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Market structure, investment and quality in the mobile industry

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1. Overview – context and summary of results

Context to our report

1.1 Over the past ten years or so, there has been ongoing discussion in Europe and beyond about whether higher levels of concentration in mobile telecoms markets result in benefits for consumers - by enabling Mobile Network Operators (MNOs) to invest more in their networks and thereby offer better quality services; or whether, instead, more concentrated markets work against consumers by resulting in higher prices which do not translate into consumer benefits. This debate has been particularly relevant in the context of merger investigations in the mobile sector in a number of jurisdictions around the world.

1.2 The recent EU General Court (GC) annulment of the European Commission's (EC) decision to block the Three/O2 merger in the UK has highlighted again the debate about consolidation in the mobile sector. The test to gain merger clearance generally requires that the merger should not reduce competition to an extent that results in consumer harm. Normally, when price is the main competitive variable, consumer harm is expected to follow if the merger is likely to lead to a price increase of at least 5%-10%. In cases where such price rises are expected, a merger may still be cleared if it gives rise to efficiency gains translating into consumer benefits that significantly reduce or eliminate the consumer harm generated by the price increase. The GC specifically stated in its annulment of the Three/O2 decision that the EC should have considered in its assessment the possibility of such consumer benefits emerging. Such efficiencies, however, are in general particularly hard to demonstrate to a sufficient level of confidence which meets the required standard of proof.

1.3 The industry body GSMA (2017, 2020) has contributed to this discussion through two empirical studies of the relationship between mobile consolidation and quality outcomes. These reports claim to evidence the view that consolidation can improve consumer outcomes by increasing the ability and incentives for MNOs to invest in networks: which is one of a number of elements of the analysis that a merger authority would consider in deciding whether to approve a merger.[1]

1.4 As the UK telecoms regulator, although not responsible for merger clearance, which is within the remit of the Competition and Markets Authority (CMA), Ofcom closely follows developments in this discussion, we typically provide advice to the CMA on mergers in telecoms markets and conduct our own analysis and research.

[1] GSMA, "Mobile market structure and performance in Europe: Lessons from the 4G era", February 2020
GSMA, "Assessing the impact of mobile consolidation on innovation and quality: An evaluation of the Hutchison/Orange merger in Austria", 2017
HSBC Global Research, "Supersonic: European telecoms mergers will boost capex, driving prices lower and speeds higher", April 2015; and HSBC Global Research, "Supercollider: European mobile consolidation is win-win for operators and citizens alike", February 2014.

1.5 With this in mind, we have reviewed the GSMA's reports, together with existing empirical studies in the area. As part of this review, we have conducted our own analysis to understand in detail the strengths and limitations of these existing studies.

1.6 We find significant limitations with existing empirical evidence in the area, which is either inconclusive or does not support the inferences being made. The results of our own empirical analysis do not lend support to the conclusions MNOs have drawn based on past research. That is, we find no evidence that service quality increases when markets become more concentrated.

1.7 Clearly empirical analysis of this type is by its very nature a simplification of the commercial decisions facing companies. We also recognise that it considers the historic relationship between consolidation and investment/quality, at a time when we anticipate significant change in both the mobile industry and communications markets more broadly and so past performance may not be the best guide to any future impact. Nonetheless, we consider it useful to contribute to the discussion by setting out our views on the existing empirical work in this area. We hope that, by doing so, we will encourage MNOs and researchers in this field to keep engaging in this debate, to ensure that we find sufficiently robust results to provide clear guidance for policy purposes.

1.8 It is important to emphasise that - in our view - there is no magic number of MNOs for a well-functioning, competitive, mobile market. Whilst Ofcom has acted to maintain the existing level of competition in the UK market in previous policy decisions, we recognise that the consumer impact of any potential future consolidation would be specific to the transaction itself, and dependent on a range of factors – including market conditions prevalent at the time and in the country of the transaction. As a result, while empirical analyses such as this can be informative to the debate, each potential future consolidation must be considered on its own merits.

Summary of our findings – in brief

This report looks at empirical evidence on the relationship between market structure, investment and quality in mobile markets. It summarises the relevant recent studies in this field which have prompted our own work, and their limitations. We conduct our own empirical analysis to address these limitations and find that the conclusions drawn by some of these studies do not hold. However, it is important to note that our analysis does not assess the overall consumer impact of changes in market concentration, which would (at a minimum) need to take into account any impact on prices as well as other dimensions of quality which are important to consumers.

We consider the relationship between mobile market structure, investment and quality using two different econometric techniques. Specifically, we carry out:

a) An analysis of the relationship between mobile market structure and investment across 30 European countries over an 18-year period (2000 – 2018), as well as the relationship between mobile market structure and quality (2011 – 2018) using **panel data techniques**. This analysis

identifies the average effect on investment and quality outcomes over all the changes in concentration we observe in our datasets; and

b) An investigation of the impact of mobile consolidation on investment and quality in individual merger cases based on **synthetic control methods**. This analysis allows for the fact that the circumstances of each merger are unique and the impact in individual cases may be different from the average experience. It looks separately at the following three mobile mergers which led to increased concentration (albeit remedied via different measures) in the individual national markets:

i) Hutchison/Orange Austria merger in 2012;

ii) Telefónica /E-Plus merger in Germany in 2013/14; and

iii) Hutchison/Telefónica merger in Ireland in 2013/14.[2]

Our panel data analysis finds that country-level investment is lower in more concentrated markets. This could mean that higher concentration implies:

a) Less competition, which in turn leads to lower investment and lower network quality; and / or

b) Greater network efficiency, whereby less investment can achieve the same or better network quality.

We assess which of these two effects dominates by exploring the relationship between concentration and network quality outcomes (measured in terms of average download speeds). Our analysis provides no evidence that the efficiency effect dominates. That is, we find no evidence that quality is higher when markets are more concentrated. Our country-specific merger studies using synthetic control methods support our panel data results.

However, we note that our assessment considers one dimension of quality only (4G download speeds) and recognise that other dimensions of quality are also important to consumers. Also, our analysis does not include prices, which are an important factor in the overall consumer impact of any merger. These considerations may provide avenues for future research in this area.

[2] We do not include the Netherlands or Italy in our country-specific analysis, although both countries recently experienced a mobile merger. In the case of the Netherlands, this is because the merger occurred too recently for our dataset (which ran to 2018). In the case of Italy, the merger was only cleared conditional on a fourth player being recreated, thus leading to no net change in number of MNOs.

2. Introduction

Purpose of study

In the course of a mobile merger, MNOs often argue that the merger would improve consumer outcomes through a positive impact on investment and service quality: but to date there is no credible evidence in support of this claim

2.1 The impact of mergers on pricing is a key consideration for competition authorities in the course of a merger investigation. In several cases, the European Commission has concluded that proposed mergers between MNOs would sufficiently reduce competitive pressure such that prices would increase.[3] However, price is only one of the relevant variables for consumers. Merger investigations have also taken account of other key dimensions of competition, including quality, investment and innovation. In particular, merging parties have often argued that:

a) efficiencies from mobile mergers, lead to material improvements in network quality to the benefit of consumers; and

b) increased EBITDA margins (resulting from higher prices) increase MNOs' ability and incentive to invest, again promoting improved quality through faster network rollout to the benefit of consumers.

2.2 However, competition authorities have often disregarded these claims in the absence of credible evidence demonstrating this effect to the required standard of proof.

Several studies have considered the impact of mobile market structure on investment, but the evidence is inconclusive

2.3 Given the wave of mergers in mobile markets between 2012 and 2016, several studies have looked at the empirical relationship between mobile consolidation and investment. These studies suggest that the impact of mobile consolidation on investment varies depending on whether operator-level investment or industry investment is considered. While they find a positive impact of mobile consolidation on operator-level investment, they find no link between mobile consolidation and industry-wide investment.

[3] For example, in the Hutchison/Telefónica merger in the UK in 2015, the European Commission blocked the merger because they considered that the transaction would likely have resulted in price increases for mobile services and less choice for consumers in the UK. It is worth noting that Hutchinson appealed the decision and in May 2020, the General Court annulled the European Commission's decision. In other mergers such as the Hutchinson/Orange merger in Austria in 2012, the Hutchison/Telefónica merger in Ireland in 2013/14, the Telefónica/E-Plus merger in Germany in 2014, the Hutchison/WIND merger in Italy in 2016 etc, the European Commission also expressed concerns that these mergers would reduce competitive pressure such that prices would increase. However, the European Commission approved them subject to a package of commitments, which they considered offset the price effects from the merger.

2.4 This discrepancy could be explained by the fact that when two firms merge, investment of the merged operator will inevitably increase.[4] This is because the combined capital expenditure of the merged firm is larger than average operator-level investment pre-merger, unless the merged firm cuts back dramatically on investment. Therefore, the positive impact of a merger on operator investment may reflect that, in more concentrated markets, each individual network is larger on average.[5] As a result, we do not consider results on operator-level investment can be used to infer anything about the consumer impact of consolidation.

2.5 We also find it is not possible to draw inference from existing industry-level investment studies (or from those operator-level studies that control for number of subscribers on a network). Data limitations mean the estimates from these studies are not precise enough to draw any conclusions. The lack of significant results could mean that consolidation has no effect on industry-level investment but could equally reflect noise in the data.

2.6 Annex A1 provides a brief overview of these studies and explains in more detail the limitations we find.

The GSMA has considered the impact of mobile market structure on quality, and has concluded that higher concentration can lead to improved quality

2.7 In 2017 the GSMA analysed the impact of the 2012 Hutchison/Orange merger in Austria (a 4-to-3 merger) on quality using difference-in-differences (DD) and synthetic control methods.[6] Based on this study, the GSMA concluded that the merger in Austria had a positive and statistically significant effect on quality outcomes.

2.8 However, their conclusions critically rely on the DD method, which is not well suited to studies of this nature where only one unit is subject to a treatment effect (see Annex A1). Moreover, the lack of pre-merger data on quality outcomes means that their analysis is not actually able to measure the impact of the merger (see Annex A1 for further detail). We therefore place little weight on these findings.

2.9 In 2020, the GSMA published another study which considered the impact of mobile market structure on quality using panel data techniques and applying these to operator-level data for 29 European countries covering the period 2011 to 2018.[7] We find a number of limitations with this study which indicate that it does not support the inference the GSMA draws, for reasons we set out in full in Annex A1. An important limitation is that it does not control for factors that may help to isolate the impact of market structure, such as lagged

[4] In the sense of being greater than average operator-level investment pre-merger: though potentially less than the sum of the two merging parties' pre-merger investment levels, reflecting merger synergies.
[5] Whether this effect is persistent or not depends on whether we are considering the impact of a higher level of concentration on the level of investment, or the impact of an increase in market concentration on changes in investment. Expressed in level terms, we would expect fewer MNOs in the market to imply a persistently higher (average) level of investment per operator. When considering the impact of a change in the number of MNOs on the change in investment levels, we would only expect to see an effect around the time of the merger.
[6] Assessing the impact of mobile consolidation on innovation and quality: An evaluation of the Hutchison/Orange merger in Austria, 2017. Available at https://www.gsma.com/publicpolicy/resources/evaluation-hutchison-orange-merger-austria
[7] Mobile market structure and performance in Europe: Lessons from the 4G era, February 2020.

investment and technology cycles. As we discuss in Section 3, the omission of these factors is likely to generate bias in the results of any empirical analysis of the relationship between market structure and quality outcomes.

We have explored the question further by conducting our own analysis

2.10 In order to explore the question to further depth, we have carried out our own analysis, building on and extending previous studies in this area. Our analysis uses two different econometric approaches - panel data and synthetic control methods - to investigate the impact of mobile market structure on investment and then on quality.

Outline of the document

2.11 The remainder of this document is structured as follows:

a) Section 3 provides a brief overview of the theoretical relationships between market structure, investment and quality;

b) Section 4 describes the data and sources we use in our analysis;

c) Section 5 sets out our methodology using panel data techniques to assess the relationship between market concentration, investment and quality; and

d) Section 6 discusses our panel data results;

e) Section 7 outlines our methodology for our country-specific merger studies;

f) Section 8 discusses our country-specific merger study results;

g) Section 9 sets out the limitations of our analysis; and

h) Section 10 concludes.

3. Relationship between changes in market concentration, investment and quality

Introduction

3.1 We are interested in testing the hypothesis that increases in concentration in mobile markets could lead to better outcomes for consumers by enabling MNOs to undertake higher levels of investment and thereby offer better quality services. To do this, we look at empirical evidence on the impact of past changes in market concentration on investment and quality outcomes. In doing so, we recognise we are focussing on one potential consumer outcome only, and that changes in market structure could affect a number of dimensions of competition that are important to consumers (including price and innovative tariffs).

3.2 Our focus is on a relatively narrow range of changes in the number of MNOs (typically four versus three MNOs) rather than a broader consideration of possible market structures (e.g. from monopoly to competition): as these are the events we typically observe in our data.[8] In our econometric analysis, we assess the impact of all changes in market concentration (i.e. entry events as well as mergers) on investment and quality. Although we are interested primarily in the effect of increases in concentration, we consider that in the long run what should matter for outcomes is the number of MNOs: and so an increase in concentration from four to three MNOs should have the same (but opposite) effect on outcomes as a reduction in concentration from three to four MNOs. Our country-specific studies focus solely on increases in concentration from four to three MNOs.

3.3 In this section, we first consider the drivers of network quality to help explain the ways in which we think an increase in market concentration could potentially affect quality. In modelling the impact of changes in concentration on quality (both directly and indirectly through its impact on investment), it is important to control for all relevant drivers of quality and investment, particularly those which may also be related to changes in concentration. In this section, we therefore also set out what we consider to be the key determinants of investment and quality: focussing particularly on past investment and technology cycles, which have not been included in previous studies.

3.4 This section explains the determinants of investment and quality, which we then draw on in the next sections when we explain our modelling approach and interpret our results.

[8] Whilst we do observe two instances in our dataset where the market concerned moves from monopoly to duopoly, the most common change in number of MNO is from three to four or vice versa (21 out of 46 events).

Changes in market concentration can impact network quality

Determinants of network quality

3.5 Network quality is an important dimension in the quality of service experienced by consumers. This has different dimensions including: coverage, average speeds and congestion. In this study, we focus on average download speeds, i.e. the average rate at which consumers are able to download data, as this is an aspect of quality which is both important to consumers and for which there is readily available data.[9]

3.6 Broadly speaking, average download speeds are faster when networks are less congested, which is the case when the volume of data traffic being carried over these networks is low relative to their carrying capacity (i.e. the total amount of data or voice traffic they are able to transfer to and from customers).

3.7 Greater network capacity, all else equal, will support higher download speeds. Network capacity is itself largely determined by the amount of spectrum each MNO has, the efficiency with which that spectrum is used ('spectral efficiency') and/or the density of the network (i.e. the number of radio base stations in a given area). There is thus a strong link between investment levels and quality outcomes. Spectrum holdings and the technology being used (e.g. 3G/4G) will also be important factors in the quality users experience.

3.8 For a given level of network capacity, greater volumes of data traffic tend to result in slower average speeds – which may impact the consumer experience depending on the magnitude of the reduction in speed and the application the consumer is using (i.e. whether they notice any deterioration in service). Anything which affects demand for mobile data (e.g. price, availability of applications requiring more data, smartphone penetration, income etc) may therefore impact quality.

3.9 In light of this, we consider changes in concentration could affect our measure of quality in various ways.

Change in concentration may impact network quality directly by affecting consumer usage and the way that mobile spectrum is utilised

3.10 Changes in market concentration may have a direct impact on quality outcomes by affecting consumer demand. This is because the degree of competition in a market is likely to impact the price consumers pay for mobile data, which may in turn affect usage. For example, where a reduction in concentration leads to lower prices due to an increase in competition, this could cause consumers increase their usage of existing networks. This

[9] We recognise average speeds may not be the most important aspect of quality to consumers. Dropped calls or an inability to access the service consumers want to use due to network congestion is likely to have a worse consumer impact than a reduction in average speeds, with some consumers potentially not noticing the latter – depending on the application they are using and the magnitude of any reduction in speed. We note later in this report that extending the analysis to capture other dimensions of quality is a possible avenue for future research.

could in turn reduce observed network quality, such as mobile data speeds, by increasing congestion on the network.

3.11 Separately, changes in market concentration could impact network quality directly by affecting the way that spectrum is utilised. MNOs wishing to merge have claimed that spectrum could be used more efficiently if it is concentrated with fewer MNOs (for example, allowing for carrier aggregation or increased spectral efficiency).

Changes in concentration may also impact quality indirectly by affecting MNOs' ability and incentive to invest

3.12 As the network quality that customers experience will depend in part on investments made by MNOs, one route through which an increase in concentration might affect network quality is through its impact on MNOs' ability and incentives to invest.

3.13 There is a substantive body of work in the economic literature that looks at the theoretical relationship between competition and investment.[10]

3.14 One strand of the literature contends that market power (i.e. weaker competition) may be needed to allow firms to earn sufficient returns on their investments to justify investing in higher quality. These studies find that if there are significant fixed costs associated with producing high quality products, too much competition (or too many competitors) could erode profits. This could in turn affect the ability of firms to earn sufficient returns to offset the investment required to produce the high-quality product.[11]

3.15 Another body of work argues that greater competition provides stronger incentives for firms to innovate (including investing in the development of new and higher quality products). This strand of the literature argues that earning sufficient returns may not be enough to unlock new investment and innovation. Firms also need to be incentivised to do so, either by allowing them to increase their profits or avoid losing them. That is, competition could lead firms to invest in higher quality and/or new products in order to gain a competitive advantage over rivals which allows them to earn a positive return, or to avoid being left behind as others invest.[12]

[10] Acemoglu and Akcigit, 'Intellectual property rights: policy, competition and innovation', 2012; Aghion et al., 'Competition and innovation: an inverted-U relationship', 2005; Aghion and Griffith, 'Competition and Growth: Reconciling Theory and Evidence', 2006; Blundell et al., 'Market share, market value and innovation in a panel of British manufacturing firms', 1999; and Nickell, 'Competition and corporate performance', 1996.

[11] See Schumpeter, Joseph. 1942. Capitalism, Socialism and Democracy. New York: Harper & Brothers. Schumpeter argued that larger firms have greater incentives and ability to invest in R&D. He dismissed perfect competition as the ideal market structure, stressing the importance of temporary market power as a reward to successful innovation.

[12] Arrow, K. 1962. "Economic Welfare and the Allocation of Resources to Invention." In The Rate and Direction of Inventive Activity: Economic and Social Factors, edited by Universities- National Bureau Committee for Economic Research and the Committee on Economic Growth of the Social Science Research Councils, 467– 92. Princeton, NJ: Princeton University Press. This work argues that a monopolist's incentive to innovate is less than that of a competitive firm, due to the monopolist's financial interest in the status quo. In other words, a firm earning substantial profits has an interest in protecting the status quo and is thus less likely to invest in new quality enhancing activities unless forced to do so.

The overall impact of changes in market concentration on network quality is a combination of these direct and indirect effects

3.16 The overall impact of changes in market concentration on network quality will therefore be an aggregate of the direct impact on consumer usage and spectrum utilisation, as well as the indirect impact on investment.

3.17 To measure the indirect impact of changes in market concentration it is necessary to establish how investment translates into network quality. This is because additional investment may not necessarily result in improved consumer outcomes. For example, an increase in capital expenditure due to costs of harmonising two networks post-merger may not necessarily result in better quality outcomes for consumers.

3.18 As we discuss further in Section 5, our analysis will therefore assess the impact of changes in concentration on investment, alongside the impact of changes in investment and concentration on network quality.

Other factors that impact investment and network quality

3.19 There are a range of other factors that drive investment and network quality in mobile markets. In order to ensure that our econometric results are reliable we need to control for these factors so as to isolate the impact of changes in market concentration on network quality. This is particularly important for those factors which may also be independently linked to changes in market concentration.

Several factors that may impact investment and network quality

3.20 The mobile industry is characterised by large sunk investments. Developments in mobile technology are fast-paced, with new technologies emerging every 5-10 years leading to step-changes in investment. At the same time, demand for mobile data is continuously growing – which means that MNOs need to look ahead when making their investment plans to ensure that their network capacity continues to grow in line with demand.

3.21 As a result, MNOs make investment decisions on the basis of their forward-looking assessment of how demand is likely to evolve and the costs of meeting that demand. Annex A3 lists the factors that may influence these decisions, which can be demand- or supply-side driven. Supply-side factors affect the costs of investing in network infrastructure such as rurality of population, geography of a country and the amount of spectrum held by MNOs. Where the cost of providing a given level of quality is higher we would expect to see, all else equal, lower levels of quality. Demand-side factors affect consumer usage and willingness to pay for mobile services. Greater demand and higher willingness to pay for mobile services tends to result, all else equal, in incentivising MNOs to invest in higher levels of service quality.

3.22 In addition, some demand-side factors may also have a separate, direct impact on quality - at least in the short term. For example, an unanticipated increase in demand (e.g. captured by an increase in GDP per capita), which is expected to lead to an increased incentive to

invest due to the higher willingness to pay (and thereby potentially result in improved quality) may also increase congestion in the network for a given level of capacity, resulting in lower network quality in the short run (e.g. lower download speeds). In the longer term, however, we anticipate that MNOs will make additional investment in response to increased demand, which will improve network capacity and offset this effect.

3.23 Finally, we expect that some of the demand and supply-side factors that influence investment and quality may also influence market concentration. On the supply-side, anything which affects the cost of delivering mobile network services will also affect the decision to enter and remain in the market through its impact on expected future profitability.[13] On the demand side, anything affecting consumer willingness to pay for mobile services will similarly affect expected future profitability and, through that, the attractiveness of the market to MNOs. Given the presence of large fixed costs, it is also possible there is a minimum efficient scale MNOs must reach to be viable. In which case, anything which affects the total number of subscribers may affect the number of MNOs a given national market can support, and through that, lead to changes in market concentration.

The dynamics of multi-year investment plans and technology cycles are particularly important

3.24 Previous studies considering the impact of mobile consolidation on investment and quality have accounted for many of these demand-side and supply-side factors, including rural population, geography and spectrum holdings. However, they have not accounted for the dynamics of multi-year investment plans and technology cycles.

3.25 As noted above, demand for mobile data has been increasing continuously and rapidly for years now, and this trend is expected to continue. MNOs therefore make their investment plans over a multi-year horizon to ensure that their network capacity continues to grow in a way that supports this anticipated growth in demand. In the context of such multi-year investment plans, current investment outcomes will depend both on current and past levels of investment. They will also be affected by any transition to a new technology, as this will require a step-change in the level of investment for several years.

3.26 Past investment and technology cycles are also important drivers of network quality. This is because network capacity is a key driver of quality, and capacity will be determined by historic levels of investment. Technology cycles also have an immediate impact on quality outcomes: both because the new technology will typically deliver higher speeds, and because any congestion on the legacy network will ease as some customers move to the new network technology.

3.27 Importantly, past investment and technology cycles will also be linked to changes in market concentration. Often a switch to a new technology cycle is preceded by regulators

[13] The decision of an MNO to enter or stay in the market will be based on a consideration of future profits, which in turn will be determined by the expectation of the MNO of future revenue and costs.

releasing new spectrum licenses, giving new MNOs the opportunity to enter and potentially leading to a change in market concentration.

3.28 In addition, for those MNOs who have invested in previous technology cycles, the transition to a new technology cycle may represent a decision point about whether they continue to upgrade their networks and make multi-year plans for significant further investment for the new technology or whether they exit the market (e.g. through consolidation). Therefore, again the number of MNOs and market concentration can be affected by the transition to a new technology cycle.

3.29 We control for this in our analysis by including a dummy variable for the 4G technology cycle as well as including multiple lags of the investment variable.

To isolate the impact of increases in concentration on quality outcomes, we have to control for potential confounding factors

3.30 Taking these points together, to isolate the impact of number of MNOs on investment and quality outcomes, it is important to control for all relevant variables that affect investment and quality outcomes including:

a) The technology cycle;

b) Past investment;

c) Number of MNOs; and

d) Other supply and demand shocks (as set out in Annex A3).

4. Data

General considerations on the data

To carry out our analysis we collected data on a quarterly basis for MNOs across 30 European countries

4.1 To investigate the impact of changes in market concentration on network quality, we construct a panel consisting of quarterly data from 2000 to 2018 for MNOs operating in 30 European countries – the 28 member states of the European Union, plus Switzerland and Norway.

4.2 We limit the panel to Europe as we consider that MNOs operating in markets within Europe are more likely to face similar regulatory conditions. For example, the regulatory framework which the mobile sector is subject to is relatively harmonised across European countries.

We use data primarily from GSMA Intelligence

4.3 We source our data primarily from GSMA Intelligence. This dataset offers quarterly data on a wide range of metrics for a large number of MNOs worldwide and has been used by previous studies looking at the impact of mobile concentration on investment and quality (see Annex A1). We have made a number of exclusions and modifications to this data, which we set out in Annex A2.

Measure of investment used in our analysis

We use industry capital expenditure data sourced from GSMA Intelligence

4.4 We use capex data sourced from the GSMA Intelligence Unit database. As already mentioned, this database offers a comprehensive MNO dataset for the period under analysis. Although capex data is not always available for each individual MNOs operating within the sampled countries, it is available at an aggregate country-level.

4.5 The GSMA defines capex as the total capital expenditure incurred in the period (quarter), including both intangible and tangible assets. This mostly excludes expenditure in acquiring spectrum rights. In analysing the data, however, we observed, for a few countries, spikes in certain quarters that could only be explained by the inclusion of spectrum auction prices. Although some MNOs included their auction spending as capital expenditure, most did not. Thus, where possible, we corrected for this inconsistency in the data by manually removing spectrum auction prices using Analysys Mason's spectrum auction tracker – see Annex A2 for further details. Removing spectrum expenditure from the capex data allows us to obtain a consistent measure of investment across our panel.

Measure of network quality used in our analysis

We use average download speeds from Ookla as the quality outcome variable in our analysis

4.6 In investigating the relationship between market concentration and network quality, we could consider different dimensions to network quality. In particular, network quality comprises multiple aspects which affect consumer experience, including download speeds, upload speeds, latency, network coverage and service reliability.

4.7 Due to the data availability issues outlined in Annex A2, we have focussed our analysis on download speeds. We consider this a reasonable approach given download speeds are an important aspect of quality to consumers and these tends to be correlated with the other aspects of network quality (see discussion in Annex A2). For example, download speeds tend to be higher where there is 4G coverage, while upload speeds tend to increase with download speeds. Nonetheless, we recognise this focus on one dimension of quality is a limitation of our approach and consider widening the set of measures an avenue potentially worth exploring in future analysis.

4.8 Average quarterly download speed information is provided by Ookla at the operator[14] and national level since 2011.[15] Ookla calculates the average speeds based on the aggregation of speed tests conducted by users of its app.[16] Test runs on the app are user-initiated and results are aggregated to produce measures of average quarterly download speeds at the operator and national level.[17] This means that the data collected reflects actual consumer experience.[18]

4.9 A potential drawback of consumer-initiated testing is self-selection bias. We might expect that users are more likely to conduct a test if they are experiencing poor network performance. However, so long as the reasons why users conduct speed tests are not systemically different across time and across countries, then the data can be used to do a time series comparison across countries (i.e. a comparison of how these metrics evolve over time). We have no reason to believe that there is bias in the Ookla dataset, so we use this data for the outcome quality variable in our analysis.

[14] Ookla reports aggregate speeds for the target and the acquiring operator pre- and post-acquisition. While this could be a problem for any operator-level analysis, given that our focus is at the country-level, this should not affect our analysis.
[15] More recently Ookla has also provided this information broken down by 2G, 3G and 4G technology. As these technology-specific series are only available for shorter periods and for selected MNOs in the data set, we focus on the average download speed metrics.
[16] Ookla, Speedtest
[17] Aggregating individual readings reduces the risk of the data being skewed by test-specific factors. Such factors include but are not limited to; device used, weather conditions, time of day, network congestion, location, indoor/outdoor, and geographic topography. The ability to which these test-specific factors average out across MNOs depends on the sample size for each operator and distribution of disturbances across them.
[18] To account for repeated tests from the same user at a given time or location, observations are averaged in a two-step process. First, observations are averaged into samples by user, location and day. Second, these samples are averaged. This mitigates against results being skewed by repeated tests.

Measures of market concentration used in our panel analysis

We use two measures to capture changes in mobile market concentration

4.10 We use two measures of market structure in our panel data analysis: number of MNOs and the Herfindahl-Hirschman Index (HHI).[19,20]

4.11 Both measures capture mergers as well as other changes in market structure such as entry and exit. In addition, the HHI measure captures non-structural changes in market concentration associated with changes in the relative market shares of MNOs. This allows us to exploit as much variation as possible in the data.

4.12 We source the data from the GSMA Intelligence Unit database. Due to the reasons set out in Annex A2, we adjusted this data to: i) remove operators which are mobile virtual operators (MVNOs) – and therefore do not own a mobile network; and ii) mobile broadband operators that do not provide mobile voice services and/or provide services on a regional basis only.

4.13 This data captures 46 changes in market structure over the period from 2000 to 2018. Of these changes, 12 are mergers, 33 are entries and 1 is exit – see Table A2.3. Given that most of these changes are entry events, the effect we identify in our panel data analysis is primarily driven by entry effects. We consider this approach reasonable given that we would expect entry and merger/exit events to have a similar (but opposite) impact on investment and quality of service in the longer-term. We do however verify this assumption as part of our robustness tests, which we set out in Annex A4.

Control variables

Isolating the impact of changes in market concentration requires controlling for those factors that could influence network investment/quality and may also be related to market concentration

4.14 To identify the impact of changes in market concentration on investment and quality, we need to control for confounding factors that could also affect the outcomes of interest.

4.15 These factors include lagged investment, technology cycle, GDP per capita, population density, rurality of population, spectrum holdings, coverage and unemployment rate. We present the descriptive statistics of these factors in Table A2.5.

[19] The HHI is a measure of concentration in the market. It takes values from 0 to 10,000. The higher the HHI the more concentrated the market. We have transformed this variable and divided it by 100 to make our estimates easier to interpret.

[20] We have also interacted the latter two measures with the investment variable to test whether investment could be more efficiently made in more/less concentrated markets – see discussion in Section 5.

5. Panel data methodology

5.1 To assess the relationship between mobile market concentration, investment and quality, we use two main econometric approaches:

a) Panel data analysis; and

b) Merger specific analysis using synthetic control methods.

5.2 This section sets out the methodology used to implement our panel data analysis.

Panel data analysis

5.3 As noted in Section 3, market concentration can impact quality indirectly by affecting the ability and incentives of MNOs to invest, but it could also affect quality through direct means. Given these two possible mechanisms by which market concentration can impact quality, we analyse the following two models:

a) **Investment model** to estimate the impact of changes in market concentration in the mobile sector on investment; and

b) **Quality model** to estimate the:

i) direct effect of changes in mobile market concentration on average download speeds that arise from consumer usage changes and the way that mobile spectrum is utilised; and

ii) indirect effect of changes in mobile market concentration on quality that arise from changed firms' ability and incentives to invest in network quality improvements.

Investment model

To assess the indirect impact of changes in market concentration on quality, we first estimate the impact of market concentration on investment

5.4 To assess the impact of changes in market concentration on investment, we consider a dynamic model in which investment is a function of previous investment, market concentration and other control variables. That is, we estimate a model of the form:

$$I_{it} = \propto + \sum_{\omega=1}^{n} \rho_{i\omega} L^{\omega} I_{it} + \sum_{k=1}^{K} \delta_k X_{ikt} + \beta_2 T_t + \beta_3 MC_{it} + v_i + \varepsilon_{it} \quad [1]$$

5.5 Where:

a) I_{it} is the investment variable (i.e. capex per capita), in country i at time t;

b) $\sum_{\omega=1}^{n} \rho_{i\omega} L^{\omega} I_{it}$ is the weighted sum of lagged values of I_{it} up to the level of n where L^{ω} is the lag operator such that $L^1 I_{it}$ is equivalent to I_{it-1}, $L^2 I_{it}$ refers to I_{it-2} and so on;

c) X_{ikt} is a matrix of a control covariates which may influence I_{it}. These may include the technology cycle, GDP per capita, population density and the rurality of the population;

d) T_t is a vector of time variables including seasonal dummies and a time trend to capture any unobserved variation in consumer outcomes that can be attributed to specific time variant factors (e.g. new handset and mobile application releases);[21]

e) MC_{it} is the market concentration measure, either the number of MNOs or HHI in country i and quarter t – see Section 4;

f) v_i are country fixed effects and capture any unobserved variation in consumer outcomes that can be attributed to specific characteristics of each country (e.g. geography and topology); and

g) ε_{it} is a random error term.

5.6 Given that our investment model is a function of previous investment, the estimated impact of a change in market concentration on investment depends on the time horizon considered.[22] In the short-run, the immediate impact of a change in market concentration can be identified by β_3. This identifies the contemporaneous effect of a change in market concentration on investment levels in any given quarter. In the long-run, the impact can be identified by $\beta_3/(1-\rho L)$ where L is the lag polynomial.[23] This takes into account the fact that a change in market concentration has an impact on investment levels after the period in which the change in concentration occurs – because investment in future periods depends in part on investment today.

5.7 To isolate the impact of changes in market concentration, we control for confounding factors that may affect both investment and market concentration outcomes. As set out in Section 3, we expect investment and market concentration to be influenced by a range of demand- and supply-side factors, including lagged investment and technology cycles.

5.8 We control for these factors by including the following covariates in our investment model:

a) **4G dummy**, which we use as a proxy for technology cycle capturing the level shift in investment between investment cycles (in this case between 3G and 4G[24]);

b) **Multiple lags of the investment variable** – as MNOs make investment plans covering multiple years, current investment outcomes will be linked to investment in the recent past. We use multiple lags of the investment variable to capture these investment dynamics. This is an important contribution of our analysis, as previous studies have not controlled for the impact of lagged investment and technology cycles. We consider

[21] We have tested different forms of time trend: linear year trend, linear year trend with a break in 2016 and a non-linear trend using year dummies.

[22] This includes the investment made by MNOs which have left the market in previous periods (see Annex A4). We believe that it is important to capture these investments in our analysis as they determine in part the network capacity we see today through the transfer of assets as part of a merger or acquisition. It also removes the risk that countries with longer established incumbents incorrectly appear as having higher levels of investment.

[23] Using the lag polynomial whereby $\rho(L)I_{it} = \rho L I_{it} = \sum_{\omega=1}^{n} \rho_{\omega i} L^{\omega} I_{it}$, and re-arranging the equation gives $(1-\rho \mathrm{L})\mathrm{I}_{it} = \propto + \sum_{j=1}^{k} \delta_j X_{ijt} + \beta_2 T_t + \beta_3 MS_{it} + v_i + \varepsilon_{it}$. Using this equation, we can then derive the long-run impact of market structure on investment as $\beta_3/(1-\rho L)$

[24] This captures the start of the investment cycle in 4G networks in a given country. This may be triggered by new 4G spectrum being released by the regulator or by 2G spectrum being refarmed for 4G purposes.

that omitting lagged investment is likely to have biased their results given that lagged investment is likely to be associated with changes in market concentration (see discussion in Section 3).

c) **GDP per capita,** which we use as a proxy for income per capita;

d) **Time trends**, which we use to control for global trends in network usage due to mobile handset upgrades and the emergence of new mobile applications; and

e) **Country fixed effects**, which are country dummy variables capturing time invariant factors such as geography.

5.9 We have also tested the inclusion of other controls such as spectrum holdings, population density and rurality of population.

5.10 Note that we use capex per capita as our measure of investment which has the benefit of allowing us to control for the impact of population size on network investment.[25]

To estimate equation 1, we apply the fixed effects method and the Arellano-Bond estimator

5.11 Equation 1 above can be estimated either by the standard OLS method including dummy variables for each country as done in the GSMA 2020 study or by the fixed effects (FE) method which transforms the data by subtracting from every variable its time series average. This latter transformation has the effect of removing time invariant country specific factors from the analysis – see discussion in Annex A3.[26] Both methods produce identical estimates of the coefficients.

5.12 However, both methods above have a potential problem due to the lagged values of I_{it} appearing on the right side of the equation – see discussion in Annex A3. For standard OLS, the coefficients on the lagged values of investment have a bias that is inversely proportional to T, the number of time periods in the data. For the FE method, the lagged values induce a correlation between the error term in the equation and the regressors. As a result, for small values of T, the fixed effect method is an inconsistent estimator in this model.

[25] We also considered using capex per subscriber as our measure of investment. However, we only have data on number of connections, which is an imperfect proxy of subscribers. This is because a single subscriber can have more than one connection, e.g. personal phone and office phone. A single subscriber can also have more than one connection to avoid paying high off-net fees when making calls to contacts in alternative mobile networks. This was quite popular during the 2000s. This means that the probability of having more than one connection is likely to be linked to number of MNOs in the market and therefore to market concentration. Using investment per subscriber therefore could introduce bias in our results as the impact of changes in market concentration on investment would capture more than just changes in operator capex, it would also capture changes in number of connections as a result of changes in market structure. We consider focusing our analysis on investment per capita is a valid approach. We would expect MNOs to plan their investments to provide enough capacity for a fraction of the total population/market size. This fraction will be determined in part by the number of MNOs operating in the market, which we are already accounting for. Although number of subscribers may also play a role, cross-country differences in penetration rates are likely to be picked up by country fixed effects and increases in penetration rates over time by time trends.

[26] For a detailed description of this method see Wooldridge, "Econometric Analysis of Cross Section and Panel Data", The MIT Press, 2nd edition, 2010; and Cameron & Trivedi, "Microeconometrics: Methods and Applications", 2005.

5.13 For these reasons, we estimate the model using two estimators, the FE estimator and the Arellano-Bond (AB) estimator. The FE estimator is a consistent estimator when the number of time periods is large. In our case, we have 76 time periods/quarters in our dataset, so we believe the FE estimator bias is likely to be small. Even though we have a relatively long-time horizon in our dataset, there may still be bias in our FE estimate.[27] Therefore, we also apply the AB estimator which uses instrumental variables techniques to eliminate the bias in dynamic panel data models – see Annex A3 for a more detailed explanation of this approach.

Quality model

To estimate the impact on network quality, we consider both the direct and indirect effects of market concentration on network quality

5.14 To estimate the impact on network quality, we consider a model of the form:

$$Y_{it} = \gamma + \sum_{\omega=m}^{n} \varphi_{i\omega} L^{\omega} I_{it} + \sum_{k=1}^{K} \tau_k X_{ikt} + \mu_2 T_t + \mu_3 MC_{it} + v_i + \varepsilon_{it} \quad [2]$$

5.15 Where:

a) Y_{it} is the quality variable (i.e. average download speeds), in country i at time t;

b) $\sum_{\omega=m}^{n} \varphi_{i\omega} L^{\omega} I_{it}$ is the weighted sum of lagged values of I_{it} (capex per capita) up to the level of n where m in this equation is one – see paragraph 5.19 for an explanation as to why we do not include contemporaneous investment. L^{ω} is the lag operator such that $L^1 I_{it}$ is equivalent to I_{it-1}, $L^2 I_{it}$ refers to I_{it-2}) and so on;

c) X_{ikt} is a matrix of a control covariates which may influence Y_{it}. These may include the technology cycle, GDP per capita, population density, the rurality of the population and post-90% 4G coverage;

d) T_t is a vector of time variables including seasonal dummies and a global time trend;

e) MC_{it} is the market concentration measure, either the number of MNOs or HHI in country i and quarter t – see discussion in Annex A2;

f) v_i are country fixed effects and capture any unobserved variation in consumer outcomes that can be attributed to specific characteristics of each country (e.g. geography and topology); and

g) ε_{it} is a random error term.

[27] Judson R.A. and Owen A. (1999), Estimating dynamic panel data models: a guide for macroeconomists. Economics Letters, 1999, vol. 65, issue 1, 9-15. The authors found that even with a time dimension T as large as 30, they found that the bias may be equal to as much as 20% of the true value of the coefficient of interest. Asymptotically, the bias in the FE estimate is proportional to 1/T (where T is the number of time periods). Given that we have 76 periods in our data, the size of the bias in our FE analysis would be 0.01.

5.16 Unlike previous studies, we include the investment variable as an explanatory variable of network quality. This allows us to identify the direct and indirect impacts of market concentration on network quality:

a) The **indirect impact** can be identified by combining the results from equations 1 and 2 above: the short-run indirect impact can be identified by $\varphi L \beta_3$.[28] the long-run indirect impact can be identified by $\varphi L \times [\beta_3/(1-\rho L)]$.[29]

b) The **direct impact** of market concentration can be identified by the parameter μ_3 in equation 2.

5.17 We include the investment variable in lags. That is, we assume that average download speeds are partly determined by lagged investment, rather than by contemporaneous investment.[30] We understand that investment in mobile networks takes time to implement and feed into quality outcomes, particularly as capex is typically incurred at the time that an order is placed (rather than when equipment is received and ready for use). The delay in the impact of investment on network quality will vary depending on the asset type the investment relates to. For example, installing a new cell site could take several months to complete and for it to then become operational. Upgrading an existing cell site (e.g. by installing an additional carrier) on the other hand is likely to require less time to implement.[31] Although there is some variation in the extent of delay, it is our understanding that it would be very unusual for investment to impact network quality in the same quarter that the expenditure is incurred given the lead times between placing an order, receiving the equipment and making it operational. We outline how we determine the number of lags of investment that we include in our model in Annex A3.

5.18 To isolate the impacts of investment and market concentration on network quality, we control for other factors that may affect network quality. In addition to the controls that we include in our investment model, and similar to previous studies, we include a dummy variable that indicates when 4G coverage reaches 90% of households and have interacted this with the market concentration measure.[32] The intuition for including these controls in our model is that MNOs may focus their efforts on extending coverage first and then invest in additional capacity. Previous studies have assumed this happens at around 90% population coverage.[33] Given that 4G is a more efficient technology than 3G, we would expect the post-90% coverage dummy to have a positive impact on network quality.

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[28] The short-run impact captures two effects. The first is the short-run impact of market structure on investment equal to β_3. The second short-run impact captures the effect of past investment on network quality equal to φL.

[29] Using the lag polynomial: $\varphi(L)I_{it} = \varphi L I_{it} = \sum_{\omega=m}^{n} \varphi_{i\omega} L^{\omega} I_{it}$. Inserting this into equation (2) and then taking the partial derivative with respect to I_{it} gives φL.

[30] We nonetheless test the inclusion of contemporaneous investment in the quality model to ensure that we are not omitting relevant variables from the model. Its inclusion does not impact our results.

[31] We believe that the delay in the impact of investment on download speeds could be amplified in our data given that our data is quarterly and we understand that MNOs typically record capex spend when they place an order (i.e. in advance of when they receive and are able to deploy it).

[32] This is a dummy variable that takes a value of '1' once 90% coverage is reached in each country.

[33] Although we do not believe coverage is a strictly exogenous variable – this is likely to be a function of various factors including market structure, income and coverage obligations – not including it in our model could lead to a biased estimate

5.19 As per our analysis on investment, we estimate equation 2 using the fixed effects method.

Important considerations in our investment and quality models

We assume a linear time trend in our models

5.20 As set out above, our analysis controls for the relationship between time and investment/quality outcomes. To do this, we include two types of time variables in our models:

a) **Seasonal dummies** which account for seasonality in investment and network quality due to, for example, network usage typically peaking during the Christmas period; and

b) **Global time trends** which account for annual trends in the evolution of network usage due to handset upgrades and the emergence of new mobile applications.

5.21 To determine the exact form of the time trend in our models, we have looked at the patterns in our investment and quality data (see Annex A2). These suggest that:

a) there is a slight upward trend in the level of network capex over time (see chart A2.1), with seasonal spikes every fourth quarter. Note there is a dip in 2009, at the time of the financial crisis, which we account for with our GDP per capita measure. Network capex then rises again with the rollout of 4G networks, though this tapers off from 2014 onwards;

b) average download speeds appear to grow linearly over the study period (see chart A2.2); and

c) data usage growth is relatively flat across our sample, with seasonal spikes every fourth quarter. Data usage could partly reflect the impact of mobile application and handset releases.

5.22 Therefore, we consider that we can model the relationship between time and investment/quality by way of a linear time trend and seasonal dummies. Given that investment seems to taper off from 2014, we have also tested a non-linear relationship as a robustness test which we set out in Annex A4.

5.23 We could also use fixed time effects, or a combination of year dummies and seasonal dummies, to model the relationship between time and investment/quality. However, we consider that this approach could lead to model overfitting. This is because we would have to include an additional covariate for every quarter/year in our dataset. Given the linear patterns in our data, this is unlikely to improve the accuracy of our modelling, while it could lead to less reliable results due to over-parametrization.

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of the impact of market concentration if it is a relevant factor determining network quality. Therefore, we have tested the inclusion of post-90% coverage in our analysis.

While we consider it unlikely that number of MNOs is affected by contemporaneous investment/quality, we consider that there is a reverse link between HHI and investment/quality

5.24 To isolate the impact of changes in market concentration on investment/quality, changes in market concentration need to be independent of changes in investment/quality (i.e. market concentration should not be impacted by investment/quality, nor by unobserved factors that also drive investment/quality).

5.25 In Section 3 we explained that market concentration may be influenced by similar factors that also influence investment. We have already set out in that section how we take account of these factors.

5.26 We have not addressed however the possibility that investment and/or quality could have a direct impact on market concentration, i.e. whether there is a reverse link between market concentration and investment/quality outcomes. If a reverse link exists, this would create bias in our estimates in a similar way as omitting relevant factors from our model would.

5.27 As mentioned above, we use number of MNOs and HHI as measures of market concentration. While we believe that reverse causation is unlikely to arise between number of MNOs and investment/quality, we believe that there is a likely reverse link between HHI and investment/quality as we explain in turn.

Number of MNOs

5.28 As explained in Section 3, there are several factors that drive investment and quality which could also affect the decision of an MNO to enter or stay in the market. Therefore, to isolate the impact of market concentration on our variables of interest, it is important to control for all these potentially confounding factors.

5.29 Once these factors are controlled for, we consider it unlikely that changes in investment or quality will have a direct and contemporaneous impact on the number of MNOs in the market. This is because number of MNOs is a result of entry/merger/exit decisions which are based on a consideration of future profitability. Given that contemporaneous investment is an element at best of future profitability, we believe that changes in current investment (particularly the quarterly changes in investment that our data captures) are unlikely to trigger entry/merger/exit decisions. We also do not consider that changes in network quality outcomes (as measured by download speeds) would themselves directly cause any change in the number of MNOs.

HHI

5.30 HHI measures the degree of concentration in the mobile sector by capturing the relative market shares of the different MNOs in the market. The more concentrated the market, the higher the level of HHI is.

5.31 Although similar considerations could be made for HHI as for number of MNOs, we consider that this measure can be impacted by changes in current investment/quality. This is because changes in investment/quality will affect the attractiveness of a network to consumers. This could impact the number of subscribers a network has and thus on the level of HHI in the market. In other words, if subscribers across a fixed number of MNOs were to switch to MNOs offering improved quality of service, this would impact HHI as a result of the change in relative market shares, despite the number of MNO remaining constant. Previous studies have also assumed a reverse link between HHI and investment/quality outcomes. This indicates a problem of reverse causality.

To address the reverse causality between HHI and investment/quality, we use instrumental variable techniques

5.32 To address the reverse causality arising in the relationship between HHI and investment/quality, we use instrumental variable techniques. Intuitively, these techniques seek to isolate the impact of the variable of interest (in this case market concentration) by using an instrument that can function as a proxy of the variable of interest and which does not suffer from reverse causality.

5.33 The GSMA 2020 study uses the share of 3G spectrum holdings as the instrument for HHI. They argue that this measure is not affected by changes in investment/quality given that their study period only covers the 4G cycle (2011-2018).[34] They also consider that the share of 3G spectrum holdings is likely to be a good indicator of HHI during the 4G era as 3G auctions are likely to have shaped the structure of the market in the longer term.

5.34 We believe that there are two problems with using 3G spectrum holdings as the instrument for HHI:

a) First, the share of 3G spectrum holdings (which were allocated pre 2010) are solely a partial instrument for HHI over the period 2011-2018 as they would not have changed, unlike the actual HHI during that period; and

b) Second, given that 3G spectrum holdings would not have changed during the period of analysis, using this as an instrument puts more weight on the effect coming from countries with no changes in market structure vis-à-vis countries which did experienced structural changes.

5.35 Instead, we use the two-quarter lag of HHI as our instrument for current HHI. We consider that the lag of HHI two quarters ago is likely to be a good predictor of current HHI, while we do not expect changes in current investment/quality to affect the level of HHI two quarters before (once planned investment and recent supply/demand shocks are accounted for). We explain how we have implemented this technique in Annex A3.

[34] They thus reason that changes in investment during the 4G period would not have affected MNO decisions on 3G spectrum acquisition as 4G was unknown at that time.

Data aggregation

We use country-level data to conduct our panel data analysis

5.36 Although we have collated MNO-level data on investment and quality, we have carried out our panel data analysis using country-level data. This is due to the following reasons:

a) **MNO investment will inevitably increase with an increase in concentration** because in markets with fewer MNOs, each individual network will be on average larger in size;

b) **Country-level data is more complete**. Investment data is not available for a large proportion of MNOs, particularly the smaller ones. Given that the impact of consolidation is likely to be asymmetric across MNOs, MNO-level analysis could lead to biased results;[35] and

c) **Pre-merger quality data is not available for MNOs which have been acquired and are no longer active post-merger**. The quality data for MNOs which have been acquired is aggregated retrospectively with the data for the acquiring operator (see discussion in Annex A2). This means that quality for the acquiring MNOs cannot be separately identified in the years prior to the merger/acquisition, and so any quality analysis at operator level could introduce further bias.

[35] While MNO investment will inevitably increase for the merged entity, this may not be the case for other MNOs.

6. Panel data results

Panel data analysis

Country-level investment is lower in more concentrated markets

6.1 Table 6.1 summarises the findings from our panel data analysis of the relationship between changes in market concentration and investment. It reports our estimates of the short-run and long-run impact of changes in market concentration on capex per capita for our two measures of concentration (i.e. number of MNOs and HHI). The table also presents how our results vary depending on the method used (i.e. fixed effects and AB estimator). The reported range estimate for our results using the AB estimator reflects the sensitivities around the number of lagged instruments used to address the simultaneity issue between the investment variable and the lagged investment variables which we include as covariates in our models.

6.2 The results suggest that country-level investment is lower in more concentrated markets, regardless of the measure of concentration used:

a) For **number of MNOs**, we find that one less MNO in the market has the long-run effect of reducing country-level investment by an average of 13.2%-18.5%; and

b) For **HHI**, we estimate that a 600-points increase in HHI[36] has the long-run effect of reducing country-level investment by an average of 8.4%-19.2%.

Table 6.1: Panel data results for the impact of market concentration on capex per capita

	Number of MNOs - OLS		HHI - IV	
Method	**FE**	**AB**	**FE**	**AB**
Short-run	4.0%	4.1% to 8.5%	-1.8%	-2.4% to -10.2%
Long-run	16.8%	13.2% to 18.5%	-8.4%	-9.0% to -19.2%

Notes: Estimates are statistically significant at 5%. Impact for HHI is measured for every 600-point increase.

6.3 Our estimates are statistically significant and are robust to different model specifications. In particular, we find that our estimate of the long-run impact of changes in market concentration on investment is robust to a more parsimonious lag structure for lagged investment, a quadratic time trend, the inclusion of other controls (i.e. spectrum holdings, population density and rurality of population), and the use of the lag of HHI four-quarters ago as instrument for HHI.

6.4 The estimated impacts of our remaining control variables are as expected (see Table A4.1). The coefficient of GDP per capita is positive, which suggests that capex per capita is higher

[36] This reflects the average increase in HHI resulting from the mergers in our sample. To put this number in context, a four to three merger between the second largest and the smallest MNO with a share of 30% and 10% respectively in a market with two other MNOs with a share of 40% and 20% respectively, would result in an HHI increment of 600.

in countries with higher GDP per capita. The coefficient of the 4G dummy is also positive, meaning that capex per capita is higher during the 4G cycle *vis-a-vis* the 3G cycle.

6.5 We note that our results are different to those in previous studies which have not found a statistically significant impact of market concentration on industry capex (see Annex A1). This could be due to our use of an expanded and more complete dataset on network investment, as well as the inclusion of lagged investment and technology cycles as additional controls in our analysis.

6.6 Further details of the results from our analysis on investment are presented in Annex A4.

Less investment does not necessarily imply lower network quality

6.7 Our finding that country-level investment is lower in more concentrated markets does not necessarily imply that a reduction in competition leads to lower network quality. It could well be that more concentration leads to greater network efficiency, such that less investment achieves the same or better network quality.

6.8 To verify this, we assess the relationship between concentration, investment and quality outcomes. Higher (or similar) network quality in more concentrated markets would suggest that the reduction in investment would be more reflective of network efficiencies, rather than of reduced competition in the market; whereas lower network quality would suggest otherwise.

Our analysis suggests that an increase in market concentration does not lead to improvements in network quality

6.9 Table 6.2 summarises the findings of our panel data analysis for the relationship between market concentration and network quality. It reports our point estimates of the impact of market concentration on download speeds. These estimates are provided for our two measures of market concentration. Note that we provide estimates for the direct and indirect impacts of concentration, as well as for the combined impact.

6.10 For the direct impact of market concentration, we report our findings for both the inclusion and exclusion of the interaction between concentration and post-90% coverage. When we include the interaction, we disaggregate the effects as follows:

a) **Market concentration** – this is the average direct effect of an increase in market concentration;

b) **90% coverage interaction** – this is the incremental effect of an increase in market concentration once 4G coverage in the country reaches 90% of households (i.e. the additional effect over and above the average effect of an increase in concentration across all countries); and

c) **Market concentration after 90% coverage** – this is the cumulative effect of a) and b), i.e. the total impact of an increase in market concentration once 4G coverage in the country reaches 90%.

6.11 Our results suggest a negative relationship between market concentration and download speeds. While we find no evidence of a significant direct impact of market concentration on download speeds, we find a significant indirect impact. That is, we find that more concentrated markets tend to have lower industry investment, and this in turn leads to lower download speeds. The magnitude of the indirect impact is similar for both of our measures of concentration.

a) For **number of MNOs**, we find that one less MNO in the market leads to a reduction in download speeds of 5.1% to 7.4%; and

b) For **HHI**, we find that a 600-point increase in HHI leads to a reduction in download speeds of 3.0% to 7.8%.

Table 6.2: Panel data results for the impact of market concentration on download speeds

Coverage interaction	Number of MNOs - OLS		HHI - IV	
Coverage interaction	**Excluded**	**Included**	**Excluded**	**Included**
Indirect impact	5.3% to 7.4%	5.1% to 7.2%	-3.6% to -7.8%	-3.0% to -7.2%
Direct impact:				
Market concentration	–	–	–	–
90% coverage interaction	n/a	–	n/a	–
Market concentration after 90% coverage	n/a	–	n/a	–
Combined impact (indirect + direct)	**5.3% to 7.4%**	**5.1% to 7.2%**	**-3.6% to -7.8%**	**-3.0% to -7.2%**

– Not statistically significant at 10%

Note: Impact for HHI is measured for every 600-point increase.

6.12 Our results are robust to different model specifications, such as the inclusion of contemporaneous investment and other controls such as spectrum holdings, rurality of population and population density. They are also robust to the use of the lag of HHI four quarters ago (as opposed to the lag of HHI two quarters ago) as an instrument for HHI.

6.13 We also verified whether our findings could be driven by network duplication in less concentrated markets. That is, we tested whether a given level of investment is less effective in generating quality outcomes due to network duplication in less concentrated markets. We did this by interacting the investment and market concentration measures. We found that this interaction is not statistically significant, suggesting that investment in more concentrated markets is no more efficient than in less concentrated markets – see Annex A4 for further details. This provides reassurance that our finding of a negative

indirect impact of concentration on download speeds is not driven by duplicative investment in less concentrated markets.

6.14 We note that the coefficients of the other controls in our models have the expected sign:

a) The coefficient of the 4G dummy is positive suggesting that download speeds are higher during the 4G era (relative to the 3G era);

b) The coefficient of the post-90% coverage variable has positive sign, suggesting that download speeds are greater after 4G coverage reaches 90%[37]; and

c) The coefficient for GDP per capita is negative, reflecting the fact that an increase in demand for a given network capacity will lead to a reduction in average download speeds.

6.15 The coefficient on GDP per capita is so large that the combination of the direct and indirect effect of GDP per capita on quality remains negative and statistically significant. This could reflect that demand shocks are associated with slower speeds, even in the long run, if the network usage effects of a demand shock exceed its impact on investment incentives.

6.16 However, we think it more likely that our estimates of the impact of GDP on investment are not very precise and so do not capture the full effect of demand shocks on incentives to invest. This is because our models include:

a) country specific fixed effects which will capture most of the persistent variation in GDP across countries; and

b) time trends which will absorb much of the growth in GDP within countries over time.

6.17 We do not consider this a problem for our modelling as it will not bias the results for the coefficient we are interested in.

6.18 Further details of our results are provided in Annex A4.

Overall, our panel data analysis does not find evidence that increases in market concentration can enhance network quality on average

6.19 In Section 4, we explained that our data captures a large number of structural changes in market concentration over the period from 2000 to 2018. We use this data to analyse the relationship between changes in market concentration and investment. This is not the case though for our analysis of the relationship between market concentration and network quality, for which we use a more limited data set spanning from 2011 to 2018. Over this period, there were ten structural changes, compared to the 46 changes across our whole sample. Therefore, given the fewer structural changes captured by our analysis on network quality, we treat our findings of the impact of concentration on download speeds with caution.

[37] This is the case for our models using number of MNOs as the measure of market structure. For our models using HHI, the sign is negative, but the coefficients are not statistically significant.

6.20 Despite the above, we find that the evidence is not supportive of higher concentration having an average positive impact on investment and quality. Analysis of past investment cycles, therefore, does not support the view that greater concentration in mobile markets will necessarily facilitate investment in a way that will lead to better quality outcomes for consumers.

7. Country-specific merger study methodology

7.1 This section sets out the methodology used to implement our country-specific merger analysis.

Synthetic control analysis

We use the synthetic control method to assess the impact of three recent mergers on investment/quality outcomes in those countries

7.2 Our panel data analysis estimates the average effect of changes in market concentration on investment and quality outcomes over all changes in concentration in our sample (including entry events as well as mergers). However, we are interested primarily in the effects of mobile mergers and recognise there may be significant differences between individual transactions: including the market context, the motivation for merging and any remedies applied (as well as their success). For that reason, we have separately looked at mergers in three individual countries (Austria, Ireland and Germany) in more detail to understand their context, and to estimate the effect specific to that country. These mergers all occurred over the time period 2012 to 2014 and reduced the number of MNOs from four to three. We have not included the Hutchison/WIND merger in Italy that occurred in 2016 as the merger was only cleared conditional on a fourth player being recreated, thus leading to no net change in number of MNOs.

7.3 To assess the impact that a specific merger had on investment and quality outcomes in that country, it is necessary to consider what outcomes are likely to have resulted had the merger not occurred. The difference between this counterfactual and the actual post-merger outcomes is the true merger effect. However, because the counterfactual investment and quality outcomes cannot be observed, these need to be estimated.

7.4 We use the synthetic control method to estimate the missing counterfactual outcomes to assess the impact of mobile consolidation on country-level investment and quality outcomes. This allows us to estimate the impact of the merger on market-wide outcomes.

7.5 This method has been applied widely in the economic literature on programme evaluation and has also been used in the analysis of mobile mergers by DG Comp (2015),[38] RTR (2016),[39] and DG Comp (2017)[40] to assess the ex-post effects of mobile mergers on prices. GSMA (2017) uses this method as part of its analysis of the impact of network quality

[38] DG Competition (2015). "Ex-post analysis of two mergers: T-Mobile/tele.ring in Austria and T-Mobile/Orange in the Netherlands". Authored by Aguzzoni L., et al.
[39] RTR (2016). "Ex-post analysis of the merger between H3G Austria and Orange Austria".
[40] DG Competition (2017). "Economic impact of competition policy enforcement on the functioning of telecoms markets in the EU". Reported prepared by Lear, DIW Berlin and Analysis Mason.

(although as noted in our discussion of the limitations of this report, they are only able to obtain results using synthetic control techniques for 4G coverage outcomes).

Synthetic control method

The synthetic control method offers a data-driven procedure for the selection of a synthetic control group

7.6 This method offers a data-driven procedure to select a synthetic counterfactual from the candidate control group units. Under this method, rather than relying on the set of controls directly (as in the DD method), the control group is selected algorithmically from the candidate control group units based upon a set of pre-merger characteristics, not just the outcome variables. This is particularly useful when the control group and the treated group do not follow similar trends pre-treatment, as it relaxes one of the key assumptions needed for DD and allows a good pre-treatment match to be constructed synthetically even when this assumption does not hold.

7.7 In addition, the synthetic control method is better suited for case studies where there is only a single or small number of units that are treated. In this case, we have only one country that experienced a merger in each study.

A synthetic control group is constructed to best replicate the pre-treated characteristics of the treated unit

7.8 Based on the characteristics chosen, a 'synthetic' representation of the country where the merger occurred is constructed as a weighted average of outcomes experienced in countries where no merger occurred. This data-driven process chooses the weights such that the synthetic country mimics the treated country as closely as possible pre-merger based on the characteristics chosen.

7.9 A key measure of the accuracy of the representation of the synthetic unit is how closely the outcomes of interest (i.e. investment or average download speeds) are matched pre-merger. This equates to ensuring that pre-intervention, the outcome variable (i.e. investment or average download speeds) for the treated group (i.e. the country with the merger) and the synthetic control group (i.e. the synthetic representation of this country had the merger not occurred) are as near equivalent as possible.

7.10 In addition, to have confidence that the synthetic unit is truly representative of the country where the merger occurred, it is important that the characteristics included in the model are also broadly well matched. This is checked by looking at the difference between each characteristic in the model between the treated and synthetic unit.[41]

[41] In our analysis, some of the characteristics we matched against included GDP per capita, the 4G cycle, population density, rural population, 3G growth rates, national HHI indices, the unemployment rate and numbers of fixed telecoms and broadband subscribers. The exact variables used are presented in the discussions of particular specifications in the annexes.

7.11 Once the weights are estimated in the pre-merger period, we can compute the investment/quality outcomes of the synthetic control after the merger. This series represents the counterfactual outcomes of the treated country absent the merger.[42]

7.12 Standard statistical tests cannot be used to assess the statistical significance of the difference between the synthetic counterfactual and actual post-merger outcomes Instead, a series of alternative tests (called "placebo" tests) need to be carried out.

7.13 Further details on the synthetic control method and placebo tests are provided in Annex A5.

[42] As we explain in Annex A5, given that the timeframe of many of our mergers covers the period when 4G networks began to be rolled out, we estimate this using standard time and after rebasing around 4G rollout

8. Country-specific merger results

8.1 This section sets out the results from our analysis using synthetic control methods for the three mobile mergers which led to increased concentration (albeit remedied via different measures) in Austria, Germany and Ireland.[43]

Hutchison/Orange merger in Austria in 2012

Background to the merger

8.2 In December 2012, the European Commission (EC) approved the acquisition of Orange by Hutchison following a Phase II Merger Investigation, with the deal completed in January 2013. This was a merger between the two smallest MNOs in the country, reducing the number of MNOs in Austria from four to three. The EC had concerns with the loss of a competitive constraint in the market, but approved the transaction based on three remedies:

a) an MNO remedy – Hutchison committed to divest spectrum to a potential new MNO, and to sell and share assets to support the potential entrant;

b) an MVNO remedy – Hutchison was to host up to 16 MVNOs on pay-as-you-go-terms; and

c) an upfront remedy – the acquisition would be completed only after entering a wholesale access agreement with an MVNO

8.3 The MNO remedy did not become effective as there were no parties interested in setting up a new operator and the upfront remedy only became effective in December 2014 following the launch of UPC. Three further agreements were signed in 2015 and 2016.

Results

8.4 Due to a level shift in investment in Austria in 2010, we are unable to construct a synthetic counterfactual that matches the pre-merger outcomes in Austria sufficiently well to provide a useful guide to the post-merger effect for investment. As a result, we are unable to draw any inference about the impact of the merger on country-level investment in Austria.

8.5 In contrast, for our assessment of the merger on quality, our synthetic control group for average download speeds in Austria matched well against pre-merger outcomes. We find that average download speeds in Austria are lower than the synthetic control group for the first two years after the merger. This effect is statistically significant and robust to a number of sensitivities. After this two-year period, we find that Austrian average download speeds recover and return to a similar level to what we would predict without the merger.

[43] As noted previously, we have not included the Hutchison/WIND merger in Italy that occurred in 2016 as the merger was only cleared conditional on a fourth player being recreated, thus leading to no net change in the number of MNOs.

The difference of our synthetic control results with the GSMA study is interesting in itself and is robust to a number of sensitivities.[44] Specifically, our robustness tests – see Annex A6 - support our results of there being no positive effect on average download speeds.

8.6 Further details of our results for Austria are provided in Annex A6.

Hutchison/Telefónica merger in Ireland in 2013/14

Background to the merger

8.7 In May 2014, the EC formally cleared Hutchison's acquisition of Telefónica Ireland following a Phase II merger investigation. The merger between Hutchison and Telefónica combined the second and fourth largest MNOs in the market, reducing the number of MNOs in Ireland from four to three and led to a market structure with two MNOs with a similar market position followed by a third much smaller player.

8.8 The EC considered Hutchison as an important competitive force in the Irish market and was concerned that the merger would reduce competition and increase prices to the detriment of consumers. The merger was approved subject to three main commitments:

a) an MVNO remedy – Hutchison committed to enter capacity agreements with two MVNOs;

b) an MNO remedy – Hutchison offered to divest spectrum to the MVNOs in the previous commitment, with the option available to the MVNOs until 2026; and

c) Hutchison agreed to continue the existing network sharing agreement between Eir and Telefónica to ensure that Eir remained an effective and viable competitor.

8.9 Two MVNOs, iD Mobile and Virgin Mobile entered the Irish mobile retail market on the Hutchison network as a result of the merger commitments but neither managed to make a significant impact on the market. Having failed to gain sufficient scale iD Mobile exited the market in April 2018. In the case of Virgin Mobile, at the end of 2017 it had a market share of slightly under 1%.

Results

8.10 For our analysis of the impact of the merger on country-level investment, we find a synthetic control group for industry investment in Ireland which is a good match against all actual pre-merger outcomes. Across the whole post-merger period we find that investment in Ireland is lower than the synthetic control group, and this effect is statistically significant. Therefore, based on our dataset, our analysis suggests that following the merger, there was a decline in country-level investment in Ireland relative to a counterfactual scenario absent the merger. As discussed in Section 3, a decline in

[44] We note that even though we used the GSMA proprietary database, in discussions with the GSMA, they said that their study also used confidential data obtained directly from the MNOs. We do not know what the discrepancy is between this data and that in the GSMA proprietary database used in our study.

industry investment is not necessarily a poor outcome for consumers, as there could be significant cost savings from less duplication of networks and economies of scale.

8.11 In our further investigation of this merger and its impact on average download speeds, we find a synthetic control group for average download speeds in Ireland that matches well against pre-merger outcomes. We find that average download speeds in Ireland have a slower rate of growth than the synthetic control group resulting in lower download speeds relative to a counterfactual scenario from one-and-a-half years after the merger. This effect is statistically significant and robust to a number of sensitivities. Therefore, based on our analysis, the merger appears to have had a negative impact on network quality.

8.12 Further details of our results for Ireland are provided in Annex A7.

Telefónica/E-Plus merger in Germany in 2014

Background to the merger

8.13 In July 2014, the EC approved the acquisition of E-Plus by Telefónica following a Phase II merger investigation. This transaction reduced the number of MNOs in Germany from four to three and involved the third and fourth largest MNOs merging to become the largest player in Germany.

8.14 The merger was approved subject to a package of commitments from Telefónica to mitigate the loss of competitive pressures in the market:

a) an MVNO remedy – Telefónica committed to sell dedicated access of up to 30% of the merged company's network capacity to up to three MVNOs;

b) an MNO remedy – Telefónica committed to offer to divest spectrum and other assets to a new MNO entrant, or alternatively to the MVNOs in the previous remedy if there was no willing entrant;

c) a general remedy – Telefónica committed to extent existing wholesale agreements with Telefónica's and E-Plus' wholesale partners, and to further offer wholesale 4G services to all interested parties on 'best prices'.[45]

8.15 There was no entrant willing to enter the market. As such, the MVNO Drillisch took up the MVNO remedy, given access to 20% of of Telefónica's network capacity with the option to increase this to 30% by 2020 at guaranteed prices until at least 2030. Drillisch has been a successful entrant, leveraging its dedicated network capacity to gain significant scale.[46]

[45] In February 2019, the EC began an investigation into whether Telefónica breached this remedy. The Commission's preliminary view is that Telefónica failed to properly implement its obligations to offer 'best prices' under its wholesale 4G access obligation.

[46] In June 2019, given that its regulated agreements with Telefónica were set to expire in 2030, Drillisch successfully participated in the 5G auction, and is now committed to becoming the fourth operator in Germany. This change in market structure may therefore result in further competitive pressure in the market going forward.

Results

8.16 For our analysis of the impact of this merger on country-level investment, we find a synthetic control group for industry investment in Germany which is a good match against all actual pre-merger outcomes. The main finding from our counterfactual analysis of this merger is that for the first two years after the merger, there does not appear to be any effect on industry capex. However, in the third and fourth year following the merger, we find a statistically significant decline in industry capex relative to the counterfactual. A decline in industry investment is not necessarily however a poor outcome for consumers as there could be significant cost savings from less duplication of networks and economies of scale.

8.17 Therefore, we also considered the effect of the merger on average download speeds. In this further analysis, we find a synthetic control group for average download speeds that matches well to actual pre-merger outcomes in Germany. Comparing the synthetic Germany average download speeds with those of actual Germany, our results consistently estimate a negative impact on download speeds driven by a two-year stagnation in the rate of growth. However, on further testing, these effects are not significant. Therefore, we cannot conclude that the merger has had any effect on download speeds in Germany as a result of the Telefónica/E-Plus merger.

8.18 Further details of our results for Germany are provided in Annex A8.

Conclusion of country-specific merger studies

Our country-specific merger studies support our panel data findings

8.19 Table 8.1 summarises the results of our country specific merger studies. It shows that consolidation has either no impact or a negative impact on country-level investment and download speeds from the time of each merger until the end of 2018.

Table 8.1: Synthetic control results for the impact of consolidation on investment/quality

Merger	Impact on country-level investment (Industry capex)	Impact on country-level quality (Download speeds)
Austria – 2012 Hutchison/Orange	No inference possible*	▼ Negative effect for two years — No impact after two years
Ireland – 2014 Hutchison/Telefónica	▼ Negative effect	— No impact for first 18 months ▼ Negative effect after 18 months
Germany – 2014 Telefónica/E-Plus	— No impact for first year ▼ Negative effect after first year	— No impact

* We were unable to construct a synthetic counterfactual because industry capex in Austria is significantly higher than in the countries in the control group. This means we cannot create a weighted combination of the countries in the control group to approximate investment outcomes in Austria in the absence of the transaction.

8.20 While the results from our merger-specific analysis are mixed, none of the studies provide evidence that past four to three mergers have generated improvements in network quality to the benefit of consumers. Instead, there is some evidence that both investment and average download speeds declined following some of these mergers. These findings are in line with our panel data analysis.

9. Potential limitations of our analysis

9.1 Our modelling approach is necessarily a simplification of reality. There are three factors in particular that we are aware our analysis cannot capture or control for and which could affect our results:

a) Selection bias due to remedies/blocked mergers;

b) Network sharing agreements; and

c) Spill-over effects.

In each case, we consider the impact will be limited or, possibly, cause us to overstate any positive impact of concentration on investment/quality for reasons we explain in more detail below.

Selection bias

9.2 Our panel data approach seeks to estimate the impact of changes in market structure on investment and quality. As we describe in Section 4, the changes in market structure captured by our dataset include 33 entry events and 12 mergers. Where we observe merger events, the effects associated with these mergers are inclusive of remedies imposed by merger authorities in order to grant merger clearance, as we have not found reliable statistical instruments to disaggregate the effects resulting intrinsically from a merger and those arising from the remedies attached to it. This, along with the fact that our analysis does not capture possible mergers that did not materialise because they were blocked by authorities, or were not attempted given merging parties' expectation that authorities would not approve these mergers, creates 'selection' bias, which means that our panel data analysis may:

a) Understate the negative impact of concentration because only 'approved' mergers will be studied, and remedies have the effect of limiting the negative impact of increased concentration on quality; or

b) Understate the positive impact of concentration, if remedies have the effect of limiting the incentives to invest in quality improvement and/or authorities block mergers that could have increased quality.

9.3 However, we would not expect this bias to arise for entry and exit as these do not require approval by authorities. As such, we believe that this bias is somewhat mitigated in our panel analysis by considering not only the impact of mergers but also that of entry and exit. As many of the changes in concentration that we observe in our dataset are driven by entry events rather than mergers, we expect any selection bias issues to be relatively limited.

Network sharing

9.4 One potential benefit from mobile consolidation is the cost savings that could result from reducing network duplication (or conversely, a potential cost of entry is an increase in network duplication).[47] Mobile networks are characterized by high fixed costs, so reducing the number of networks in the market could lead to cost efficiencies in the form of economies of scale. Similar benefits could be realised by MNOs sharing their networks (i.e. by MNOs using the same network to provide services to end customers) as this would reduce the need for network duplication.[48]

9.5 There are several European countries where network sharing arrangements have been put in place. Whilst our panel data analysis controls for the average effect of network sharing agreements in our sample through the fixed effects transformation, we are unable to capture changes in these arrangements over time due to data limitations. We do not consider this will bias our results, but it does mean that our panel analysis only estimates the average effect of consolidation on quality across the network sharing strategies in countries which saw a change in market structure.[49] This may affect the extent to which our panel data results can be extrapolated to other contexts. In particular, benefits of consolidation may be lower in countries where the merging parties already have network sharing agreements, and higher in those where the merging parties do not have network sharing.

Spill-over effects

9.6 We treat MNOs which are part of a larger group as distinct entities at the national level. For example, Vodafone UK is treated as separate from Vodafone Germany or Vodafone Ireland. If financing and strategy are decided internationally, then our analysis may overstate the effect of mergers, as it fails to acknowledge spill-over effects in the control group. This is particularly important for our synthetic control analysis, where a key assumption underpinning the approach is that there are no spillover effects of a merger from the treated unit to the control group. However, we think that this is unlikely to be a

[47] This discussion focuses on the impact on our investment model. We think it unlikely there is any systematic relationship between the presence of network sharing agreements and average download speeds, and so think our estimates of the direct effect of changes in market concentration on quality are unlikely to be affected by network sharing agreements. Our estimates of the overall effect on quality will of course be affected through the indirect impact of changes in concentration on investment, to the extent our estimates of these are affected for the reasons set out above. However, as with the investment equation itself, we consider this is unlikely to be a significant issue.

[48] The extent to which network sharing could mimic the cost efficiencies from consolidation will depend on the type of network sharing agreement. MNOs could agree to solely share their passive assets (such as masts and towers) or could also agree to share their active equipment. The latter form of sharing would more closely mimic the benefits from consolidation.

[49] Any change in network sharing that happens around the time of entry/merger events will be picked up as part of the impact of the entry/merger on investment. As any change happening at the same time is likely to be caused by the entry/merger itself, we consider it is appropriate to capture this effect in our overall estimate. Any changes in arrangements not linked with the entry/merger event will simply appear as noise in our data, so may lead to less precise estimates but will not bias results.

significant issue if a mother company has sufficient access to capital, which we consider is likely to be the case for the countries included in our study.

10. Conclusions

There is no evidence from our study that mobile consolidation has a positive impact on investment and quality based on average download speeds

10.1 The analysis we have conducted finds no evidence that increases in market concentration are associated with increases in investment or average download speeds. This finding comes from considering a range of different models and robustness/sensitivity checks - all of which are consistent with there being no positive effect of an increase in concentration on investment/average download speeds.

10.2 Whilst informative, our results do not imply that the impact of any potential future consolidation from four to three MNOs will never result in better consumer outcomes. There are various dimensions to quality which affect consumer experience in addition to download speeds, and so further analysis will be required to explore whether our results hold true when considering these different quality dimensions. Moreover, our analysis does not include a consideration of prices, which are an important factor in the overall consumer outcome from consolidation. Nonetheless, an important finding from our analysis is that that previous studies in this area do not support the claims some MNOs have made about the benefits of consolidation for investment/quality outcomes. As a result, if MNOs wanted to claim an “efficiency defense” in the context of a future merger, new robust evidence should be provided.

1.2 Clearly empirical analysis of this type is by its very nature a simplification of the commercial decisions facing companies. We also recognise that it considers the historic relationship between consolidation and investment/quality, at a time when we anticipate significant change in both the mobile industry and communications markets more broadly and so past performance may not be the best guide to any future impact. Nonetheless, we consider it useful to contribute to the discussion by setting out our views on the existing empirical work in this area. We hope that, by doing so, we will encourage MNOs and researchers in this field to keep engaging in this debate, to ensure that we find sufficiently robust results to provide clear guidance for policy purposes.

1.3 It is important to emphasise that - in our view - there is no magic number of MNOs to ensure that markets work well. Whilst Ofcom has acted to maintain the existing level of competition in the UK market in previous policy decisions, we nonetheless recognise that the consumer impact of any potential future consolidation would be specific to the transaction itself, and dependent on a range of factors – including market conditions prevalent at the time and in the country of the transaction. As a result, while empirical analyses such as this can be informative to the debate, each potential future consolidation must be considered on its own merits.