz in each area, which will result in a much more even distribution of sub 1GHz spectrum in the US.

Figure 7: The FCC has prevented AT&T and Verizon from bidding for reserved spectrum in large parts of the US



Source:

Similarly, the Australian Government recently decided, on advice from the Australian Competition and Consumer Commission (ACCC) to bar Telstra from the auction of 700MHz that was unsold in 2013.

In 2013, the Australian Communications and Media Authority (ACMA) auctioned 2x45MHz in the 700MHz band. ACMA initially imposed a cap on 700MHz at 2x20MHz to ensure that all three MNOs in Australia (Telstra, Optus and Vodafone Hutchison Australia, VHA) won 700MHz.

[33] *Report and Order* at para. 4.
[34] *See infra* Sections V.B.3 and V.B.4.

As VHA decided not to participate, ACMA increased the limit to 2x25MHz. Telstra won 2x20MHz of 700MHz and Optus won 2x10MHz. The remaining 2x15MHz was unsold.

In its recent advice to Government in relation to the auction of this unsold spectrum, the ACCC recommended that Telstra not be allowed to bid.[35] The ACCC considered that barring Telstra is necessary to prevent monopolisation of the spectrum. This would allow Optus, VHA or a new entrant (TPG) to acquire at least 2x10MHz of 700MHz.

Conclusion – Ofcom's proposals for the auction should not undermine the viability of a four player market

To conclude, Ofcom has set out a clear and unambiguous commitment to a market structure containing four players. It is critically important that its proposals for the PSSR auction are consistent with that objective.

All operators need access to sufficient spectrum for a genuinely competitive four-player market to be sustained. The UK already has an extreme spectrum imbalance by any international metric. Three in particular has the smallest ratio of spectrum to data traffic of any MNO in the sample of countries assessed by Ofcom.

Judging by past experience with 900MHz, Ofcom may have overestimated its ability to make substitutable spectrum available in the future to address the problem of spectrum concentration. Ofcom appears to have a bias towards "under-intervention", while other regulators have acted decisively to address spectrum concentration.

[35] https://www.communications.gov.au/sites/g/files/net301/f/accc-advice-on-allocation-limits-for-the-auction-of-unsold-700-mhz-spectrum-executive-summary.pdf

2. The UK mobile market has rapidly evolved from voice to data

Executive Summary

Consumer preferences have now shifted. Traffic carried over UK mobile networks increased approximately eight-fold between 2011 and 2015, outstripping all expectations. In the month of October 2016 alone Three carried more traffic than [✂]. This growth in mobile data traffic is increasing MNOs' need for spectrum at an unprecedented rate.

Capacity and speeds are increasingly important to consumers given the applications they want to use, particularly video streaming, web browsing and file downloads. Independent studies confirm the vital importance of speeds if an MNO is to remain competitive.

It is essential that Ofcom's competition assessment takes account of this changing reality. In summary:

- The UK mobile market has rapidly evolved from voice to data;
- Growth in mobile data traffic has exceeded all expectations, including Ofcom's;
- Capacity and speeds are now key dimensions of competition.

We develop each of these points further below and in several technical annexes (Annexes 2 to 4).

The UK mobile market has rapidly evolved from voice to data

The retail mobile market has rapidly evolved from voice to data. 2G was suitable for making calls and sending text messages. Deployment of 3G networks in 2003 drove widespread adoption of the mobile internet with data rates and speeds steadily improving with successive 3G technologies (such as HSPA and HSDPA+).

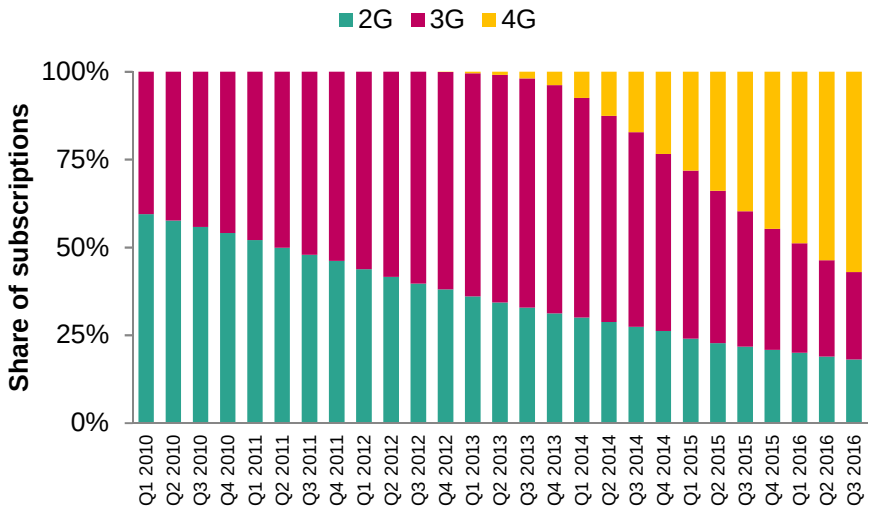
In a short space of time since the introduction of the iPhone in 2007, smartphones have now become a key part of life for millions of UK consumers. According to Ofcom's Communications Market Report 2016 71% of UK adults now own a smartphone, up from 66% in 2015.[36]

Half of all smartphone users say they are 'hooked' on their mobile phone. Widespread take-up of smartphones, together with the growing popularity of mobile applications (particularly video) and deployment of 4G networks have triggered an explosion in consumer demand for data.

[36] Ibid, Figure 4.5.

Figure 8 charts the evolution of the share of UK mobile subscriptions by technology according to GSMA Intelligence. The share of 2G voice subscriptions has rapidly declined and was overtaken by 3G subscriptions in Q2 2012. EE launched the first UK 4G network in Q4 2012. Within three years, the share of 3G subscriptions gave way to 4G subscriptions in Q3 2015 according to this data.

Figure 8: UK subscribers have rapidly shifted from 2G to 3G and 4G technology.

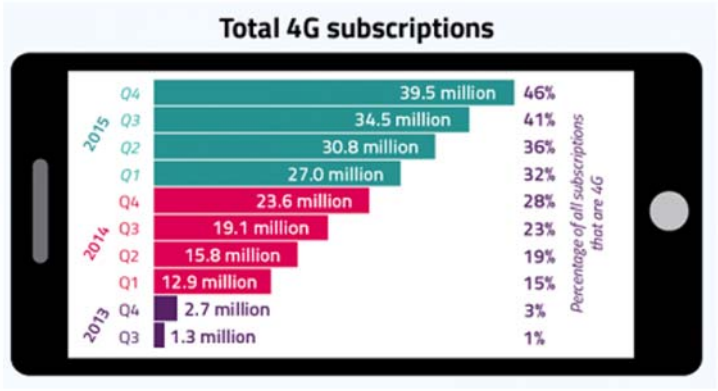


Source: GSMA Intelligence, UK Market

Consumer take-up of 4G has been particularly pronounced. As shown in Figure 9, the number of 4G subscribers increased from just 1.3m to 39.5m within two years (Q3 2013 and Q4 2015). The largest growth occurred in Q1 2014, when 10.2m consumers upgraded to a 4G package. Ofcom has attributed this growth to Three's launch of 4G in March 2014, when Three offered access to 4G services at no extra cost to its 3G subscribers.[37]

[37] Ofcom Comms Markets Report 2015, page 256

Figure 9: Take up of 4G has grown very rapidly within two years



Source: Ofcom Comms Markets Report 2016

4G services have delivered much faster data speeds and lower latency, and have resulted in an enormous increase in data usage per user, as video and music streaming are becoming increasingly popular.

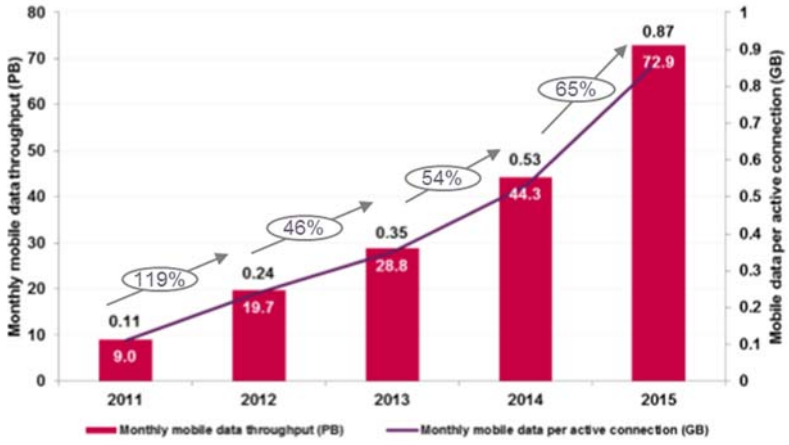
Growth in mobile data traffic has exceeded all expectations

Spectrum is increasingly important because rapidly growing traffic creates congestion that reduces average speeds and/or the number of subscribers that can be served at any given speed. This section explains that i) rapid growth of data is a phenomenon seen across the industry; ii) data growth will have a particular impact on Three; iii) capacity and speeds are now key parameters of competition between MNOs.

i. Recent growth in UK mobile data traffic has been higher than Ofcom has forecast, and is expected to continue

Figure 10 shows that traffic carried over UK mobile networks increased approximately eight-fold between 2011 and 2015, as did the average monthly data consumption per (active) connection.

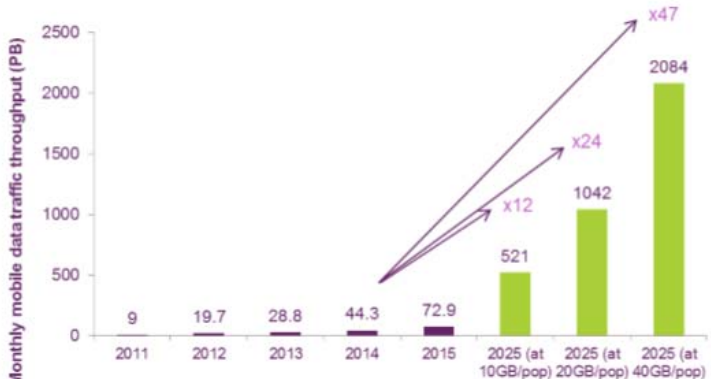
Figure 10: Total monthly mobile data consumption in the UK, Petabytes (mid-year)



Source: Ofcom, Mobile data strategy update, 30 June 2016, Figure 1

Such rapid growth has clearly surprised Ofcom. In May 2014 Ofcom was predicting an average annual growth rate of 22% in the years to 2030.[38] Ofcom now predicts an annual average industry-wide traffic growth of between 25% and 42% over the period to 2025.

Figure 11: Ofcom has had to revise data traffic forecasts to 2025



Source: Ofcom, Mobile data strategy update, 30 June 2016, Figure 4.

[38] Ofcom, Mobile data strategy: statement, 28 May 2014, Paragraph 4.43; Ofcom, Mobile data strategy update, 30 June 2016, Paragraph 3.7.

A prediction towards the top of Ofcom's range – or even beyond it – may be more accurate. Figure 10 shows that the lowest growth in any of the last five years is 46%, while Ofcom is now forecasting growth between 25% and 42% only (Figure 11).

In any event, even growth towards the lower end of Ofcom's range would imply that demand will out-strip the growth in supply in terms of the amount of new spectrum likely to be made available for mobile:

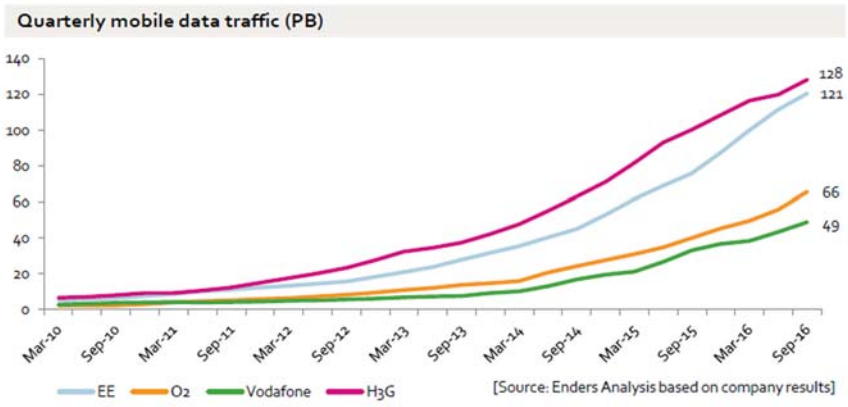
- Ofcom estimated in May 2014 that spectrum available for mobile data downlink would increase 5.1 times by 2022 and 13.4 times by 2028;[39]

- Even the lowest of Ofcom's predictions implies a growth in demand of 12 times by 2025. Existing mobile spectrum at an industry-wide level is likely to become significantly more congested in the short and medium-term.

ii. Data traffic growth has been particularly heavy for Three and that can be expected to continue

Three leads the other MNOs in terms of the total volume of traffic carried on its network, as shown in Figure 12.

Figure 12: Three has experienced a greater increase in data traffic



Source: Enders Analysis, UK Mobile Market Q3 2016

[39] Ofcom, Mobile data strategy: statement, 28 May 2014, Table 4..

On average Three's customers use their handset for data more often than customers of other networks. For instance, 71% of Three's customers download videos and music regularly, as opposed to 41%-55% for customers of other mobile networks.[40]

As the Consultation notes, Three's customers have the highest average data usage in the mobile industry. Three's 11% share of subscribers accounts for 37% of all UK data traffic.[41] This is not surprising given that Three launched as an exclusively 3G operator targeting data users.

Data use by Three's subscribers continues to grow strongly, despite the fact that their average usage is higher and despite traffic management measures discussed in Annex 2. [✂-Information on average monthly data usage by Three's subscribers.]

Figure 13: Three has experienced significant growth in average monthly use since 2014.

[✂]

Source: Three

Growth in average data traffic has been fuelled by viewing of video content. Latent demand is also a key driver of this growth. Suppressed demand surfaces when the capacity of a site in increased, which makes applications better and faster. This encourages greater use as customers start streaming video more often (as they no longer experience buffering).

Figure 14 shows that [✂-How Three has predicted traffic would grow over time.]

Figure 14: Increasing capacity on a 4G network releases significant latent demand from consumers

[✂]

Source: Three

[✂]

[40] Enders, UK Mobile Survey 2015
[41] UK mobile market Q1 2016: Future uncertain, (5th July 2016), Enders Analysis

Table 2: Deployment of 4G releases latent demand

[✂-Duration of upgrade project.]	Average uplift in traffic
Busiest 10 sites	[✂]
Busiest 39 sites	[✂]
All 116 sites upgraded	[✂]

Source: Three

Ofcom has reported this phenomenon in fixed networks in its last few annual reports on the state of the UK's telecoms infrastructure.[42] Consumers taking up superfast broadband experience faster speeds. This encourages them to use a much wider range of multimedia applications than they could with slower connections and leads to more data being consumed.

This suggests that Three's network will continue to experience strong growth in data traffic, despite the fact that its subscribers already use more than the industry average. Indeed, the deployment of additional spectrum over time, such as the 1400MHz spectrum Three acquired in 2015, and launch of additional technologies between now and 2021, will likely release additional latent demand onto its network.

Capacity and speeds are now key dimensions of competition

Capacity and speeds are two sides of the same coin. Capacity is the network's ability to carry a given volume of traffic at a given average speed. Capacity affects both the number of customers that can be served and the average speeds they will receive.

Capacity and speeds are increasingly important to consumers. Moreover, both speed and consistency of speeds are important measures of performance. Three has commissioned a study by academics at Brunel University to demonstrate the increasing importance of speed to UK consumers.

iii. Speeds are increasingly important because consumers want to use applications that require high speeds to work effectively.

[42] Connected Nations report for 2015 and 2016
https://www.ofcom.org.uk/__data/assets/pdf_file/0035/95876/CN-Report-2016.pdf

Network speeds are increasingly important to UK consumers, because good speeds are needed for the services they demand to work effectively.

For instance, in its annual assessment of mobile performance in the UK, Ofcom's metrics are almost exclusively speed-related. Ofcom focuses on download speeds and web browsing speeds, and also considers upload speeds, web browsing speeds, YouTube streaming and average web page load times, in addition to call success rates.[43]

As Ofcom has found "*download speeds matter because they determine how long consumers have to wait before getting the content on their device. Higher download speeds are particularly important for downloading larger files, such as films or apps*".[44] Video streaming, web browsing, file downloads and cloud services are all becoming ever more data-hungry and speed-sensitive. We discuss this further in Annex 3.

In summary, the key driver of network requirements in the short term will be **high quality video**. Real Wireless (RW) believes that ubiquitous HD video will be a key threshold requirement for MNOs by 2020 (see Annex 6). Video streaming already represents around [✂]% of Three's network traffic. In its report on 5G, the National Infrastructure Commission (NIC) has underlined the increasing importance of high quality mobile video:[45]

"By 2019, video over mobile is expected to account for 80 per cent of worldwide mobile traffic, with the rise of next generation ultra-high resolution video – "4K" – expected to contribute in increasing this further, particularly if mobile users choose to record and share 4K videos in large numbers"

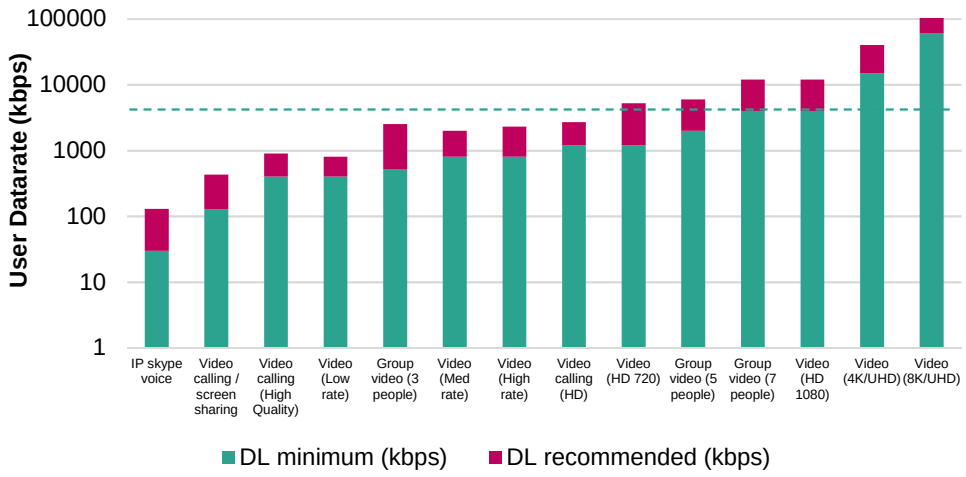
Ofcom has found that speeds under 2Mbps are insufficient to support high capacity video services or download very large files to a mobile device.[46] Vodafone already uses a 3Mbps speed threshold as one of the key performance indicators of its Project Spring investment program.[47]

Figure 15 presents the minimum and recommended downlink speeds for several video streaming services (in logarithmic scale, see RW report at Annex 11). RW has found that MNOs will need to provide ubiquitous HD video by no later than 2020. The minimum data rate to do so is 4Mbps at

[43] Smartphone Cities report 2016
[44] Smartphone Cities report 2016
[45] National Infrastructure Commission, Connected Future (2016)
[46] https://www.ofcom.org.uk/__data/assets/pdf_file/0033/79629/ofcom_mbb_performance_report_april_2015.pdf
[47] http://www.vodafone.com/content/dam/vodafone/investors/financial_results_feeds/tradingupdate_31december2015/q3-15-16-presentation.pdf

the cell edge, with 8Mbps recommended. The 4K videos discussed in the NIC report require minimum speeds in excess of 10Mbps.

Figure 15: Minimum and recommended speeds required for different streaming applications (logarithmic scale)



Source: Real Wireless report, Annex 11

As Ofcom has found, file downloading and browsing the web are also key applications that require good speeds to work effectively.[48] These services do not have a hard minimum speed requirement, but the quality of experience increases with speed:

- **Web pages** are getting larger and more content-rich, so data speeds need to increase commensurately to provide a good consumer experience. The size of the average web page has roughly trebled from around 700kB in 2010 to over 2100kB in 2015. To load a web page of this size in around 3 seconds, which is what customers consider to be a good experience, a data speed of around **8-10Mbit/s** is necessary;

- **File downloads** are increasingly common. Speeds determine how quickly large files will download and how may files can be downloaded per second. Table 3 shows the speeds required to download representative files (a media file or media album)

[48] Smartphone Cities report 2016

instantly (i.e. less than 3 seconds) or more slowly (between 3 and 10 seconds).

Table 3: Speeds needed for instant or slower downloads

Media type	Timeframe	Average speed (Mbps)
One Media file: photo, song, eBook or report	Instant (<3 s)	13.3
	Slower (3 ->10s)	4.0
One Media Album: 10 Media files	Instant (<3 s)	133.3
	Slower (3 ->10s)	40.0

Source: RW Report at Annex 11

Ofcom suggests that having the fastest speed does not necessarily mean offering the best customer experience.[49] However, as discussed above video requires a hard minimum speed to work, and a higher speed again for viewing and a minimum recommended quality.

Table 3 also shows that greater speeds improve the quality of file downloads and enable more files to be downloaded per unit of time. The user experience is always better when incrementally higher data speeds are available. In all the applications above, there is no 'cut-off speed' above which performance plateaus.

These issues are discussed further in Annex 3, including by reference to simulations we have run and real-world data collected by P3 and by Ofcom. As a result of the factors set out above, differences in capacity and speed will certainly have an impact on competition between MNOs.

iv. Both speed and consistency of speeds are key measures of performance

The Consultation suggests that customer satisfaction of speeds is more commonly driven by the experience in heavily loaded cells than in lightly loaded cells, because the avoidance of negative experiences may be more important for consumers than the occurrence of positive ones.[50]

In Three's experience, this is fundamentally incorrect and at odds with Ofcom's statements elsewhere. Ofcom's Smartphone Cities Report

[49] Paragraph A7.91
[50] Paragraph A8.57-A8.58

states (correctly) that *"both the speed of mobile broadband services and their consistency are important as measures of performance*".

In reality, customers expect consistently good network performance regardless of location or time of day. The speed experienced by users across the network, in both congested and uncongested sites, is a critical element of how they perceive network quality and reliability. To be competitive, an MNO needs to both minimize congestion and provide good speeds across the network as a whole.

'Congestion' indicates the extent to which speeds in the most heavily loaded sites degrades to an unacceptable level (e.g. video streaming stops working or consumers experience very slow browsing).

Whilst important, congestion says very little about the overall quality of service because the vast majority of sites are not congested, and even the most heavily congested sites may not be congested outside the peak hour.

As shown in Figure 18 in Section 3, is not even meaningful to talk about 'congestion' or 'heavily loaded cells' in contrast with 'lightly loaded cells'. In reality, individual sites vary from the very congested to the virtually empty. Correspondingly, there is a continuum of speeds experienced by UK consumers depending on their location.

The fundamental change with the deployment of 4G (and the advent of 5G) is increasing consumer demand for bandwidth and the impact of greater speeds on the customer experience. Network performance across all sites, not just the most heavily loaded sites, is critical to an MNO's competitiveness.

Average speeds provide an indication of performance across the entire network, but they can be misleading because they are heavily skewed. As shown in Figure 16, there are significantly more instances of speeds below the mean than above it, and a significant proportion of consumers will receive a speed that is below the average.

Figure 16: Both average speeds and the distribution of speeds across sites are important to consumers

Source: P3 Drive Survey Q1 2015

v. Independent studies confirm the vital importance of speeds if an MNO is to remain competitive.

The Consultation includes an assessment of the relative importance of different parameters of competition, including a consumer survey by Enders. Enders has found that reliability is the most important factor for consumers when considering the quality of a mobile network, followed by coverage. Speed is a distant third, although Enders suggests that its importance is increasing.[51]

However, as Ofcom notes network quality is a broad concept that includes several interrelated aspects (such as network reliability, coverage, speeds, latency, jitter, etc.). Reliability includes speed, because too low a speed will have the same effect as a disconnection from the customer's perspective. Consumers do not always appreciate the subtle distinctions between these concepts and consider download speeds and coverage when qualifying a network as "reliable".[52]

Academics at Brunel University have conducted an independent study for Three that demonstrates that speed is emerging as the most important element of network quality for UK consumers. The full report can be found in Annex 4.

The study tests the factors that make UK customers' consider switching to another MNO. The authors conducted an extensive quantitative survey of 1,254 UK adults between 29 September and 03 October 2016 for the purposes of Three's response to the Ofcom consultation. The construct of the study and the data collected were subjected to a rigorous statistical analysis founded on published scientific research.

The Brunel study analyses the causal relationships between i) various aspects of mobile service quality (e.g. speed, reliability of network coverage and call and text quality) and brand; and ii) customer

[51] Paragraph A7.74
[52] Paragraph A7.73

satisfaction. The study then analyses the interrelationship between customer satisfaction and customers' switching intention.

In summary, the study finds that customer satisfaction is a proxy for switching intention and that network quality (i.e. speed, reliability of network coverage, call & text quality) is the foundation of customer satisfaction. The reasons for this are twofold:

- Firstly, taken together speed, reliability of network coverage, call and text quality all contribute directly to customer satisfaction; and

- Secondly, speed, reliability of network coverage, call and text quality all affect customer satisfaction indirectly, by enforcing brand image and perceived value.

The study has found that the ability of an MNO to manage network quality is crucial in influencing its ability to retain and grow its customer base. Moreover, speed is emerging as the most important element of network service quality. Customers value speed almost as much as call and text quality, and of all network service quality elements speed has the highest impact on brand image.

Conclusion – the UK's mobile market is now firmly data-centric

In conclusion, growth in data usage is significantly outstripping all expectation, and will continue to grow strongly as latent demand is released. According to Ofcom mobile traffic could be ten, twenty-five or even fifty times larger within eight years (i.e. by 2025).

This section demonstrates the increasing importance of capacity and speeds to UK consumers, in light of rapid take-up of smartphone and exploding demand for data. Consumer demand for faster download speeds is rapidly growing as a result of a) changes in the services they use (particularly video content, which is expected to account for 80% of traffic as early as 2020); and b) changing expectations on what mobile networks can deliver

To be competitive, an MNO now needs to be able to greatly expand capacity at lower cost, minimise congestion and provide good speeds across the network. This will be key to an operator's ability to compete in this data-centric world, and will be critical both during Ofcom's transitional period and in the longer-term.

As discussed in the next section, spectrum is an essential input in the provision of capacity and speeds, and one which cannot be replicated by other alternatives.

3. Spectrum is an essential input in a data-centric market

Executive Summary

Ofcom suggests that an MNO can be credible with a 10-15% share of spectrum, because it does not need to have the same capacity as larger MNOs and can trade-off network investment with spectrum.[53] Ofcom accepts, however, that the trade-off is not perfect.

In reality, an MNO needs more than 15% of spectrum to be credible in a data-centric market. Spectrum is now an essential input because the alternatives (such as site densification) are not good substitutes.

Three has asked Real Wireless (RW) and Qualcomm to assess the substitutability between spectrum and sites. Both reports, and Three's own technical simulations, confirm that [✂-network densification is not an appropriate alternative to spectrum.]

The current imbalance in usable spectrum is going to create serious competition concerns even in the transitional period, [✂]. In summary:

- Sites cannot substitute for spectrum in a data-centric market;
- [✂-Findings from independent analysis of the relationship between speed, capacity, network size and spectrum holdings.]
- An MNO with a smaller spectrum share has a much higher marginal cost of expanding capacity than an MNO with twice the spectrum;
- [✂-Findings from independent analysis of the relationship between speed, capacity, network size and spectrum holdings.]

Sites cannot substitute for spectrum in a data-centric market

Ofcom is primarily interested in an MNO's ability to add capacity in the transitional period without 2.3GHz.[54] Ofcom believes that an MNO will be credible in the transitional period with just 10-15% of immediately usable spectrum, because it does not need to have the same capacity as larger MNOs and can trade-off network investment with spectrum.[55]

Ofcom accepts, however, that the trade-off is not perfect. According to Ofcom, there are two limits to this trade-off:

[53] Paragraphs 4.121 and 1.21
[54] Paragraph 4.72, footnote 44, 1.27
[55] Paragraphs 4.121 and 1.21

- **Timing and practical restrictions** – i.e. an MNO may be limited in its ability to use sites and other alternatives in the transitional period, due to difficulties in finding suitable sites, etc.[56] But over a longer timeframe Ofcom expects that MNOs can deploy macro sites or small cells in high-density urban areas.[57]

- **Imperfect substitutability** – i.e. an MNO with a smaller share of usable spectrum may have lower capacity and market share, compete less strongly for some segments and incur higher marginal costs of adding capacity, but it could still be credible provided it can constrain rivals.[58]

There are indeed practical constraints to an MNO's ability to deploy macro sites, small cells or similar alternatives to spectrum. These restrictions are set out in Annex 2.

In summary, an MNO's site portfolio is the product of years of effort trying to locate the best site locations. Expanding capacity through sites, etc. is very costly and can literally take years. There are practical limits on the speed with which new sites can be added, due to the need to negotiate leases, planning restrictions and the fact that the best site locations are already taken.

More fundamentally, however, Ofcom has seriously overestimated that substitutability between sites and spectrum. It is not just that the trade-off is not perfect. In reality, sites cannot adequately substitute for spectrum in a data-centric market. The rest of this section sets out the reasons for this view.

[✂-The number of sites required to match speeds offered by a MNO with more spectrum.]

To assess the substitutability of sites and spectrum, Three has categorised its sites as "Heavily loaded", "High Load", "Mid load" and "Low load" sites using traffic measurements from its network. [✂-More information on the categories used.]

[56] Paragraph 4.27-4.28, 4.137
[57] Paragraph 4.72, footnote 44, 1.27
[58] Paragraph 4.137

Figure 17: [✂-Chart showing results of the analysis.]

[✂]

Source: [✂]

[✂-Results of the analysis.]

In reality, there are no heavily loaded, high loaded or less loaded sites. Ofcom is incorrect to suggest that it is mostly the experience in the former sites that matters to consumers.[59] These are just categories to aid the analysis. Figure 18 shows that usage of the network varies by site and time of day, much like traffic on the UK's highways.

Figure 18: [✂]

[✂]

Source: [✂]

The left of Figure 18 plots site utilisation (as proxied by the average number of users simultaneously trying to download data in the busy hour, ABHU) against Three's sites (ranked by ABHU). [✂-What Figure 18 shows.]

The right of Figure 18 shows the profile of traffic going through Three's core network from all sites at different times of the day, including the network-wide busy hour [✂-Time of day.]. Even the busiest site may be more lightly used much of the time, in the same way that the busiest highway in the UK may have few cars outside peak hours.

[✂-Results of Three's analysis.][60]

Table 4: [✂]

Source: [✂]

[59] Paragraph A8.58
[60] [✂]

An MNO with a smaller spectrum share has a much higher marginal cost of expanding capacity than an MNO with twice the spectrum

As Ofcom has noted, MNOs with smaller spectrum holdings have higher marginal costs of adding capacity, because they need to build many more sites (whereas an MNO with a high spectrum share can simply deploy additional spectrum on its existing sites).[61]

However, the Consultation includes no empirical evidence on the size of the marginal cost differences that is going to arise in the transitional period. At critical parts the Consultation relies largely on a priori reasoning and assertion.

Three has estimated those cost differences in this section. [✂-Three's estimate of cost differences.]

Table 5: [✂]

Source: [✂]

[✂]

[✂-The relationship between spectrum holdings and network size in the context of video capacity.]

Three has also quantified the number of sites needed to match the video user capacity than can be provided by an MNO with twice as much spectrum, to ensure that 95% of users achieve a given minimum target speed (2 Mbps, 4 Mbps and 8 Mbps).

[✂-Results of Three's analysis.]

Table 6: [✂]

Source: [✂]

[✂]

Figure 19: [✂]

[61] Paragraph 4.27

[✂]

Source: [✂]

[✂-Real Wireless has found similar results.]

RW has reached very similar results (Annex 6). RW has i) conducted a qualitative review of the technical literature on the trade-off between spectrum and sites; and ii) has also carried out a quantitative assessment based on network simulations.

Based on its qualitative assessment, RW has concluded that [✂-Findings made by Real Wireless.]

Figure 20: [✂]

[✂]

Source: [✂]

RW highlights that network densification in urban areas of the UK is *"extremely challenging and time-consuming".* In its experience it is extremely challenging to deploy new sites in central London and doing so usually takes up to 18-24 months.

[✂-Qualcomm has reached similar conclusions as well.]

Qualcomm has estimated the number of extra sites that MNO A with 10MHz (assumed to be Three) would need to achieve the target throughput of MNO B with 20MHz in three scenarios: low loaded, medium loaded and high loaded.

Qualcomm has used an existing LTE 1800MHz macro network of seven sites near Three's head office in Maidenhead for this purpose. Table 7 sets out the number of sites needed in each scenario for MNO A to match the user throughput that can be provided by MNO B. These results are in line with Three's technical simulations presented above.

Table 7: [✂-Qualcomm's results.]

Source: [✂]

Figure 21 presents the Cumulative Frequency Distribution of user throughputs in the medium loaded scenario. [✂-Qualcomm's results.]

Figure 21: [✂]

[✂]

Source: [✂]

Conclusion – sites are a highly imperfect substitute for spectrum in a data-centric market

In conclusion, [✂-Overall conclusions drawn from Three's analysis and the work by Real Wireless and Qualcomm.].[62] [✂]

[62] [✂]

4. Spectrum shares must be kept between a 20% floor and a 30% cap for a four-player market to be sustained

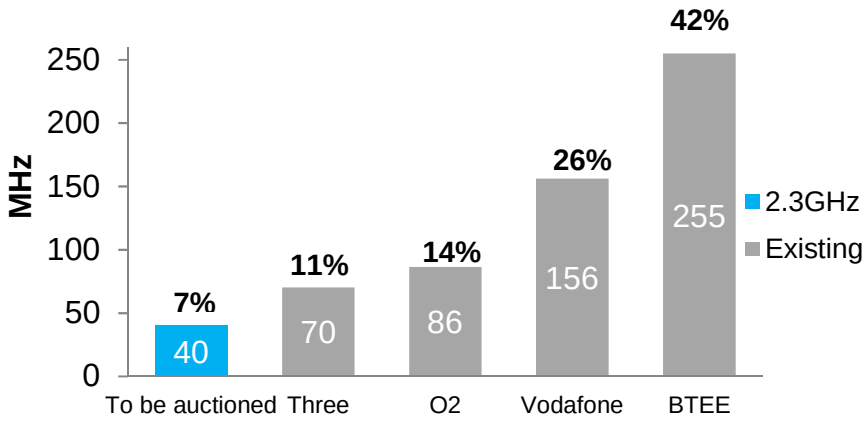
Executive Summary

This section explains why Three believes that shares of relevant spectrum must be kept within a 20% floor and a 30% ceiling. Relevant spectrum in the transitional period includes spectrum currently usable for mobile plus the 2.3GHz to be awarded (i.e. Ofcom's IUS). From 2020, the relevant spectrum will also include 1400MHz and 3.4GHz, which are both expected to become usable in that year, but not 3.6GHz (Section 6).

This section considers the scale of the competition issues now and in the transitional period as a result of concentration of IUS. Section 5 presents the consumer harm that has arisen because shares of IUS are nowhere near the 20%-30% range. Second 6 covers the competition issues that will arise in the longer term if spectrum holdings (including 1400MHz and 3.4GHz) are not within that range following the PSSR auction.

Figure 22 presents the distribution of Ofcom's IUS, including 2.3GHz.

Figure 22: Distribution of Ofcom's Immediately Usable Spectrum



Source: Ofcom

Ofcom believes that this imbalance in IUS holdings has not affected the competitiveness of the market, and it only aims to stop the imbalance from growing further by capping shares of IUS at 42%. In Ofcom's view, UK MNOs need no more than 10-15% of spectrum to be credible.[63] Ofcom thinks unlikely that Three not be credible in the transitional period with 11% of IUS, even if it won no 2.3GHz.[64]

[63] Paragraph 4.136
[64] Paragraph 4.150

According to Ofcom, Three has grown its subscriber share, is strongly cash-flow positive and has the highest EBITDA margin in the industry.[65] In its submissions to the EC, Ofcom also suggested that Three has established itself as a viable MNO and has benefited "*from much of the economies of scale available"* by sharing its radio network with EE.[66]

In effect, Ofcom would only intervene when an MNO has four times more IUS than another (i.e. 42% cap compared with the lower end of Ofcom's 10%-15% range). Three believes that capping IUS at 42% is not sufficient for an MNO with only 10-15% to remain credible in a data-centric market. Ofcom must act to reduce concentration of IUS spectrum, not just prevent further asymmetry.

Shares of relevant spectrum must be kept within 20% and 30% for a four-player market to be sustainable in a data-centric world. Table 8 sets out Three's view of the minimum capacity requirement for an MNO to be credible in a data centric world, in the transitional period and beyond.

Table 8: **[✂-**Three's assessment of what it will take to be a credible competitor.]

Required capability		
Can add capacity at competitive cost (see Section 3)		
Sufficient scale (20% market share)		
Can keep congestion at sustainable levels		
Can provide minimum speeds across network		

Source: [✂]

[✂] In summary:

- Economies of scale related to capacity are going to threaten the viability of a four-player market;

[65] Paragraph 4.149
[66] Phase I Submission to the EC, paragraphs 8.2, 9.24-9.30

- An MNO needs to keep congestion at sustainable levels and be able to grow its market share to be credible in the transitional period and beyond;

- An MNO need to provide sufficient speeds across the network to be credible in the transitional period and beyond;

- Spectrum shares must be kept between a 20% floor and a 30% ceiling for a competitive four-player market to be maintained.

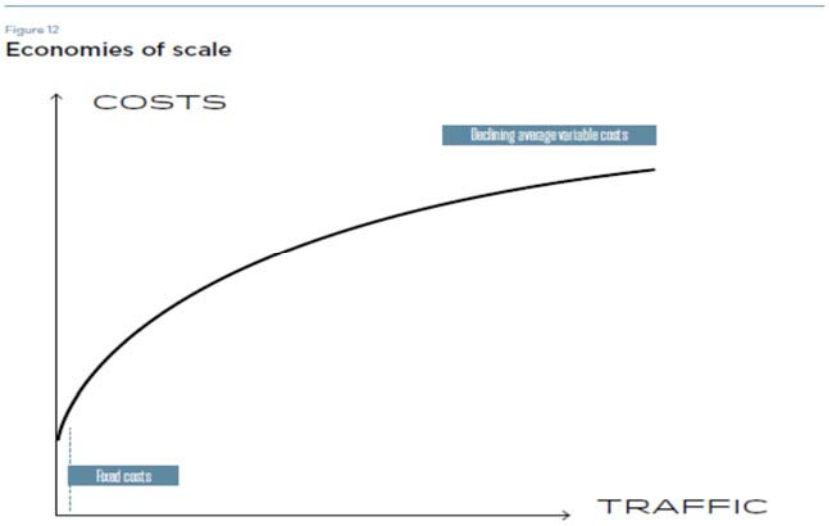
Economies of scale related to capacity are going to threaten the viability of a four-player market

Three is still sub-scale despite its RAN sharing agreement with EE. Ofcom appears to have confused two different scale economies in the mobile industry – i.e. two different reasons why (long run) average costs fall at higher levels of output:

- **Fixed costs from the coverage network** – in a voice-centric market the main source of scale economies was the cost of the coverage grid, or the network of sites needed to provide a minimum level of coverage throughout the country. This is the height of the fixed costs next to the origin in Figure 23;

- **(Long run) average variable costs falling with mobile traffic** – i.e. there are increasing returns to scale related to capacity. Simultaneously increasing spectrum and sites in an area increases capacity more than proportionately and lowers the (long run) cost per unit of capacity. This is shown by the decreasing slope of the cost curve in Figure 23.

Figure 23: Two distinct economies of scale in mobile: economies of capacity and economies from the coverage network.



Source: Three

This section discusses both scale economies and why economies related to capacity are going to threaten the viability of a four-player market.

i. Three has not reached scale through its network sharing agreement with EE

Three has had to deploy thousands of sites in order to cover the UK's geography since its creation in 2003. The cost of this coverage network is largely fixed and independent of traffic or market share, but variable with respect to the area covered.

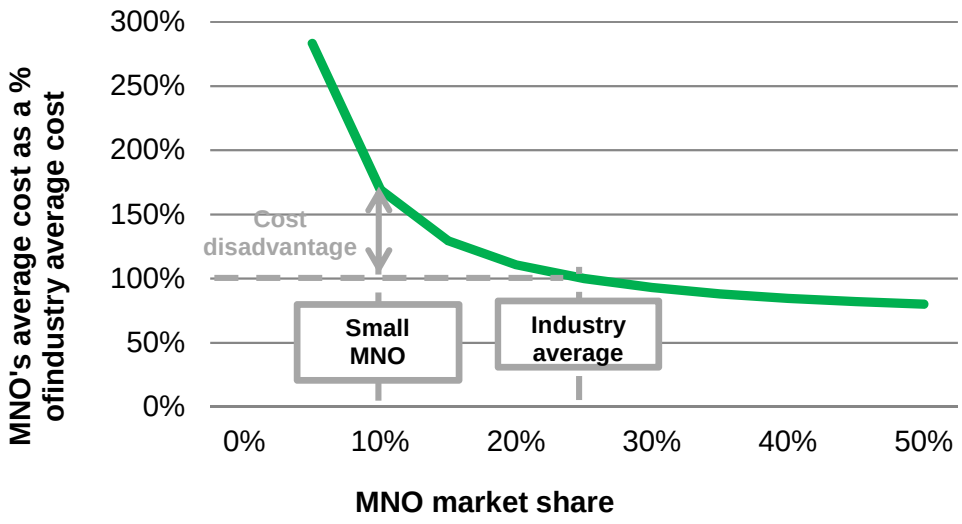
A minimum outlay on sites, equipment and backhaul must be incurred in order to enable a voice call anywhere in the country, even if the network is virtually empty. Even in the long run, the cost of the coverage network can only be eliminated by discontinuing service altogether.

Because that cost is largely fixed and has to be incurred irrespective of an MNO's size, Three is at a large cost disadvantage against larger rivals. The extent of this disadvantage can be quantified using Ofcom's Mobile Call Termination model (MCT), as discussed in Annex 22.

The MCT model estimates the scale and cost of a mobile network with an assumed 25% market share, but it can also be used to estimate network costs at the levels of traffic implied by other market shares. The model

takes account of network sharing and is calibrated against financial data from MNOs. Figure 24 shows how the average unit cost of an MNO (in relation to the industry average cost) varies with market share in the MCT model.

Figure 24: Three has historically suffered a large cost disadvantage due to its lack of scale



Source: Three

On the basis of the relationship between fixed and variable costs implied by Ofcom's MCT model:

- An MNO with 10% market share has an average unit cost 69% higher than the industry average;
- An MNO with 35% market share has an average unit cost 12% lower than the industry average.

The main cause of the fixed costs in the MCT model is the cost of the cell site network in rural areas (i.e, the cost of the coverage network), as the number of sites required for coverage provides sufficient capacity for even a very large operator.

As a result of this cost [✂] disadvantage, since its creation in 2003 Three was heavily loss-making and only became cash flow positive in 2011. Three took four years (from 2003 to 2007) to increase the number of sites in its 3G network from 5,000 to 7,500.

These economies of scale led UK MNOs share their RAN in the previous decade. Three and T-Mobile agreed to share their 3G RANs in December 2007. This has helped to [✂] and expanding Three's coverage significantly (see Figure 25). In March 2009 Vodafone and O2 announced a similar deal.

Figure 25: Three's network sharing agreement with EE improved its coverage

[✂]

Source: [✂]

However, Three continues to be at a cost disadvantage against larger rivals. As shown in Figure 24, Ofcom's MCT model suggests that economies of scale from coverage only become less pronounced when an MNO reaches a minimum market share of 20%.

This is consistent with the EC's Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates, which explicitly states that "*in the mobile market it can be expected to take three to four years after entry to reach a market share of between 15 and 20%, thereby approaching the level of the minimum efficient scale*", and that new entrants may have higher unit costs before they reach that scale.[67]

As explained below, [✂-Three's assessment of its current position in the market.] Moreover, all UK MNOs benefit from the reduction in fixed costs from network sharing, but Three can only spread the (reduced) fixed costs over a smaller subscriber base. In that context, the 90% coverage obligation agreed with Government in 2014 has only increased the extent of this disadvantage for Three.

ii. Economies of scale related to capacity are critical in an increasingly data-centric market.

The second type of scale economies – economies from capacity – is now critically important to competition in mobile.

Three has commissioned Professor Jon M. Peha from Carnegie Mellon University to analyse the underlying reasons driving market consolidation and the implications for Ofcom's 10-15% minimum spectrum share.

[67] http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2009/c_2009_3359_en.pdf

Professor Peha served as Chief Technologist at the US' telecoms regulator (Federal Communications Commission). His report is in Annex 5.

Professor Peha's report provides the strongest theoretical proof available that, in the age of the smartphone, new economies of scale related to capacity are going to make competition increasingly difficult to sustain in the presence of large disparities in spectrum holdings between MNOs.

Professor Peha explains that all MNOs have achieved good coverage levels and must now meet the explosion in traffic volumes to remain competitive. This effect becomes more important with every passing year. Ofcom's policy should keep up with this changing reality.

An MNO with 10% of spectrum will find it increasingly hard to compete with MNOs that have far more than 10%. Absent intervention by Ofcom, economies of scale from capacity are going to make large MNOs ever larger, because they can expand capacity at lower cost.

Professor Peha assumes that capacity in a capacity-constrained area is roughly proportional to the product of spectrum and sites, so that it increases linearly with the number of sites (for a given amount of spectrum) and also with the amount of spectrum (for a given number of sites). The report explains that, in reality, spectrum is more effective in adding capacity than sites (as discussed in Section 3).

An MNO must choose the combination of sites and spectrum that delivers greatest capacity at a given cost (or minimises the cost of achieving a given capacity). MNOs have to keep sites and spectrum in balance over time, estimating at each step which of the two methods delivers greater capacity for a given outlay.

In that context, an MNO with more spectrum benefits more from every new site, because the capacity added by an extra site is directly proportional to the amount of spectrum held. If BTEE has four times more spectrum than Three, it will be able to deploy four times as much spectrum on every new site and will gain four times more capacity than Three from the same site.

Similarly, an MNO with more sites benefits more from every new block of spectrum, as the capacity added by the block is directly proportional to the number of sites deployed. If BTEE has [✂-X%] more sites than Three (18,000 compared with [✂-number]), it will be able to deploy the new block on [✂-X%] more sites and derive [✂-X%] more capacity than Three from the same block of spectrum.

Hence, MNOs with more spectrum are going to find it profitable to also deploy more sites, and will only tend to get larger and larger. The cost of

adding capacity reduces the more spectrum and sites an MNO has, so this creates long-term competition issues. Moreover, once a large disparity exists, it is likely to grow. The MNO with more spectrum will be willing to pay more for additional spectrum.

Professor Peha provides a critical assessment of Ofcom's view that MNOs with less spectrum can compensate by building more sites. Sites and spectrum are not independent. MNOs must keep sites and spectrum in balance. An MNO with too many sites relative to spectrum will find that the cost of adding capacity through site densification with a given amount of spectrum becomes more and more costly. At some point it will simply stop expanding capacity – it does not pay to deploy more sites.

The report concludes that MNOs with less spectrum are going to find it increasingly harder to compete. The trend is ultimately for spectrum and sites to consolidate into fewer and fewer hands. Absent intervention by Ofcom, the natural end point is a single mobile network making use of huge blocks of spectrum, as opposed to multiple networks with partially duplicative facilities in competition with each other.

This need to reach scale to meet explosive growth in data traffic at lower cost is a key force driving industry consolidation, including Three's failed acquisition of O2. By pooling the spectrum and sites separately held by two MNOs, the resulting network has much greater capacity than the sum of the individual networks. This lowers the cost of serving additional subscribers and allows the merged entity to expand output and lower prices, relative to the situation in the absence of the merger.[68]

This is a fundamental issue for Ofcom to resolve. Ofcom has previously taken the view that having multiple competing networks determines its approach to mobile regulation more than any other feature of the market.[69] It is critical that Ofcom adopts a spectrum policy that does not undermine its objective of a market structure containing four MNOs.

Professor Peha considers the trade-off between two key policy objectives: cost efficiency (i.e. reducing the cost of the industry's capacity) and competition. The report shows that any division of spectrum that is optimal with respect to both objectives will split spectrum fairly evenly among MNOs.

[68] In the context of Three's acquisition of O2 Ofcom challenged this simple fact based on technicalities, but did not deny the existence or importance of these merger efficiencies. Ofcom variously claimed that the efficiencies of the merger were not "*sufficiently verifiable*" and that *"Three has not shown that consumers will benefit"* from those efficiencies. See Ofcom Comments on the Effect of the Three/O2 merger on prices. Ofcom submission to the EC

[69] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/37138/msa_statement.pdf , paragraph 3.11

Professor Peha warns that inconsistent antitrust and spectrum policies may deliver poor consumer outcomes in respect of both efficiency and competition:

"If four carriers is indeed the long-term goal, then a 42% cap is dangerously high. Worse yet, if a nation has a spectrum policy that allows three but not four carriers to obtain the spectrum they need to expand capacity at costs that are consistent with competitive prices, and an antitrust policy that prevents that fourth carrier from merging with one of the other three, then we may see a poor result with respect to both policy objectives: effective competition and efficiency. We may get the effective competition one would expect with just three significant carriers, and the lower efficiency of four".

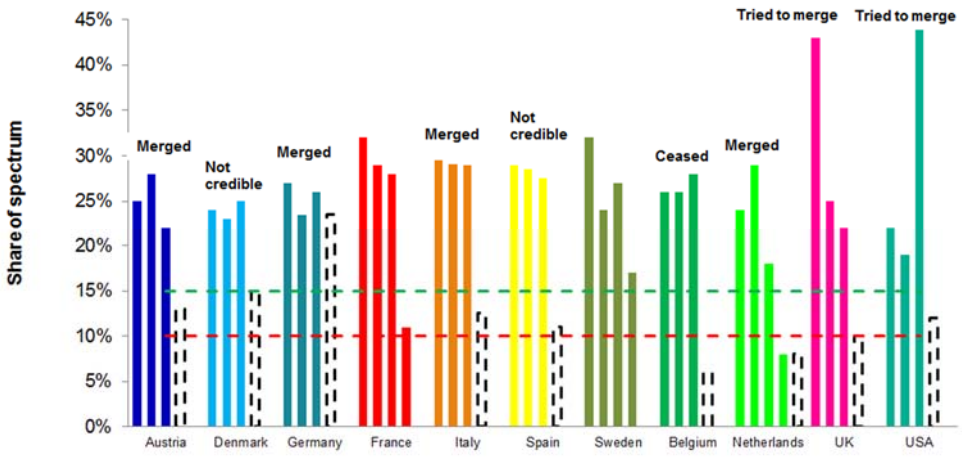
iii. MNOs with a 10-15% share of spectrum in four-player markets are rapidly disappearing or merging in Europe and elsewhere

Ofcom set its view on the 10-15% minimum share of spectrum in 2012. This was partly based on the observation that it was unusual for MNOs in four-player markets in Western Europe and the US to have less than 10% of the available spectrum. This indicated that it may be difficult to be credible with less than 10% of the available spectrum.[70]

It is instructive to analyse the market situation in the countries Ofcom used as reference points for its assessment. Figure 26 updates Ofcom's analysis.[71]

[70] 4G Auction Statement, paragraph A2.189
[71] See Figures 3.6 and 3.8, Annex 6. Second consultation on future mobile competition. Also 4G Auction Statement, paragraph A2.189

Figure 26: MNOs with a 10-15% share of spectrum since 2012 have largely merged, gained scale or ceased operations.



Source: Three, based on Ofcom's 4G Auction Statement

Back in 2012 there were ten MNOs in the countries assessed by Ofcom with a spectrum share within (or below) Ofcom's 10-15% range. The success rate of those MNOs has been very low indeed. Within four years, eight out of the ten small MNOs (in the dashed columns) have merged, had their merger prohibited, discontinued service or failed to gain scale. In particular:

- One has ceased operations – Telenet Tecneo in Belgium;
- Three have merged –Three Austria, Three Italy and Ziggo in the Netherlands;
- Two had their merger prohibited – Three UK and T-Mobile USA;
- Two have not gained scale and are not considered credible by Ofcom – Yoigo in Spain (which was recently sold and has stalled at 6% market share) and Three Denmark (which Ofcom considered a failed operator in its Phase I submission to the EC).

In summary, the market now regards an MNO with a 10-15% share of spectrum as sub-scale. Only two small MNOs have so far managed to escape the fate of the other players. France's Free Iliad has grown its subscriber base and now has 16% of spectrum, but it is also a fixed line operator so it does not rely principally on its mobile business. The other MNO, Tele 2 in the Netherlands, was an MVNO in 2012 and has only recently launched its own 4G service in November 2015.

E-plus in Germany, which had significantly more spectrum than 15% in 2012, has also merged (in the dashed column). Telia Sonera and Telenor in Denmark, which had much more than 15% of spectrum also tried to merge but abandoned their plans due to opposition by the EC.

Ofcom's attempt to update its earlier analysis in the Consultation is deficient. Ofcom notes "*that there are European operators within the 10-15% spectrum range which have apparently been able to compete*".[72] This is not a balanced assessment in light of the evidence in Figure 26.

The only examples given by Ofcom are Free (Iliad) in France and Telemach in Slovenia. But Ofcom had not even considered Slovenia back in 2012. Moreover, the latest Enders report on European Mobile suggests that consolidation talks have restarted in France "*with Orange and Iliad (at least) reported to be involved, with the long term sustainability of a four-player market still very much in question"*.[73]

An MNO must keep congestion at sustainable levels and be able to grow its market share to be credible

To be credible in the transitional period, an MNO needs to be able to grow its market share and expand output (or increase quality) in response to price increases or reductions in quality by larger MNOs.

[✂]

(i) [✂-Three's forecasts for future congestion.]

[✂]

[74] [✂]Three has developed a new congestion model with the help of Frontier Economics to address Ofcom's criticisms of its earlier model during the Three/O2 merger process. Details are in Annex 10.

Three's congestion model produces estimates of the number of sites and customers likely to be affected by congestion over time. By comparing forecast capacity to forecast demand on each cell, the model determines which specific cells will be congested.

[72] Paragraph 4.130
[73] European Mobile in Q2 2016. Down but resilient
[74] [✂]

The model focuses on individual cells in Three's 1800MHz 4G network, which covers the areas with highest traffic density. Where forecast demand exceeds 95% of the capacity of a cell, the model classifies the cell as congested – i.e. users will perceive a notable reduction in their quality of service.

The demand forecast in the congestion model assumes that throughput in each cell grows at the same rate as overall network traffic. This in turn is based on assumptions on the rate of growth of data usage per subscriber and customer growth in the absence of capacity constraints. The assumptions on the growth in data usage per subscriber are more conservative than forecasts from other industry experts.

The capacity forecast for each cell depends on two factors:

- **Technical enhancements** – the model factors in expected capacity uplifts from carrier aggregation, LTE Advanced and the deployment of 4x2 and 4x4 MIMO, all of which increase a cell's capacity through increased spectral efficiency;

- **Investments in capacity enhancements** – the model assumes that once a cell becomes congested, a capacity solution is deployed in the following year. The model initially deploys more spectrum on the cell (including 1400MHz and [✂]), and subsequently deploys more sites (macro sites, small cell or an in-building system) where needed.

This analysis shows that, [✂-Results of the analysis by Frontier.]

Figure 27: [✂]

[✂]

Source: [✂]

[✂]

Figure 28: [✂]

[✂]

Source: [✂]

(ii) [✂-Three's assessment of its market and financial performance.]

[✂]

Figure 29: [✂]

[✂]

Source: [✂]

[✂]

(iii) [✂]

[✂]

Figure 30: [✂]

[✂]

Source: [✂]

[✂]

Table 9: [✂]

Source: [✂]

[✂]

An MNO need to provide sufficient speeds across the network to be credible in the transitional period and beyond

Speeds are now a key dimension of competition and spectrum is a key determinant of user speeds, particularly with Carrier Aggregation technology (CA). With CA, the amount of spectrum held by an MNO sets a physical limit on the speeds (lowest, average and peak) the MNO can provide to users.

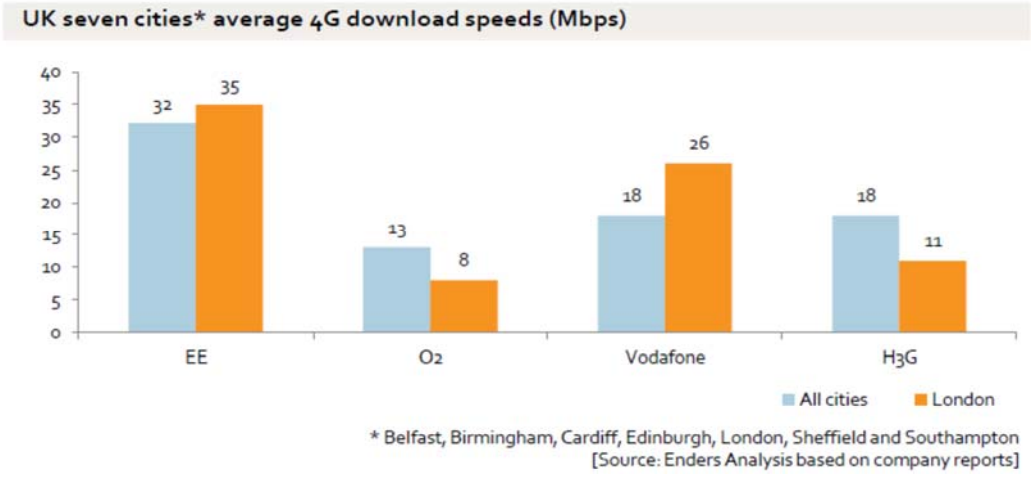
CA allows customers to access different spectrum bands deployed at a cell, thus increasing the speed available to the customer. Today, CA is possible with many combinations of three and four different bands. Five band CA is standardised already and available for select band combinations, with more combinations expected to be standardised in 2017-2019. Initial support for five band CA is expected in 2018.

[✂-Three's assessment of how differences in spectrum holdings affect current and will affect future MNO performance.]

Ofcom has recently published its Smartphone Cities report for 2016. The report compares MNOs' 4G network performance in tests carried out between July and October 2016 across seven UK cities. Ofcom has benchmarked download speeds, web browsing times, upload speeds, call quality and call success rates across UK MNOs.

Ofcom's report [✂-shows a strong performance for] EE's 4G network, even though BTEE is only using a fraction of its 4G spectrum. EE comes on top in every single category but has a particularly large advantage on average download speeds. EE's 4G network is already twice as fast on average (32Mbit/s vs 18Mbit/s for Vodafone and Three and 13Mbit/s for O2) and also in each of the seven cities individually.

Figure 31: Three is already at a large performance disadvantage.



Source: Enders UK Mobile Market Q3 2016

[✂-Three's assessment of how differences in spectrum holdings affects current and will affect future MNO performance, including analysis by Real Wireless.][75]

[✂]

Table 10: [✂]

Source: [✂]

[✂]

Three has commissioned RW to compare speed differences between MNOs during Ofcom's transitional period as a result of differences in existing spectrum holdings (i.e. ignoring the PSSR award). This assumes that BTEE and Vodafone deploy their currently unused and lightly used spectrum in the transitional period.

As discussed in Section 2, RW has examined an MNO's ability to support two main types of service likely to be demanded by UK consumers in the transitional period (and certainly by mid-2020) with their existing spectrum:

- **Video streaming** – video will represent 80% of mobile traffic by 2020. RW believes that MNOs will need to provide ubiquitous HD video as a critical requirement to be credible. This would require a minimum of 4Mbps at the cell edge in order for this service to function, with a recommended rate for viewing of 8Mbps;

- **File downloads (i.e. songs, large media files) or cloud sync services** – consumers are likely to value higher speeds for file transfers or cloud sync. Section 2 explains that average speeds of 13.3Mbps are required for users to download typical multimedia files instantly (i.e. less than 3 seconds) and 4Mbps is needed to do so in less than 10 seconds.

[✂]

Figure 32: [✂]

[75] [✂]

[✂]

Source: [✂]

[✂]

Figure 33: [✂]

[✂]

Source: [✂]

[✂]

Table 11: [✂]

Source: [✂]

Spectrum shares must be kept between a 20% floor and a 30% ceiling for a competitive four-player market to be maintained

The key question for Ofcom to resolve is what level of spectrum asymmetry is consistent with a competitive four-player market, both in the transitional period and beyond.

Three fundamentally believes that shares of relevant spectrum must be kept within a 20%-30% range to preserve a market structure containing four MNOs. This is for the following reasons:

- Evidence suggests that a 10% to 15% spectrum share is too low in a data-centric market – MNOs with that share of spectrum are rapidly merging or disappearing, in Europe and elsewhere. [✂- The competitive disadvantage of an MNO with a 15% share of spectrum.]

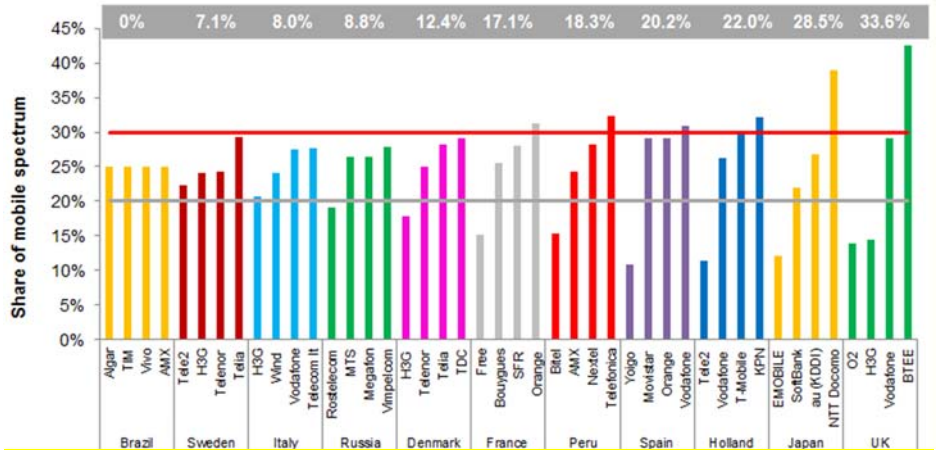
- 25% shares – even shares in a four-player market – would be too restrictive. Some asymmetry in spectrum distribution is desirable to allow MNOs room to innovate and differentiate;

- An MNO with a 20% share of relevant spectrum would be much better placed to provide competitive capacity and speeds (provided no MNO has more than 30%). [✂-Three's view on the acceptability of a 20% share of spectrum.]

- At the other end, spectrum shares must be capped at 30%. In a four-player market, if an MNO has 20% share and another a 35% share, the other two would have 22.5% share each (if the remaining spectrum was split equally). MNOs with 20% or 22.5% share would have a much greater cost of expanding capacity and would struggle to compete against the MNO with 35%.

Figure 34 compares spectrum shares in all four-player markets in the top 50 countries by GDP, including the 20% to 30% range and the Gini Index of spectrum concentration (the grey bar on top).

Figure 34: The UK has the largest spectrum imbalance of any four-player market in the top 50 countries by GDP.



Source: Three

About half of the four-player markets are already within or very near the 20% to 30% range proposed by Three. Three expects spectrum shares to converge towards 20-30% where the national regulator wants to preserve a market structure containing four players. If not, consolidation is likely. Three Italy has recently merged its operations with Wind, and as discussed above there are currently merger talks in France involving Free Iliad.

Conclusion – UK spectrum shares must be kept between 20% and 30% for a market structure containing four players to be viable

Bringing together the key messages in Sections 2 to 4, a key reason for the wave of mobile consolidation is the need to achieve economies of scale from capacity and meet explosive growth in data traffic at lower cost. Larger MNOs can expand capacity at much lower cost than smaller MNOs and will only tend to get larger. Smaller MNOs are not able to deploy sites to compensate.

To credibly compete in the transitional period and beyond, an MNO must be able to expand capacity, grow its market share, keep congestion at sustainable levels and provide the minimum required speeds to support the services that consumers increasingly demand.

It is therefore critical to keep shares of relevant spectrum within a 20% floor and a 30% ceiling. [✂-The likely consequences of a continuing severe spectrum imbalance.]

Ofcom's proposals for 2.3GHz must therefore take clear steps towards the desired longer-term range, in order to limit the scale of the potential competition problem in the transitional period. Ofcom's proposal for 3.4GHz should also recognise the importance of moving towards this position sooner rather than later.

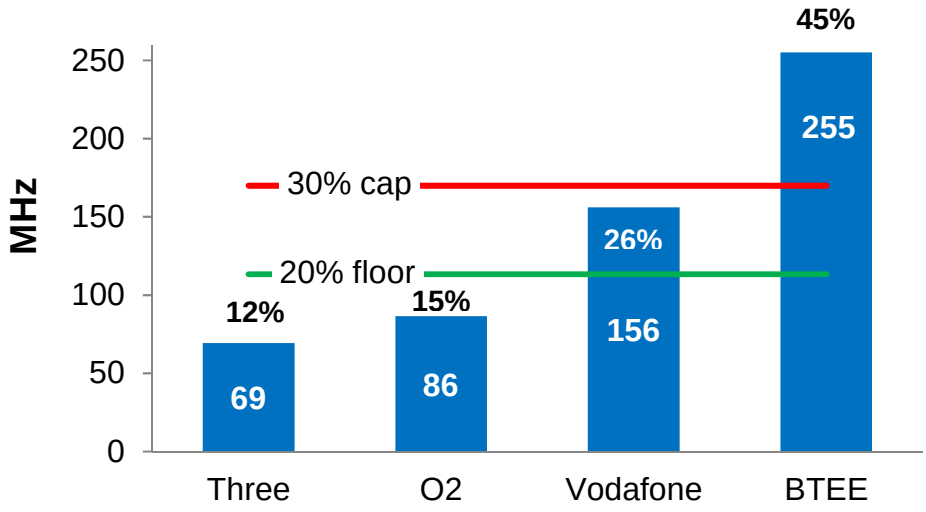
To highlight the importance of Ofcom intervening decisively now, we discuss in the next section how UK consumers are already suffering the consequences of concentration of Immediately Usable Spectrum.

5. UK consumers are already suffering the consequences of concentration of usable spectrum

Executive Summary

The distribution of usable spectrum is very far from the 20% to 30% range needed for competition to be sustained in an data-centric market.

Figure 35: Usable spectrum is far from the 20-30% range needed to sustain competition.



Source: Three

Ofcom suggests that the mobile market is working well despite this imbalance in usable spectrum.[76] However, UK consumers have already started to feel the consequences of concentration of usable spectrum:

- Retail mobile prices significantly increased in 2015 and 2016, following years of continuous price decreases;
- Ofcom has expressed serious concerns itself about the intensity of competition in the wholesale market;
- Spectrum hoarding by BTEE and Vodafone is throttling Three's growth and denying UK consumers the benefit of greater capacity, speeds and a better quality of service;
- UK consumers have had to endure partial not spots and a lack of choice in rural areas as the direct result of concentration of sub 1GHz spectrum; and

[76] Paragraph 2.25

- The UK fares poorly in comparison with other European countries in terms of network quality and performance.

This evidence is not consistent with the picture of a healthy and competitive mobile market. The full consequences of the current imbalance in usable spectrum, however, will only become apparent in the next few years as BTEE and Vodafone have only deployed a fraction of their usable spectrum.

Mobile prices have significantly increased in 2015 and 2016 after years of price decreases

In its Strategic Review of Digital Telecoms, Ofcom has underlined the significance of spectrum in enabling Three's role as the UK's market challenger between 2003 and 2012.[77]

"In mobile, competition has cut the price of a typical bundle of mobile services by two thirds in real terms, from around £40 in 2003 to £13 in 2012. Access to spectrum has kindled this competition, with the 3G spectrum auction designed to encourage a new network operator into the market, and the 4G auction to maintain four national wholesalers. Lower prices have been accompanied by innovation: for example, Three, as a challenger brand, introduced 'all you can eat' data tariffs and use of Skype voice over IP (VoIP) services, and scrapped roaming charges from a number of countries."

However, [✂]. In particular:

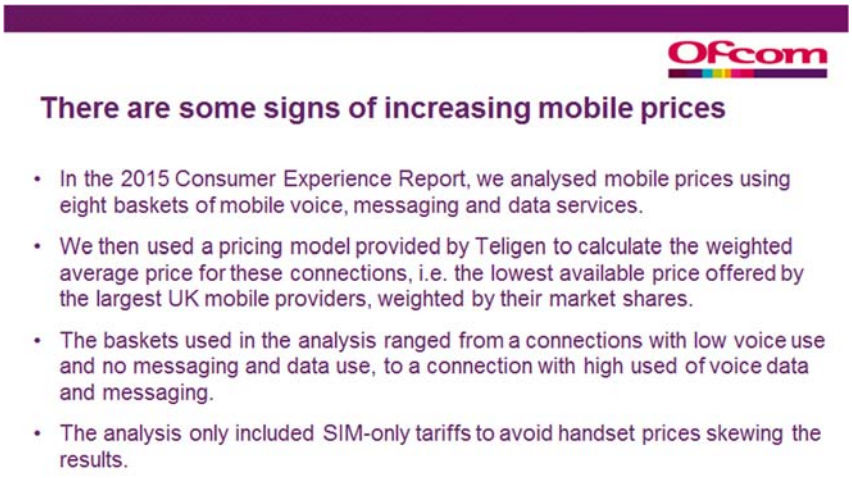
- Various Ofcom reports indicate that UK mobile prices are on the rise;
- An independent study by Frontier Economics confirms that post-pay prices have significantly increased in 2015 and 2016; and
- [✂].

[77] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/63444/digital-comms-review.pdf

(i) Various reports from Ofcom indicate that UK mobile prices are on the rise

Ofcom is clearly concerned about an increase in mobile prices after years of price decreases. In its proposed Annual Report for 2017/2018, Ofcom sets out its intention to monitor the evolution of fixed and mobile prices.[78] Three has recently met Ofcom in this context, as shown in Figure 36.

Figure 36: Ofcom is concerned about the evolution of mobile prices



Source: Ofcom

Three has received an information request from Ofcom in this context. This highlights Ofcom's concerns and its intention to "*publish a study on the relative impact of recent price trends in fixed and mobile markets on particular consumer segments (including potentially vulnerable consumers*)."

The Consultation presents evidence suggesting that UK mobile prices may be increasing.[79] Ofcom quotes an EC' study on Mobile Broadband Prices in Europe 2016 which states that UK handset plans have increased by an average of 4% between 2015 and 2016, compared to an average 7% decrease across the EU.[80]
Ofcom also reviews its International Communications Market Report (ICMR) for 2015, which found a 12% increase in UK mobile prices in 2015, the first since Ofcom started tracking those prices back in 2011. Ofcom has recently published its ICMR for 2016. This finds significant

[78] https://www.ofcom.org.uk/__data/assets/pdf_file/0027/94743/Proposed-Annual-Plan-2017-18.pdf
[79] Annex 7
[80] Paragraph A7.55

price reductions in 2016, but this is because Ofcom has changed its methodology and now focuses exclusively on the one segment where mobile prices are going down (SIM-only contracts).

(ii) An independent study by Frontier Economics confirms that post-pay prices have significantly increased in 2015 and 2016

Three has commissioned Frontier Economics to produce an independent study of mobile pricing focussed on the post-pay segment (which constitutes 65% of subscribers in the UK), including both contract handset and SIM-only tariffs. The report can be found in Annex 21.

The Frontier report provides clear evidence that post-pay prices in the UK have significantly increased since 2015. Frontier has used Pure Pricing tariff level data from 2013 to November 2016. Frontier has removed the wholesale cost of handsets to ensure that price changes reflect changes in airtime costs, not handset costs.

Frontier has conducted two separate analyses to assess the evolution of mobile prices in the UK:

- **A basket analysis** – Frontier has replicated Ofcom's basket analysis in the ICMR reports, estimating the prices that minimise what a mobile subscriber would spend on a representative basket of mobile services. Frontier has improved on the ICMR analysis in two respects. Frontier considers both contracts with handsets and SIM-only contracts (rather than just SIM–only), and also takes an average price throughout the year for each basket (rather than the price in one particular week);

- **An econometric analysis** of contract handset pricing over the last three years – to overcome the limitations of a basket analysis (discussed below).

Frontier's basket analysis concludes that post-pay prices have increased by 7.8 to 9.4% between 2014 and 2016. This is based on a weighted average of prices for both SIM-only and contracts with handsets. In terms of the breakdown:

- Contract handset prices increased by 13% between 2014 and 2016 (excluding the impact of changes in handset prices);

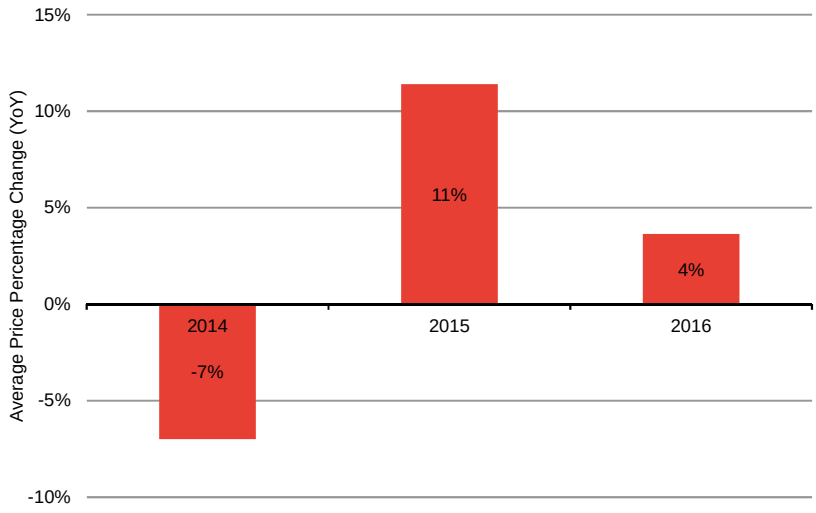
- SIM-only prices decreased by 16% between 2014 and 2016.

There are clear limitations with Ofcom's basket analysis. All tariffs except those that minimise spend on the representative baskets of consumption are ignored, and the baskets are kept constant over time. The results are also sensitive to the month chosen to assess prices (July in Ofcom's report) and can be affected by temporary promotions.

To overcome these limitations Frontier has also produced a regression analysis of all contract handset tariffs from MNOs using over 160,000 tariffs in the Pure Pricing dataset. This is superior to a basket approach as it assesses price changes based on all tariffs and controls for changes in the bundle allowance (of minutes, SMS and data). This isolates pure price changes from changes in the size of bundle allowances over time.

This econometric analysis has found that contract handset prices decreased by 7% in 2014, but then increased by 11% in 2015 and 4% in 2016. This is shown in Figure 37.

Figure 37: Contract handset prices are increasing since 2015.



Source: Frontier Pricing Report at Annex 21

(iii) [✂-Three's assessment of certain pricing trends in the market, conducted with the assistance of Frontier.]

[✂]

Figure 38: [✂]

[✂]

Source: [✂]

[✂]

Figure 39: [✂]

[✂]

Source: [✂]

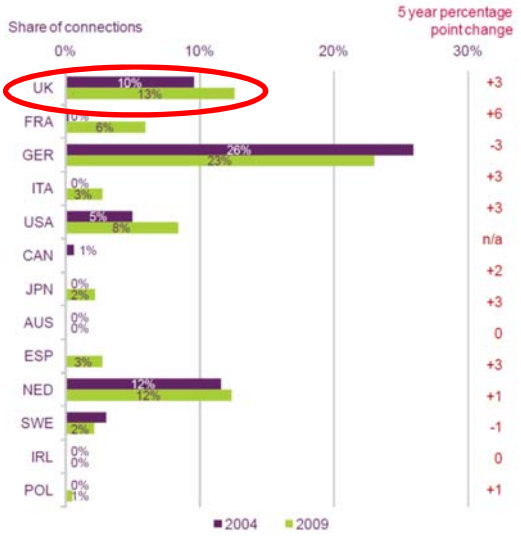
[✂]

Ofcom has expressed serious concerns about the state of competition in the wholesale market

Ofcom assessed the state of mobile competition in 2009, in its Mobile Evolution: Ofcom's Mobile Sector Assessment (MSA).[81] The MSA found that the wholesale market was competitive, as shown by the fact that the retail market share of all MVNOs (13%) had increased since 2004 and was higher in the UK than in many foreign markets.

[81] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/37138/msa_statement.pdf

Figure 40: In 2009 MVNOs had a 13% share of connections in the retail market



Source: Ofcom Mobile Sector Assessment (2009)

More recently Ofcom has been more pessimistic about the state of competition in the wholesale market. In at least three recent publications Ofcom has expressed serious concerns about MNOs reducing MVNOs' ability to compete at the retail level.[82] These submissions are not consistent with the well-functioning market presented in the Consultation.

The EC largely relied on Ofcom's submissions in relation to the wholesale market in its decision to prohibit Three's acquisition of O2. The EC found that the ability of UK MVNOs to compete has decreased since 2009 to the point that they "*are unable to meaningfully constrain the competitive behaviour of MNOs on the retail market for mobile telecommunications services today*".[83]

Specifically, Ofcom told the EC that *"MVNOs are increasingly becoming less relevant as consumers become more data orientated*".[84] Ofcom cited the following evidence in support of its view:

- The proportion of mobile data used by MVNO customers has fallen considerably from 14% in 2011 to 7% now;

[82] Strategic Review of Digital Communications, Phase 2 submissions to the CMA in the context of BTEE's acquisition of EE https://assets.publishing.service.gov.uk/media/56992242ed915d4747000026/BT_EE_final_report.pdf
Phase I submission to the EC in relation to Three's proposed acquisition of O2
[83] EC Decision, paragraph 969 and 971.
[84] Phase I submission to the EC in relation to Three's proposed acquisition of O2, paragraph 3.7

- MVNOs that are completely independent of MNOs (i.e. excluding Tesco Mobile) now account for only 10% of retail subscriptions;

- The only MVNOs with a subscriber share above 2% are Tesco Mobile and Virgin Media, and no MVNO has achieved a 5% share.

Ofcom said that MVNOs now *"make a limited contribution to retail competition compared to MNOs"* and are unable to compete for high value customers with high data tariffs due to per unit usage pricing structures offered by MNOs (such as per minute, per text and per GB). [85]

According to Ofcom this type of pricing prevents MVNOs from growing their market share. [86] Ofcom suggested that MVNOs have had to focus on consumers that their host MNO may not serve as effectively, for example, minority ethnic groups.

Ofcom also indicated that MVNOs have limited market power *"as evidenced by the difficulty that some MVNOs have had in negotiating the supply of 4G*", noting that MVNOs are not given access to the latest technologies or only years after they are launched by MNOs.

Ofcom made similar submissions to the CMA in the context of the BTEE merger:[87]

- MVNOs face some difficulties in switching MNO suppliers which may affect their buyer power;

- Usage pricing in wholesale supply agreements may provide MVNOs with different incentives to MNOs in the retail market and may be a cause of MVNOs' focus on lower revenue and lower data usage customers; and

- MNOs consider the risk of substitution of existing customers and revenue when responding to MVNO tenders, and this may limit the extent to which MNOs compete to supply MVNOs.

TalkTalk, Sky and other MVNOs told the CMA that competition in the wholesale mobile market was limited, and that the market is highly concentrated with very few potential hosts, is "*dysfunctional and very fragile*", with even the current level of competition barely enough to secure reasonably competitive outcomes.[88]

[85] Ibid, paragraph 1.5
[86] Ibid, paragraph 1.5
[87] https://assets.publishing.service.gov.uk/media/56992242ed915d4747000026/BT_EE_final_report.pdf, paragraph 14.33
[88] https://assets.publishing.service.gov.uk/media/56992242ed915d4747000026/BT_EE_final_report.pdf , paragraph 14.30

Three did not agree with these submissions. However, Ofcom may want to consider whether the current spectrum imbalance (and specifically the fact that two out of four potential hosts are increasingly capacity-constrained) may be responsible for the outcomes it identifies. [✂-Three's discussions with MVNOs and the relevance of spectrum holdings in connection with the same.][89]

[✂]

BTEE and Vodafone are hoarding large amounts of spectrum to the detriment of consumers and MVNOs

The Consultation makes clear that BTEE and Vodafone are currently sitting on 65MHz of prime 2.6GHz spectrum purchased four years ago in the UK's 4G auction. They are also only "lightly using" an additional 70MHz of 2.6GHz:

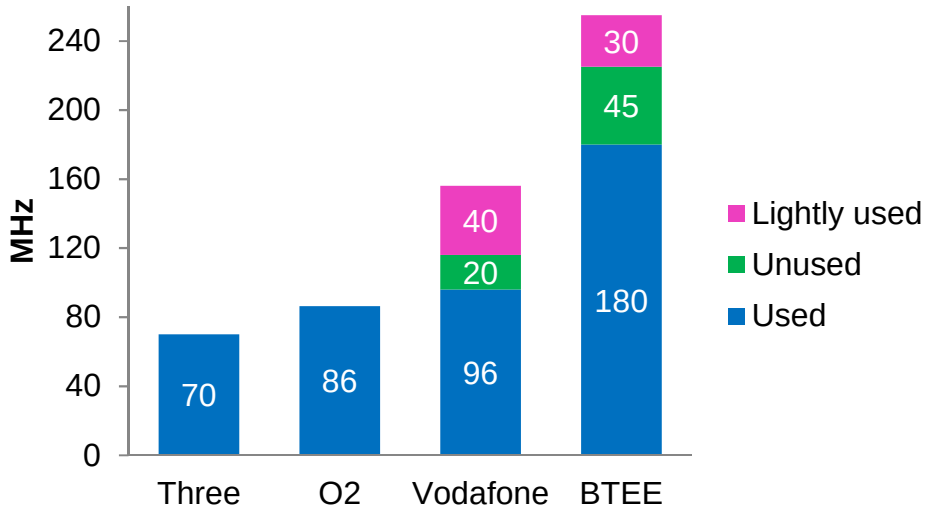
- *"BTEE/EE is not currently deploying all of its existing spectrum widely*".[90] EE had already deployed 2x20MHz of its 2.6GHz paired, but it has only recently deployed the remaining 2x15MHz of 2.6GHz paired it won in the 4G auction on a number of sites in Central London and Wembley;

- BT's 45MHz of 2.6GHz spectrum is unused. BT has only begun "*small scale deployment*" of its 2x15MHz 2.6GHz paired and 1x15MHz of (unrestricted) 2.6GHz unpaired;

- Vodafone has deployed its 2x20MHz of 2.6GHz paired "*on only a small proportion of total sites*". It is only "*trialling"* the (unrestricted) 1x20MHz of 2.6GHz unpaired it bought in the 4G auction.[91]

[89] [✂]
[90] Paragraph 5.37
[91] Paragraphs 5.37 and 5.60

Figure 41: BTEE and Vodafone are hoarding large amounts of "usable" spectrum



Source: Ofcom consultation, paragraphs 5.37 and 5.60

Three has assessed how intensively BTEE and Vodafone are actually using their 2.6GHz spectrum. We show below the share of P3 drive trial measurements spent by Vodafone and BTEE devices on:

- 2.6GHz only (i.e. standalone, non-carrier aggregated mode); and
- 2.6 GHz aggregated with another band – Vodafone combines its 2.6GHz paired spectrum with 800MHz, and BTEE with 1800MHz.

Table 12: BTEE and Vodafone are barely using their 2.6GHz spectrum as of Q4 2016

Band (Mode)	**Vodafone**	**BTEE**
% P3 measurements on 2.6GHz FDD **(Non-CA mode)**	**1.4%** *2.6GHz FDD (20 MHz)*	**5.0%** *2.6GHz FDD (20 MHz)*
% P3 measurements on 2.6 GHz FDD + another band **(CA mode)**	**7.1%** *800MHz(10MHz)+ 2.6GHz FDD (20MHz)*	**30.1%** *2.6GHz FDD (20MHz)+ 1800MHz (20MHz)*

Source: P3 tests

In Q4 2016 only a very small share of P3 measurements was on 2.6GHz

paired in a non-aggregated mode: 1.4% and 5% for Vodafone and BTEE respectively. For Vodafone, just 7.1% of measurements were on 2.6GHz FDD (aggregated with 800MHz). In BTEE's case, 30.1% of tests were on aggregated 2.6GHz and 1800MHz.

There are no P3 measurements for Vodafone's 2.6GHz unpaired, EE's 2x15MHz 2.6GHz or BT's 2x15MHz and 1x15MHz 2.6GHz. That spectrum remains entirely or almost entirely unused since it was purchased four years ago.

This is not an efficient use of a key public resource. Spectrum hoarding is stalling Three's growth and denying the benefit of increased capacity and speeds to its customers. In Annex 9 Three has estimated the speed uplift that consumers would receive if the 135MHz of unused or 'lightly used' 2.6GHz spectrum was reallocated to Three and O2 as follows:

Table 13: Assumed split of unused and lightly used spectrum.

MNO	2.6 GHz unpaired (MHz)	2.6 GHz paired (MHz)	Sub-total per MNO (MHz)
Three	1x20	2x25	70
O_2	1x15	2x25	65

Source: Three

The impact on Three's and O2's average speeds of the assumed reallocation of the unused (or lightly used) spectrum would be as follows:

Table 14: Three's customers would greatly benefit from a redistribution of unused spectrum.

Effect on Avg Download Speeds[92]	Three	O2	Vodafone	BTEE	Mean avg speeds
Unused Vodafone and BTEE divided 50% between Three and O_2	[✂]	[✂]	0%	0%	[✂]

[92] Use of re-distributed spectrum is maximised (where possible). Due to technical limitations in the number of carriers that can be aggregated, Three would be able to utilise the majority but not all of EE's unused spectrum

Source: Three

In summary, Three's customers would benefit from an increase in average download speeds of nearly [✂]%. [✂-How Three would deploy the unused spectrum.] O2 would derive a larger speed uplift. This is partly due to the fact that O2 has less 4G spectrum today, so any additional re-distributed spectrum is proportionally more beneficial.

Ofcom has a duty to promote the optimal use of the spectrum. Section 7 shows that EE's bids for 2.6GHz spectrum in the 4G auction were generally between two and five times higher than Three's, despite the fact that EE was the least capacity-constrained MNO.

The Consultation says explicitly that an MNO with a very high share of spectrum may make limited use of it in order to deny to rivals.[93] It states in terms that BTEE and Vodafone are making limited use of 2.6GHz spectrum, but it includes no measure to put that spectrum to work to the benefit of UK consumers. [94]

Ofcom's failure to deal with the issue is all the more surprising in circumstances where European legislation specifically permits measures to prevent spectrum hoarding[95] and where national legislation already exists to facilitate this sort of conditional divestment.[96]

UK consumers continue to suffer from partial not spots as a result of historical concentration of sub 1GHz spectrum

Until 2013, sub 1GHz spectrum was concentrated in the hands of Vodafone and O2. [✂-Differences in voice coverage.]

Historical concentration of sub 1GHz spectrum has led to a proliferation of 'partial not spots'. These are areas of the UK where voice coverage is provided by some but not all MNOs, particularly in Scotland, Wales and Northern Ireland, which have a higher proportion of rural areas.[97]

[✂]

[93] Paragraphs 4.25-4.26
[94] Paragraphs 5.28-5.29
[95] Article 9(7), Framework Directive (Directive 2002/21/EC, as amended).
[96] Section 14(5), Wireless Telegraphy Act 2006.
[97] 89% of landmass in Wales and 97% of the landmass in Scotland is rural, whereas 32% of the Northern Irish population is rural).

Figure 42: [✂]

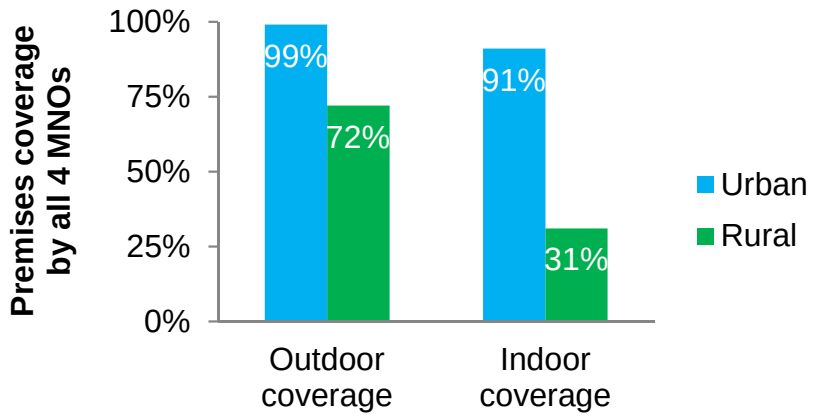
[✂]

Source: [✂]

[✂]

According to Ofcom 99% of urban premises receive outdoor voice coverage (2G and 3G) from all four MNOs, compared to only 72% of premises in rural areas. Only 31% of rural premises benefit from indoor voice coverage from all four operators, compared to 91% in urban areas.[98]

Figure 43: Partial not spots are greatly reducing consumer choice in rural areas of the UK.



Source: Ofcom Connected Nations 2015

These coverage differences still harm UK consumers in two main ways. First, those living and working in those areas have fewer choices in terms of operator, tariff, handset plans, etc. Second, consumers travelling into the affected areas lose connectivity if the area is not covered by their operator. Partial not spots will only be reduced by December 2017, when UK MNOs cover 90% of the UK's landmass following their agreement with Government of December 2014.

[98] Ofcom Connected Nation 2015, para 2.25

The UK does not score well against other countries in terms of network quality and performance

The intensity of competition between MNOs is a key determinant of the quality of mobile networks in a country. Capacity, coverage and speeds all depend on the amount (and type) of spectrum and the number of sites deployed by an MNO. MNOs are driven by competition to invest on spectrum and sites to differentiate themselves on capacity, coverage and speeds.

As explained in Section 4, an MNO's optimal strategy to expand capacity is to keep spectrum and sites in balance. Without additional spectrum an MNO may not find it economic to significantly expand capacity through sites. [✂-Recent roll-out activity.]

Figure 44: [✂]

[✂]

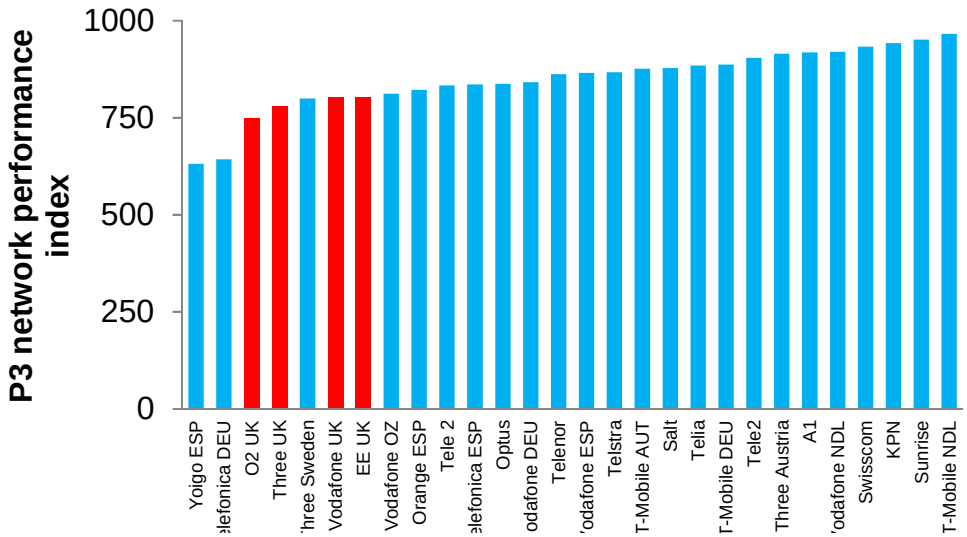
Source: [✂]

This suggests that the current spectrum imbalance may be constraining the growth of at least one of the UK's mobile networks and reducing competitive pressure on BTEE and Vodafone to improve their own networks. This is consistent with spectrum hoarding by BTEE and Vodafone.P3 is the world leader in mobile network testing. P3 conducts the most authoritative network quality tests in Germany, Sweden, Australia, Spain, the UK, Netherlands, Austria and Switzerland.[99] Since the UK was added to the list of countries tested in 2015, UK MNOs have consistently fared poorly in comparison with MNOs in those other countries.

P3 measures voice and data performance. These metrics are summarized in a network performance index. For data, KPIs include average session time to access web pages or transmit small files, throughput rates, average start times and resolution for YouTube videos. For voice, P3's tests measure call set-up time, call success ratio and speech quality. The results of the latest set of tests are shown below.

[99] http://www.p3-group.com/en/wp-content/uploads/2016/11/Report-UK-2016.pdf

Figure 45: UK mobile networks compare poorly against networks in comparable countries



Source: P3

The UK's mobile networks are bottom of the list. Yoigo (the Spanish MNO that Ofcom does not consider credible in the Consultation) is bottom, followed by Telefonica Germany. The four UK networks are next, significantly behind the best networks in the comparable countries.

Similarly, the UK's National Infrastructure Commission has recently reported that the UK is languishing in the digital slow lane and ranks 54th in the world for 4G coverage.[100] The report explains that:

"*The UK's 4G network is worse than Romania and Albania, Panama and Peru. Our roads and railways can feel like digital deserts and even our city centres are plagued by not spots where connectivity is impossible. That isn't just frustrating, it is increasingly holding British business back as more and more of our economy requires a connected workforce*".

[100] https://www.gov.uk/government/news/government-must-take-action-now-to-secure-our-connected-future-so-we-are-ready-for-5g-and-essential-services-are-genuinely-available-where-they-are-n

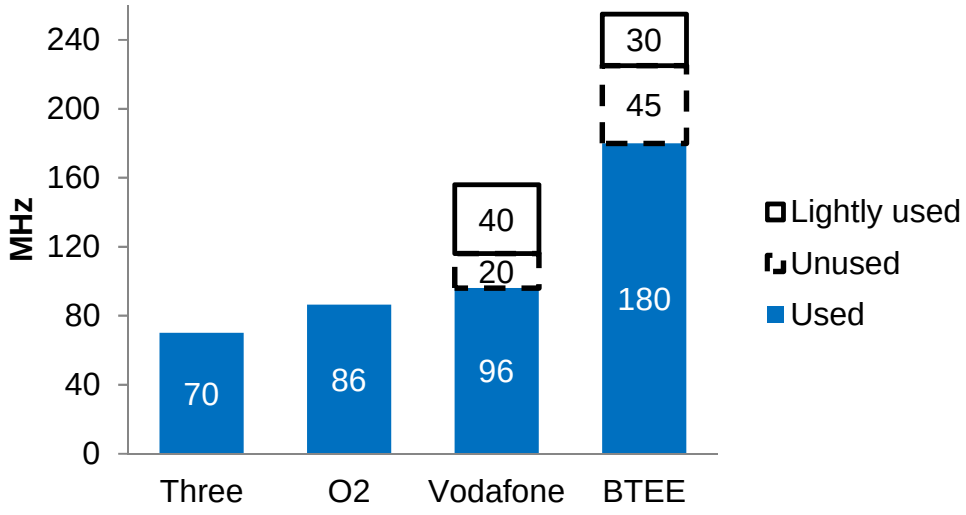
The Consultation suggests that UK consumers are benefitting from competition and significant levels of investment. Network tests by P3 and the NIC report suggest otherwise. Rivalry between UK MNOs has not delivered high quality networks by international standards.

UK consumers will only experience the full consequences of concentration of current spectrum holdings in the future

Section 5 has set out the consumer harm that is starting to emerge, both in the retail and wholesale markets, from concentration of IUS. But this is only the beginning. UK consumers are yet to experience the full consequences of spectrum concentration.

Ofcom rightly believes that spectrum concentration can weaken competition because an MNO with a very high spectrum share may offer services that rivals cannot replicate.[101] But BTEE and Vodafone have not yet fully exploited this advantage, as they have only deployed a fraction of their useable spectrum. Not all "usable spectrum" is actually being used. This shows that Three, O2, and Vodafone are not in a too dissimilar position in terms of spectrum in use.

Figure 46: BTEE and Vodafone have only deployed a fraction of their spectrum to date.



Source: Ofcom consultation, paragraphs 5.37 and 5.60

[101] Paragraph 4.23

Conclusion – UK consumers are already feeling the consequences of concentration if IUS spectrum

UK consumers have already started to feel the consequences of concentration of usable spectrum, because spectrum shares are nowhere near the range that is sustainable for competition in a data-centric market.

[✂]

6. Severe competition concerns will arise if Ofcom adopts a ‘wait and see’ approach now

Executive Summary

The previous two sections considered the competition concerns that will arise in the transitional period to about 2020, and which have already started to arise, from concentration of IUS spectrum.

This section considers the competition issues in the longer term, and in particular during the period in which 3.4GHz and 1400MHz spectrum become usable but before 3.6GHz does.

The competition concerns arising from an auction scenario where [✂-Three’s anticipated auction outcome occurs.] would be severe. In summary:

- [✂-Spectrum distribution after the auction.];
- Ofcom would not be able to intervene quickly to resolve the competition issues – the likely usable date of 700MHz and 3.6GHz and the proven ability of MNOs to delay awards through legal challenge make it highly unlikely that Ofcom could act quickly to address the imbalance;
- [✂-How competition will be affected.];
- Ofcom’s proposal would compromise innovation and the speed of deployment of 5G, and put at risk significant economic benefits.

[✂-Spectrum distribution after the auction.]

[✂]Figure 47 presents the auction outcome that Three’s auction advisor, Professor Ausubel of the University of Maryland, considers most likely under Ofcom’s preferred Option A (see Section 7).

Figure 47: [✂-Likely auction outcome under Option A]

[✂]

Source: [✂]

[✂-Likely auction outcome under Option A]

Ofcom would not be able to intervene quickly to resolve the competition issues

Ofcom concludes that no restrictions are needed on 3.4GHz. This is on the basis that 3.4GHz is not immediately usable over the transitional period and, by the time it is, 700MHz and possibly 3.6GHz will also become usable for mobile.[102]

Ofcom recognises the risk that 3.6GHz spectrum may not be usable as soon as 3.4GHz and may therefore not be available to mitigate a very asymmetric distribution resulting from the auction.[103] Ofcom believes, however, that should any competition issues arise now it will be able to impose measures (if proportionate to do so) in future awards of 700MHz and 3.6GHz.[104]

However, Ofcom will not be able to intervene to resolve the competition issues promptly due to: i) the likely useable date of the spectrum; and ii) the proven ability of MNOs to delay awards and/or liberalisation of spectrum through legal challenge. Each of these is discussed below.

(i) Ofcom would be unable to act promptly to remedy an extreme spectrum imbalance due to the likely timing of the availability of different spectrum bands

Ofcom's assessment rests on a false dichotomy between 'immediately usable' spectrum at 2.3GHz and 'not immediately usable' spectrum at 3.4GHz, 700MHz and 3.6GHz.

In reality, 700MHz and 3.6GHz spectrum will not become usable at around the same time as 3.4GHz. This is the main conclusion of the timing analysis of spectrum availability by both Analysys Mason and Real Wireless in Annexes 12 and 13.

[102] Paragraphs 4.54, 5.75
[103] Paragraph 5.84
[104] Paragraph 4.46

Figure 48: Timing of the availability of different bands.

Source: Analysys Mason Report at Annex 13

In summary, even absent delaying litigation, there will likely be a gap of at least a year between 3.4GHz and 700MHz spectrum becoming usable, and a further two years between 700MHz and 3.6GHz becoming usable. This is because:

- **As Ofcom suggests, 3.4GHz will be usable by 2020** – there is a narrow range of devices available now, but Three expects the ecosystem to develop (as confirmed by key handset vendors) and for both the 3.4GHz and the L-Band (i.e. Three's 1400MHz) to be fully ready for mobile by about 2020;

- **700MHz will become usable later than Ofcom has assumed** – 700MHz is unlikely to be made available before Q2 2020, as it is used for broadcasting and PMSE. Were an auction to be held before then, and assuming a highly developed ecosystem, it would still take until 2021 at the earliest before paired 700MHz spectrum could be intensively used, with 700MHz unpaired lagging significantly behind. Two others risks could further delay availability: (i) the need to complete the award of 700MHz spectrum by Q2 2020 and (ii) the need to complete DTT and PMSE clearance by this time;

- **The 3.6GHz band is likely to develop much more slowly –** a market for devices does not currently exist, with only one TD-LTE deployment globally. Harmonisation for mobile is much more limited relative to 3.4GHz, creating uncertainty around the band's usability and the timing of device support. The 3.6GHz band is

also encumbered by fixed links and satellite users. It is not straightforward to bring this spectrum to market. Both options for making this spectrum usable for mobile proposed by Ofcom in its recent consultation ("Retain" and "Remove" existing users) imply a long lead time before this spectrum will be intensively usable.

In practice, this means that, if Three does not win sufficient PSSR spectrum it would have to wait a minimum of six years after the auction (from late 2017 to 2023) before a large amount of substitutable capacity spectrum (116MHz at 3.6GHz) becomes available to remedy an extreme spectrum imbalance.

700MHz, which could be available (absent litigation) from 2021, is not substitutable spectrum. 700MHz is "coverage", not capacity spectrum. With only 2x30MHz available there is just not enough of it to address an extreme spectrum imbalance, particularly as the usability of the 700MHz unpaired in the centre band (1x20MHz) is likely to lag significantly behind.

(ii) Tactical litigation and the auction process would delay the availability of 700MHz and 3.6GHz spectrum

Section 1 explains that Ofcom has previously overestimated its ability to rely on the availability of future spectrum to address spectrum concentration. Ofcom is now proposing a similar 'wait and see approach. Judging by the experience with 900MHz liberalization, this could create a very litigious environment, delay the availability of 5G services to consumers and intensify competition concerns in the interim.

Ofcom should consider that, even when previous awards have been uncontroversial, it has still taken Ofcom a minimum of two to three years to conduct the auction from the issue of the first auction consultation document (see Annex 14).

Both the 700MHz and 3.6GHz bands are at a very early stage in the award process. As regards 700MHz Ofcom decided on 17 October 2016 to "work to accelerate the programme by 18 months" to release the 700MHz band in Q2 2020.[105] No consultations have been published in relation to the award itself.

The release of 3.6-3.8GHz for mobile use is *"not as certain as at 700MHz"*.[106] Ofcom cannot really be said to have even begun to prepare

[105] *Statement – Maximising the benefits of 700MHz clearance*, 17 October 2016.
[106] Paragraph 4.50.

an award. It is not even mentioned in the "prospective awards" section of Ofcom's website. Indeed, all that Ofcom has done is publish a consultation document on 6 October 2016[107] presenting *"our initial thinking on how we could expand spectrum access for mobile services in the 3.6-3.8 GHz band"*.

Where the award has been more controversial, it has taken Ofcom as long as eight years to award the spectrum. Ofcom's proposals will give BTEE and Vodafone an even stronger incentive to sweep the PSSR spectrum and then seek to delay future auctions and/or liberalisation of already awarded spectrum through lobbying and litigation in order to cement their spectrum advantage.

The Administrative Court would seek to deal quickly with any challenge but this would likely delay progress by six months to a year for each challenge (and there may be several at different points), even if Ofcom were successful and there were no appeals. If Ofcom lost any judicial review, it would likely need to run at least one more new consultation, which could easily add another six months to a year to that timeframe.

Hence, Ofcom cannot use 700MHz or 3.6GHz as an excuse not to act now, because those bands may not be available when Ofcom wants them to be.

[✂-**Detail on how competition will be affected.]**

Figure 49: [✂]

[✂]

Source: [✂]

[✂]

Figure 50: [✂]

[✂]

[107] *Improving consumer access to mobile services at 3.6 GHz to 3.8 GHz*, 6 October 2016.

Source: [✂]

[✂]

Table 15: [✂]

Source: [✂]

Ofcom's proposal compromises innovation and the speed of deployment of 5G, and puts at risk significant economic benefits

Failing to act on 3.4GHz gives rise to major risks for Government and Ofcom. 3.4GHz will likely provide the earliest route to 5G, followed, potentially, by 700MHz and then 3.6–3.8GHz a few years later (see above).

As the initial likely 5G spectrum, 3.4GHz will set the stage for competition and innovation in the UK and determine the speed of deployment of 5G technology. However, Ofcom's proposal allows BTEE and/or Vodafone to buy all 3.4GHz spectrum.

Absent sufficient competitive pressure from Three (and O2), there is a clear risk that BTEE and Vodafone could decide to slow down their 5G rollouts, or to roll out less extensively than might otherwise be the case to the detriment of UK consumers.

Ofcom's proposal is at odds with Government's ambition for the UK to become a world leader in 5G. Government has pledged to invest £740m to lay the ground for 5G mobile networks and to publish its 5G strategy in the early part of 2017. The aim is to boost the next generation of mobile connectivity and keep the UK in the forefront of the development of the Internet of Things.

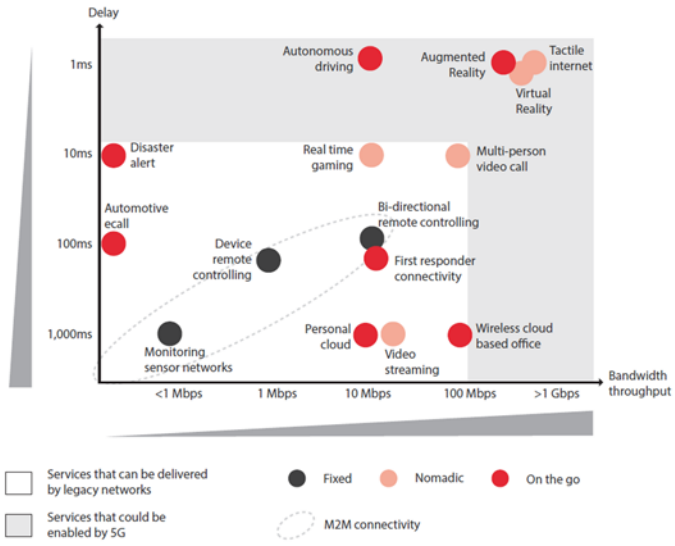
Similarly, the National Infrastructure Commission recently published its final report into 5G. The NIC has asked Government to play an active role to ensure that the UK's roads, railways and city centres are made 5G-ready as quickly as possible. The NIC's goal is for the UK to take early advantage of the potential applications of 5G services.[108]

[108] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577906/CONNECTED_FUTURE_ACCESSIBLE.pdf

5G is expected to be transformative across a number of sectors including health, transport and education. 5G holds the promise of sub-1ms latency and 1Gbps downlink speeds to deliver a step change in ultrafast mobile connectivity for existing services, plus the ability to support a wide range of new applications from connected and autonomous vehicles to the Internet of Things and virtual reality.

Figure 51 illustrates the latency and speed requirements of various use cases for 5G.

Figure 51: 5G holds the promise of a step change in existing services and new applications



Source: GSMA, Understanding 5G

A 2016 EU study estimates that, in 2025, benefits from the introduction of 5G could reach €113.1 billion per year in the four key sectors which will be the first users of 5G: automotive, health, transport and energy. Ofcom has previously carried out illustrative calculations of the cost to consumers of delayed innovation.

For example, in 2007 Ofcom estimated that a one-year delay in the launch of a major enhancement to mobile services (such as 4G) might result in a total welfare loss in the region of between £250m and £1.5bn.[109]

[109] Application of spectrum liberalisation and trading to the mobile sector, Consultation, Ofcom, 20 September 2007, paragraph 11.26

As the NIC has noted, the UK has the potential to be amongst the leaders in growth industries developing around internet and cloud-based applications and services that depend on the widespread deployment of advanced mobile connectivity like 5G. But this potential will only be fully realised if the slow roll-out and availability of 4G networks in the UK is not repeated. Failure to act now risks consigning the UK to the bottom of the league tables for connectivity as 5G is rolled out.

Conclusion – significant competition concerns are likely to arise if Ofcom adopts a 'wait and see' approach

Ofcom has failed to recognise the significance of the medium-term competition issues which could arise beyond its transitional period, when 3.4GHz is available but before the benefits of 700MHz and 3.6GHz can be fully realised.

Ofcom has also overstated its ability to intervene effectively in the future through the availability of 700MHz and 3.6GHz, and has overlooked that it may not be able to bring about a timely award in the face of an even more extreme spectrum imbalance.

The next section further explains why auction outcomes that increase spectrum asymmetries are likely.

7. [✂-Three's view of the likely auction outcome.]

Executive Summary

In the context of Three's acquisition of O2, Ofcom told the EC that, absent the transaction, it expected [✂-Ofcom's prediction of the auction outcome during the Three/O2 merger review process.][110]

Figure 52: [✂]

[✂]

Source: [✂]

[✂][111] [✂][112]

[✂-How the Consultation compares to what Ofcom said in the merger review process.] Ofcom recognises that "*as a result of the auction overall mobile spectrum shares could become very asymmetric*" due to differences in intrinsic values or strategic bidding by MNOs.[113] Ofcom is particularly concerned about strategic investment in 2.3GHz by BTEE and Vodafone.[114]

[✂-Why Three anticipates the auction results that it does.]

[✂-**Three's views on intrinsic value.]**

Ofcom has acknowledged in the Consultation that the general tendency for the value of spectrum to decrease with the amount of spectrum held by an MNO is not always the most important factor in spectrum valuation.[115]

[✂-Three's views on intrinsic value.] This is for the following reasons:

[110] [✂]
[111] [✂]
[111] [✂]
[112] [✂]
[113] Paragraph 4.54, 1.26, 4.168, 1.25-1.26, 4.14, 4.178-4.206 and 4.244
[114] Paragraphs 1.25-1.26, 4.14, 4.178-4.206 and 4.244
[115] Paragraph 4.166

- A technical assessment indicates that more capacity-constrained MNOs do not necessarily have a higher intrinsic value for spectrum;

- [✂-A summary of the arguments made by Three later in the section.];

- Evidence from the UK's 4G auction suggests that larger MNOs have a higher value for spectrum (or alternatively bid strategically to deny spectrum to Three);

- [✂-A summary of the arguments made by Three later in the section.]

(i) A technical assessment indicates that more capacity-constrained players do not necessarily have a higher intrinsic value for spectrum

It is not possible to say a priori whether a more capacity-constrained MNO should have a higher or lower intrinsic value for spectrum. [✂-Summary of this sub-section and what it means for Three.]

[✂]

An MNO's intrinsic value for spectrum will be based on the difference in expected profits with and without the spectrum. All else the same, an MNO's willingness to pay for extra spectrum (i.e. its demand price for it):

- **Decreases with the amount of spectrum the MNO has** – as Ofcom notes, an MNO would avoid fewer sites the more spectrum it has. [✂-What the previous text means in relation to Three.];

- **Increases with the number of sites an MNO has** – spectrum adds more capacity the more sites an MNO has in capacity-constrained areas, because it can then be deployed over a larger number of sites (as explained in Section 4). [✂-What the previous text means in relation to Three.]; and

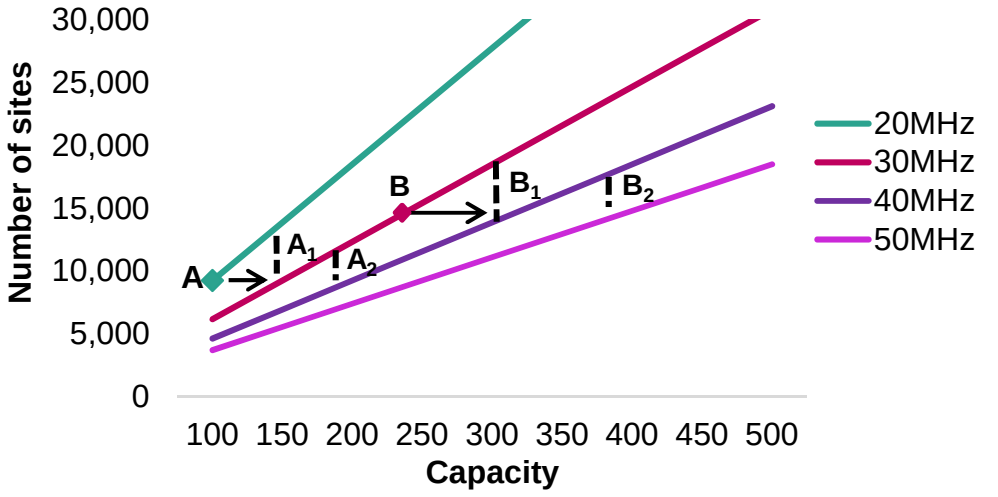
- **Increases with the incremental revenue per unit of capacity** – i.e. the higher the revenue that an MNO can generate from the incremental capacity contributed by the spectrum. [✂-What the previous text means in relation to Three.]

Table 16: [✂]

Source: [✂]

Figure 53 illustrates these factors based on Ofcom's view of the relationship between network capacity, spectrum and sites. In its 4G Auction statement Ofcom suggested that sites and spectrum are largely interchangeable because capacity increases linearly with both – i.e. for a given amount of spectrum, doubling the number of sites doubles capacity; and for a given number of sites, doubling spectrum also doubles capacity.[116]

Figure 53: Ofcom's view about the relationship between capacity, spectrum and sites



Source: Three, based on Figure A7.43 of Ofcom's 4G auction Statement

In Figure 53, MNO A has 20MHz and 10,000 sites in capacity constrained areas, while MNO B has 30MHz and 14,000 sites. Both MNOs are assumed to carry the same volume of traffic so MNO A is much more capacity-constrained. They can expand capacity by adding new sites (i.e. moving up their respective curves) or by buying more spectrum and deploying it on existing sites (i.e. by moving horizontally to other curves).

[116] Annex 7, Ofcom 4G auction statement, paragraphs A7.130-A7.133

This shows that an MNO's intrinsic value decreases with its spectrum holdings ($A_2 < A_1$ and $B_2 < B_1$), because both MNOs avoid fewer and fewer sites the more spectrum they have.[117] On the other hand, an MNO's value for spectrum increases the more sites it has. An extra block of spectrum saves more sites to MNO B than to A (i.e. $B_1 > A_1$).

In this example, MNO B has a higher value for an extra 10MHz of spectrum than A, even though MNO B is less capacity-constrained. An extra 10MHz increases A's capacity by 50 units (from 100 to 150), which A could also obtain with 3,000 extra sites (i.e. the length of A_1).

By contrast, an additional 10MHz would increase MNO B's capacity by 75 units (225 to 300 units), which B could also obtain with an extra 4,000 sites (B_1). As a first approximation, MNO A's value for 10MHz would reflect the cost of 3,000 sites (A_1), whereas B would be willing to pay more, up to the cost of 4,000 sites (i.e. $B_1 > A_1$).

In addition, the amount of capacity a capacity-constrained MNO can add depends on the business case. The technical value of spectrum to an MNO does not depend on the number of congested sites the MNO will have absent spectrum (as Ofcom told the EC), but rather on the number of sites it would profitably deploy with and without the spectrum, based on its congestion forecasts, capacity needs and the profitability of its investment in capacity.

Absent spectrum both MNOs would invest in extra sites if the cost of the sites (which is the same for both MNOs) is lower than the loss of profit from congestion. If MNO B has more customers in the area and/or if those customers are more profitable, MNO B may find it profitable to add more sites in the area than MNO A, even if MNO A is more capacity-constrained. All else the same, this means that MNO B should have a higher technical value for spectrum.

[✂-Sites vs. spectrum.]

The analysis above assumes that there is a given level of future demand an MNO must meet, and that the MNO would be indifferent between serving that given level of demand with extra sites or with additional spectrum.

[117] The first 10MHz block saves it 3,000 sites (A_1), but the second 10MHz only saves 1,500 sites (A_2). The same is true of MNO B (i.e. B2 is smaller than B1).

In that view, the saved costs of densification would be reflected in an MNO's intrinsic value for spectrum.[118] In other words, the MNO will simply reflect in its spectrum valuation the cost of reaching comparable capacity with sites (e.g. the vertical distance A_1 in Figure 53).

[✂-What Three would do to its network with a particular auction outcome.]

(ii) [✂-Three commissioned a cross-country econometric assessment to test the drivers of spectrum values]

The Consultation includes a general discussion about the drivers of spectrum values and the level of likely intrinsic values for BTEE and Vodafone.[119] However, Ofcom relies largely on a priori reasoning and has not carried out an empirical assessment to support its analysis.

Three has commissioned FTI Consulting (FTI) to assess the key drivers of outcomes in auctions that include capacity spectrum (Annex 17). FTI has compiled an extensive dataset of 323 observations from 80 auctions since Q2 2008, including 223 MNOs across 52 countries. FTI used all available data for auctions with a significant amount of capacity spectrum (over 1400MHz) available from reliable sources at the time of writing the report.

FTI has arrived at the following conclusions from its cross-country econometric assessment:

- [✂-Conclusions reached by FTI];

Figure 54: [✂]

[✂]

Source: [✂]

[✂]

[118] Paragraphs A8.26 and A8.58. In this case the difference in the valuation with and without the spectrum is solely the (net present) value of the costs of completely substituting the spectrum with equipment (for example sites). MNOs sometimes make this simplifying assumption when 'technical' valuations of spectrum are derived. Rather than modelling the complex trade-off between investment and the profit-maximising volume of traffic, the level of demand is assumed to be fixed at the level consistent with acquiring the spectrum.
[119] Paragraphs 5.60, 5.36-5.37

Figure 55: [✂].

[✂]

Source: [✂]

(iii) Evidence from the UK's 4G auction suggests that EE had a much higher value for capacity spectrum (or alternatively bid strategically to deny spectrum to Three)

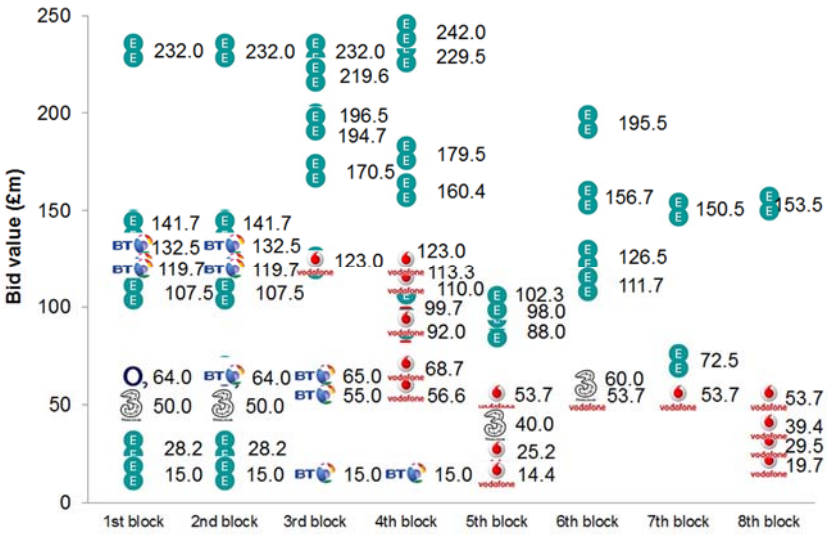
The available empirical evidence from the UK's 4G auction suggests that market share may be a more important determinant of auction outcomes than capacity constraints. Annex 15 sets out this evidence. In summary, if less capacity-constrained MNOs had a lower value for capacity spectrum, they would have bid comparatively smaller amounts for 2.6GHz spectrum in the 4G auction.

But the converse was true. EE, which was the least capacity-constrained MNO, bid by far the highest incremental values for 2.6GHz. In fact, EE bid up to the 37% overall cap set by Ofcom and won half of the 2.6GHz paired band (in addition to an 800MHz block). Much of that spectrum has been unused since it was purchased in Feb 2013.

To illustrate, Figure 56 shows MNOs' incremental bids for 2.6GHz paired spectrum in the 4G auction (in combination with fixed amounts of 800MHz and 2.6GHz unpaired).[120] An assessment of bid values for 2.6GHz unpaired spectrum presents a very similar picture.

[120] For example, EE's of £153.5m bid for an eight 2.6GHz FDD block compares EE's bids for eight 2.6GHz FDD blocks only (i.e. in combination with no other spectrum) with its bid for seven 2.6GHz FDD blocks only (£850m - £696.5m = £153.5m).

Figure 56: EE bid much higher incremental values for 2.6GHz in the 4G auction than any other bidder.



Source: Three

This suggests that EE may have had the highest intrinsic value for 2.6GHz spectrum (despite being less capacity-constrained) or, alternatively, that EE bid strategically in the auction to deny 2.6GHz spectrum to smaller rivals.

(iv) [✂-Economic modelling of PSSR spectrum value]

Three has commissioned Analysys Mason (AM) to analyse potential ranges of values for PSSR spectrum for UK MNOs. This work can be found in Annex 16**.** [✂-Conclusion from AM analysis.]

AM has assumed that 2.3GHz and 3.4GHz bands will be used in the macrocell layer for 4G, as there is insufficient information available to build an accurate 5G valuation model. AM has taken as its starting point Ofcom's view of relative technical values between MNOs – i.e. assumes

that Three and O2 have a higher technical value for PSSR spectrum than Vodafone and BTEE because they are more capacity-constrained.

AM has then estimated a range of plausible commercial values for each MNO and has added those estimates to the assumed technical values. [✂-Conclusion from AM analysis.]

AM's illustrative intrinsic value ranges are summarised for a set of key packages below. The lower and upper ends of these ranges do not represent strict lower and upper limits on the value of the spectrum to each MNO, but rather separate low and high estimates for intrinsic values based on different combinations of input parameters.

Figure 57: [✂-Conclusions from AM analysis.]

[✂]

Source: [✂]

[✂-Conclusions from AM analysis.]

As the U.S. Department of Justice has noted in the context of the US Incentive Auction, it is a "*well-established competition principle that those with market power may be willing to pay the most to reinforce a leading position*."[121] EE has said itself that strategic bidding can occur even if there is little prospect of eliminating a competitor, as it is possible to weaken a rival's ability to compete and raise its costs by denying spectrum to it.[122]

[✂-Conclusion from AM analysis.]

Figure 58: [✂]

[✂]

Source: [✂]

[121] https://www.justice.gov/atr/file/630891/download
[122] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/74227/ee.pdf , page 48

[✂][123]

[✂][124] [✂]

Figure 59: [✂]

[✂]

Source: [✂]

[✂]

Three has commissioned Professor Larry Ausubel from the University of Maryland to assess [✂ - the] ability to bid strategically in the auction. Professor Ausubel is one of leading auction theorists in the world and one of the creators of the Combinatorial Clock Auction format used by Ofcom in the UK's 4G auction. Details of his analysis (under the name of his company, Power Auctions) can be found in Annex 19.

In summary, Professor Ausubel concludes that [✂-bidders] will find strategic bidding much easier than Ofcom has anticipated because:

- [✂-Likely bid behaviour]
- None of the reasons provided by Ofcom will prevent strategic bidding in the PSSR auction.

(i) [✂-Likely bid behaviour]

Figure 60: [✂]

[✂]

Source: [✂]

[✂]

[123] [✂]
[124] [✂]

The Consultation [✂-refers to] the existence of [✂] complementarities in the first 20MHz for both 2.3GHz and 3.4GHz spectrum, but disputes their existence beyond 20MHz for 3.4GHz.[125] Other parts of the document, however, explain that MNOs may want large blocks of 3.4GHz (as much as 80MHz or even 100MHz) for 5G.[126]

[✂-What blocks of spectrum are likely to be purchased.]

(ii) None of the reasons provided by Ofcom will prevent strategic bidding in the PSSR auction.

[✂-Why Professor Ausubel does not agree with Ofcom on the risk of strategic bidding.][127]

[✂][128]

[✂]

Figure 61: [✂]

[✂]

Source: [✂]

[✂]

Conclusion – [✂-Conclusions from the discussion in the section.]

[125] Paragraph 4.226
[126] Paragraphs 4.233, 5.74, 5.80, 5.88 of the Consultation
[127] [✂]
[128] [✂]

8. Ofcom must promote competition by imposing a reservation and a 30% cap on overall spectrum

Executive Summary

This section assesses the competition measures that are more likely to further Ofcom's objectives of ensuring that the UK continues to benefit from a competitive mobile market and promoting optimal use of the radio spectrum. In summary:

- A spectrum reservation for Three and a 30% cap on overall spectrum holdings are needed to maintain competition in a data-centric market;
- Options A to E all risk material competition concerns in the transitional period, and during the period when 3.4GHz is available but 3.6GHz is not;
- The potential consumer loss from a reduction in competition with Ofcom's options could be very significant, and it can be conservatively estimated at £6.3bn;
- Three's proposal is unlikely to generate a significant loss in efficiency – it has a maximum impact of about [✂-£100-200]m;
- The risk of intervention is asymmetric – if Ofcom does not intervene when it should, competition may not recover; if it intervenes when it need not have the impact to consumers is likely to be small;
- Ofcom will need to make a bigger and more difficult intervention in the future if it does not act now, or it will risk rendering competition ineffective and potentially irreversibly so.

A spectrum reservation for Three and a 30% cap on overall spectrum holdings are needed to maintain competition in a data-centric market

Ofcom has stated that having multiple competing networks determines its approach to mobile regulation more than any other feature of the market.[129] It is critical that Ofcom's proposals for the auction do not undermine its objective of a market structure containing four MNOs.

[129] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/37138/msa_statement.pdf , paragraph 3.11

Evidence presented in this response suggests that shares of relevant spectrum should be kept between a 20% floor and a 30% ceiling to ensure the viability of a four-player market.

[✂-Likely auction outcomes.]

Figure 62: [✂]

[✂]

Source: [✂]

[✂] Strong competition measures are needed to boost spectrum shares at the lower end towards 20% (while simultaneously reining in BTEE at the top end) to achieve a more balanced distribution of spectrum.

This can be achieved by reserving 20MHz of 2.3GHz and 40MHz of 3.4GHz for Three (and new entrants), and also by implementing a 30% cap on overall spectrum holdings post-auction.

A cap set at that level would prevent BTEE from bidding in the auction unless it gives up spectrum (particularly its unused spectrum at 2.6GHz). This would put currently unused spectrum into use to the benefit if UK consumers, consistent with Ofcom's objective of ensuring optimal use of the radio spectrum.

Options A to E all risk material competition concerns in the transitional period, and during the period when 3.4GHz is available but 3.6GHz is not

[✂-Spectrum holdings following likely auction outcomes.]

Table 17: [✂]

Source: [✂]

[✂]

The consumer loss from a reduction in competition with Ofcom's options could be huge

Sections 4 and 6 of this response set out the minimum requirements required for an MNO to be credible, in the transitional period and beyond. These are summarised below. [✂-Consequences of likely auction outcomes.]

Table 18: [✂]

Source: [✂]

[✂]

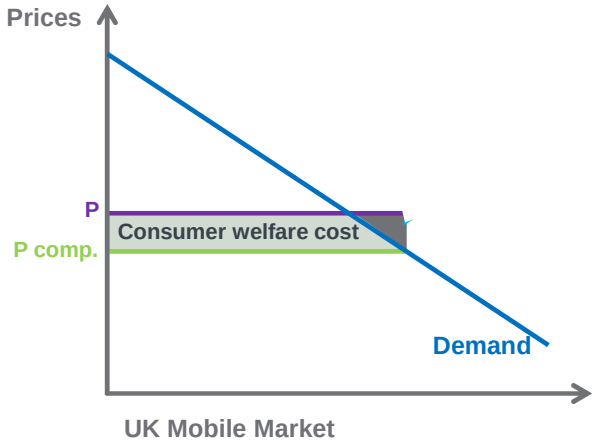
The consumer impact of a reduction in competitive intensity could be very significant. Ofcom has previously estimated that reduced competitive intensity leading a 1% loss of consumer surplus would have a net present value of £1.1bn if sustained over five years.[130]

Given the scale of the competition concerns above, the impact on prices would likely be much higher than 1%. In the context of the Three/O2 merger Ofcom characterized Three as a 'key disruptor' and estimated that mobile prices are between 10.7% and 12.4% lower in countries with a disruptive player, and 17.2% to 20.5% lower in four-player markets including a disruptive firm.[131] Three disagreed with Ofcom's findings and its characterisation.

Ofcom must therefore consider the potential loss in consumer welfare of a 10% to 12% increase in mobile prices if Three was no longer able to act as a 'key disruptor' (even if it continued to be credible). [✂-Consequences of likely auction outcomes.] Figure 63 illustrates the potential impact.

[130] 4G Auction Statement, paragraph 4.22

Figure 63: Illustration of consumer impact of Three's diminished ability to compete



Source: Annex 24

Three has estimated the loss of consumer welfare. This assumes that average UK mobile prices would have been 10% or [✂-a higher percentage] higher in 2015 had Three not been able to act as key disruptor [✂], as Ofcom has suggested.

This could result in a consumer benefit loss of the order of £6.3bn-[✂-a higher figure], depending on whether the higher prices were sustained over five or ten years. The lowest figure in the range (£6.3bn) would be equivalent to £2 a month for every citizen of the UK.

Table 19: Potential loss to UK consumers of a sustained 10% increase in mobile prices

Price increase	Sustained over 5 years	Sustained over 10 years
1%	£1.1bn (Ofcom)	-
10%	£6.3bn	£10.2bn
[✂]	[✂]	[✂]

Source: Three

Three's proposal is unlikely to generate a significant loss in efficiency

Ofcom has considered the trade-off between the potential adverse effect on competition from BTEE and Vodafone obtaining spectrum on the one hand, and on the other the potential consumer harm if the operator with the highest intrinsic value is unable to buy spectrum when it might offer the most attractive services to consumers with it.[132]

There is good reason to expect, however, that the loss of efficiency associated with Three's proposals is likely to be small when compared against the impact of reduced competitive intensity set out above. This is for three main reasons:

- [✂]
- The efficiency impact of Three's proposal is [✂-£100-200m] at most;
- Three would Three would pay a fair price for the reserved spectrum which reflects the underlying value of the spectrum to it.

(i) [✂]

[✂]

(ii) The efficiency impact of Three's proposal is £[✂-100-200]m at most

[✂-Cross-reference to Section 7.] Ofcom considers now that BTEE could have a higher intrinsic value for 3.4GHz, and Vodafone may have a higher value for 2.3GHz. This is why Ofcom is reluctant to exclude both bidders from those bands.[133]

The likely cost of Three's proposals, relative to Ofcom's options, relate to whether Three's proposal would preclude otherwise efficient outcomes. Three has considered the scale of any potential efficiency loss from preventing an MNO with a higher intrinsic value than Three (excluding strategic value) from buying spectrum as a result of Three's proposal.

[132] Paragraph 4.165, 5.36, 5.58
[133] Paragraph 5.74, 5.60

It is possible to estimate this loss using AM's intrinsic values in Section 7. It is generally accepted that intrinsic value and consumer surplus will be correlated. Using intrinsic values as a proxy for the magnitude of the consumer surplus generated by each MNO, differences in total intrinsic values in each of the auction outcomes for each option can be used to estimate the potential magnitude of the efficiency cost of our proposals.

Figure 64 presents intrinsic values for the most likely auction scenarios in each of Ofcom's options A to C and Three's proposal, together with possible outcomes for options D and E (which do not have a likeliest outcome) as discussed in Section 7

Figure 64: [✂-The differences in intrinsic values between different likely auction outcomes as estimated by AM.]

[✂]

Source: [✂]

In summary, the efficiency cost of Three's proposal is at most £[✂-100-200m],[✂- the difference in intrinsic values between different auction options.]

We think, therefore, that there are likely to be significant net benefits for UK consumers from Three's proposal when compared Ofcom's options. Any potential efficiency loss (estimated at [✂-£100-200m]) would not be nearly as severe as the consumer loss estimated above, which can be conservatively estimated at £6.3bn on Ofcom's own case.

(iii) Three would pay a fair price which reflects the underlying value of the spectrum to it

There are several options as regards the price payable in respect of the spectrum reservation proposed by Three.

One would be the application of a threshold price. The Consultation discusses the possibility that competition measures in the auction could apply only after the round price in the principal stage reached a threshold price set by Ofcom (above the reserve price) for 2.3GHz and 3.4GHz.[134]

[134] Paragraphs 5.115 to 5.132

Until the threshold price was reached, all operators could bid on the reserved spectrum as in the US incentive auction (see Section 1). Once the threshold price was reached in each band, non-eligible bidders would not be allowed to submit new bids for the relevant spectrum, and eligible bidders would continue to bid until supply equalled demand.

[✂-Discussion of the possibility of basing the price for reserved spectrum on the intrinsic value of operators excluded from bidding for it.]

Another option may be for Ofcom to set the threshold price as a percentage (say 80-90%) of Ofcom's estimate of the intrinsic value of the bidder(s) for which the spectrum is reserved, as opposed to the excluded bidder. In that way the price would be low enough to ensure that the bidder would purchase the reserved spectrum at that price.

Alternatively, if new entrants participate in the auction (particularly operators interested in deploying an 'inside-out' network, which are likely to need spectrum to do so) competition for the reserved spectrum could be relied upon to determine the price payable for the reserved spectrum.

In the event that there is insufficient competition for the reserved lots, Ofcom could derive an implied price from bids for other lots in the auction. In practice, this might involve the auction taking place and then reserved bidders being offered first refusal on reserved lots at a price determined by the auction (using either bids for the reserved lots or bids across all lots in the auction).

The risk of intervention is asymmetric – if Ofcom does not intervene when it should, competition may not recover; if it intervenes when it need not have, the impact to consumers is likely to be small

Three believes that the case for decisive intervention is clear. The risk of 'over-intervention' when such intervention is not needed is much greater than the risk of inaction when decisive action is required.

As set out above, the detriment to consumers of over-intervention is likely to be small. The consumer loss is equal to the loss of the services that BTEE and Vodafone could have offered with more spectrum, net of the additional services that Three and O2 will offer with the spectrum they would not have otherwise acquired.

There are three reasons why Three has estimated this consumer loss to be small (in the region of £[✂-100-200]m):

- BTEE and Vodafone already have lightly used and unused spectrum. [✂-Speeds possible without further spectrum.]

- Any efficiency impact would be limited to the segment of the market seeking the specific high quality services offered by BTEE and Vodafone;

- The consumer harm would be limited in time, as BTEE and Vodafone would have other opportunities to acquire spectrum in the 700MHz and 3.6GHz auctions to improve the services they provide to UK consumers.

The detriment to consumers of inaction however is much more tangible and would likely run into the billions. The price increases if the ability to compete of one or more MNOs is weakened could be very significant. Moreover, the price increases would impact all UK consumers, and the loss of competition could be irreversible given the high barriers to entry to the market.

Ofcom needs to assess whether it will need a far bigger and more painful intervention in the future, or risk rendering competition ineffective and potentially irreversibly so

Ofcom's proposal has not been supported by any proper risk analysis or assessment of the proportionality of intervening at this stage, as opposed to some later point.

Ofcom accepts that spectrum imbalances can be damaging to competition and that regulatory intervention is required to ensure that damaging imbalances do not arise or are addressed if they do. Having identified an important competition problem which requires intervention, this logic requires Ofcom to assess the relative merits of implementing competition measures now, as opposed to doing so at a later date.

In fact, Ofcom appears to have simply *assumed* that it will be able to intervene effectively to address any harm caused by spectrum imbalance and/or an absence of four "credible" MNOs at the end of the "transitional period". This is not a safe approach. A proper analysis is required, which should include:

- modelling of possible risks to competition over likely future time frames within which regulatory intervention would be possible (factoring in likely delays caused by incumbent operators resisting such intervention as well as technical delays). This requires Ofcom to look at:

    - the possible outcomes of the auction; and
    - the potential impact of those outcomes on competition;

- consideration of the regulatory tools that would then be available to Ofcom;

- consideration of whether and to what extent the regulatory tools available might be effective to address the identified competition risks (factoring in the extent to which those tools might be susceptible to challenge by incumbent operators); and

- for each regulatory tool available, conducting a proportionality analysis taking into account, *inter* alia, the potential adverse effects that would be associated with the proposed action to be taken now versus the action that might be required in future, should the identified competition risks transpire.

If Ofcom were to continue on the basis of its current assumption and, as a result, find itself unable to address deficiencies in two to three years' time, this will have irreversible negative consequences for consumers. A failure to properly analyse this risk could have serious long-term consequences for the MNO market.

In order to assess whether its proposed approach is proportionate, Ofcom must determine that this approach is the least intrusive means of addressing the risk of the competition problem arising over the appropriate reference period.

That assessment requires Ofcom to compare the implications of implementing measures now which would mitigate the risk of an anti-competitive outcome and the implications of future measures which would be required if (as is likely) the competition problems arise (or, more accurately, increase).

As part of that assessment, Ofcom must take account of the real risk that future competition measures will be be incapable of undoing the harm that has arisen and, even if they are capable of doing so, that they will need to be more intrusive than the type of competition measures which would suffice at this stage (given the exacerbation of the asymmetry that already exists).

There is no evidence in the Consultation (or elsewhere) that Ofcom has undertaken this exercise. Consequently, Ofcom has not asked itself the

correct questions necessary to properly undertake the required proportionality analysis.

Annex A Confidential – Three's proposed acquisition of UK Broadband

On 6th February 2017, Hutchison 3G UK Limited ("Three") entered into an agreement (the "Agreement") with PCCW Limited ("PCCW") and its indirect subsidiaries Seamless Industries Limited ("Seller") and UK Broadband Limited ("UKB").

The Agreement provides that Three shall acquire the entire issued share capital of Transvision Invesments Limited ("Transvision") from the Seller. Transvision is the holding company of UKB. As a result of the transaction, Three will obtain full control of UKB. [✂-Further non-public details of the UKB transaction.]

UKB has the following spectrum licences:

Table 20: UKB's spectrum licences

Frequencies	Size of Holding	Licence No.
3480-3500MHz and 3580-3600MHz ("3.4GHz licence")	40 MHz (currently in 2 x 20MHz blocks)	1040769
3605-3689MHz, 3926-4009MHz ("3.6/3.9GHz licence")	84 MHz (of 3.6 GHz) + 84 MHz (of 3.9 GHz)	0823615
28.3325-28.4445GHz paired with 29.3405-29.4525GHz [BWA3 Regions A, B & C] ("First 28GHz licence")	2 x 112 MHz	1066573
28.3325-28.4445GHz paired with 29.3405-29.4525GHz [BWA 3, Regions D to N (i.e., Rest of Country)] ("Second 28GHz licence")	2 x 112 MHz	0823608
27.8285-28.445GHz paired with 28.8365-29.4525GHz [BWA 2, Regions D to H, K & M] (the "Third 28GHz licence") (collectively, the "28GHz licences")	2 x 112 MHz	0838326
41-42GHz paired with 42.5-43.5GHz ("40GHz licence")	2 x 1 GHz	0307344
1781.7-1785.0 MHz paired with 1876.7-1880.0 MHz	2 x 3.3 MHz	0823599

As Ofcom is aware, the 3.4GHz licence is jointly held between UKB and UKB Networks Limited ("UKBN"). Three will not acquire control of UKBN as a consequence of this transaction. As noted above, completion is conditional on transfer of the relevant rights into the hands of UKB alone.

[✂-Comments on the value of spectrum licences obtained by Three through the UKB transaction.]

Impact on the PSSR auction

[✂-Significance of the UKB transaction for the auction.]Three accepts that if the transaction completes this will lessen the case for Ofcom to intervene to ensure that Three has access to 3.4GHz spectrum specifically.

[✂-Likely auction outcomes and consequences of the same. Relevance of the transaction in considering likely auction outcomes. Comments on the draft auction rules that are specific to the UKB transaction.]

Annex B List of Annexes attached to Three's response

Table 21: List of Annexes

Annex 1 – Comparison of international spectrum concentration
Annex 2 - Alternatives to spectrum are inadequate substitutes
Annex 3 - The importance of data speeds to consumers
Annex 4 - Brunel University investigation on importance of speeds to UK consumers
Annex 5 – Professor Jon Peha report on spectrum disparities
Annex 6 - Real Wireless - analysis of substitutability between sites and spectrum
Annex 7 a - Three – analysis of substitutability between sites and spectrum
Annex 7 b - appendix to annex 7 - Samsung for Three sites v spectrum
Annex 8 - Qualcomm - analysis of substitutability between sites and spectrum
Annex 9 - The consumer impact of using unused spectrum
Annex 10 - Frontier Economics - analysis of Three's congestion model
Annex 11 - Real Wireless – UK MNO network capability – present and future
Annex 12 - Real Wireless - timing of availability of different spectrum bands
Annex 13 - Analysys Mason - timing of availability of different spectrum bands
Annex 14 – Potential delays to awards for 3.6GHz and 700MHz
Annex 15 - Evidence from the UK's 4G auction
Annex 16 - Analysys Mason - difficulties Three faces in winning PSSR spectrum
Annex 17 - FTI - drivers of the intrinsic value of high frequency spectrum
Annex 18 - Frontier - the risk of strategic investment in the PSSR auction
Annex 19 - Power Auctions - competition policy for the 2.3 and 3.4GHz award
Annex 20 – Potential consumer loss from Ofcom's Options
Annex 21 - Frontier – evolution of mobile pricing in the UK
Annex 22 - Economies of scale from the coverage network