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Conference Paper

Assessing the impact of mobile consolidation on innovation and quality: An evaluation of the Hutchison/Orange merger in Austria

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Assessing the impact of mobile consolidation on innovation and quality

An evaluation of the Hutchison/Orange merger in Austria

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Executive summary

This study analyses the impact of the 2012 merger between two mobile operators in Austria – Hutchison 3G Austria and Orange – on 4G network coverage, download speeds and upload speeds. It is the first of its kind to measure the impact of a mobile merger on network quality and innovation outcomes as experienced by the consumer.

The merger between Hutchison and Orange in Austria involved the combination of the two smallest operators in a four-player market, which included rivals A1 Telekom and T-Mobile. In its assessment, the European Commission (EC) argued that Hutchison and Orange were close competitors and Hutchison was regarded as an important competitive constraint. For this reason, the EC concluded that the merger would reduce competition and increase prices, to the detriment of consumers.

At the time of the assessment, Hutchison claimed that the merger would deliver a number of efficiencies, including improved 4G coverage and improved quality of service. These did not pass the burden of proof, in particular with regards to merger-specificity and benefits to consumers. Eventually the merger was approved after Hutchison agreed to implement a set of remedies.

We find that the merger had a significant positive impact for Austrian consumers. Hutchison was able to accelerate population coverage of its 4G network by 20–30 percentage points as a result of the merger, with this taking effect after two years. Hutchison's 4G network quality also increased significantly, with 4G download and upload speeds increasing by 7 Mbps and 3Mbps respectively two years after the merger.

We also find positive effects on the quality of mobile networks in the Austrian market as a whole, with 4G download and upload speeds increasing by more than 13 Mbps and 4 Mbps in 2013 and 2014 respectively after the merger, and 3G download speeds increasing by 1.5 Mbps after 2014.

While this study and its findings are specific to Austria, the results show that a 4-to-3 mobile merger intensified competition in quality-related aspects and that a three-player market delivered more widely available and faster 4G services than those experienced in four-player markets. It also shows that a merger between the two smallest operators in Austria allowed them to significantly outperform other operators in Europe with a similar position in the market.

The report therefore makes an important contribution to building the evidence on which competition authorities and regulators can base their decisions when considering dynamic efficiencies and the relationship between market structure and market performance in mobile markets. In particular, the findings from this study have two key policy implications:

- First, merger efficiencies and the impact they have on consumers can be measured with the right framework and data. Competition authorities can leverage this study and newly available data to develop analytical approaches that systemically assess the likely impact of a merger on network quality and innovation (as is currently done for price), test merger-specific effects, as well as model quality and innovation impacts in antitrust cases.
- Second, Efficiency effects can be significant but can take time to directly benefit consumers. For competition authorities to take into account all relevant effects, merger control tools need to consider effects beyond the short-term.

1. Introduction

This report assesses the impact of a merger in the mobile sector on direct measures of consumer welfare other than prices – in particular, the network quality and network coverage levels experienced by consumers. Using data from GSMA Intelligence and Ookla, this original work evaluates the impact of the merger between Hutchison and Orange in 2012 in Austria. We use two well-established policy evaluation methods, recently used by RTR (2016) and DG Competition (2015), while innovatively applying them to direct measures of network quality and coverage.

Our results indicate that the Hutchison/Orange merger led to improvements in network quality and coverage in the Austrian market. Two years after the merger, Hutchison's 4G population coverage was 20–30 percentage points higher than it would have been if the merger had not taken place. The merger also significantly increased Hutchison's 4G download and upload speeds by approximately 7 Mbps and 3 Mbps respectively. Moreover, merger effects spilled over to rivals A1 Telekom and T-Mobile, with statistically significant improvements in 3G and 4G network quality.

These are significant findings as the impact of consolidation on mobile markets continues to be a matter of debate, in Europe and beyond. While a number of countries in Europe have experienced a reduction in the number of network operators from four to three players (Austria in 2012, Ireland and Germany in 2014), in other countries merger proposals have been blocked by competition authorities (e.g. the UK in 2016) or in the case of Italy approved on the condition that the market retains four players.¹

As a matter of law and practice, competition authorities should generally try to assess the impact of mergers on overall consumer welfare, encompassing factors such as price, quality and innovation. However, some recent assessments of proposed mobile mergers have primarily relied on (often short-term) price effects as the main source of evidence for the impact on consumers – for instance, with the use of calculations such as upwards pricing pressure tests. Meanwhile, efficiency considerations on how the merger can affect quality and innovation outcomes have received less weight and have often not been considered in the initial review, with authorities requiring a high burden of proof.

Recent survey evidence shows that while prices are important to consumers, other features of mobile services such as network coverage and the quality of service are equally important. For instance, in 2016 77% of Austrian mobile consumers said that network coverage was either 'the most important' or 'a very important' factor when switching operator, compared to 75% for cost and 63% for reliable data connection speeds.² At the same time, governments have set ambitious goals with regards to mobile internet performance and coverage. This will require continued levels of investment and network innovation, for example to roll out 5G technology.

A mobile merger can affect quality and innovation in different ways. On the one hand, competition authorities are concerned that the increased concentration may drive a potential loss of competition that could reduce the incentives to invest. On the other hand, existing market structures in some markets may hinder operators' incentive and ability to invest and achieve greater efficiencies. Going forward, this may make it difficult for operators to meet expectations around technology upgrades, universal coverage and quality of services. In this

¹ See cases M.6497 for Austria in 2012, M.6992 for Ireland in 2014, M.7018 for Germany in 2014, M.7612 for UK in 2016, M.7758 for Italy in 2016.

² Source: GSMA Intelligence Consumer Survey

context, merging parties often argue that consolidation gives them stronger investment incentives – due to greater financial strength and substantial scale efficiencies – that may result in a better experience for consumers of mobile services.

Recent research has attempted to understand how a change in market structure affects quality and innovation from the investment angle. At this stage, the available evidence indicates that more market concentration has either a positive or neutral effect on investment – so far, no study has found a negative effect. However, no research has assessed the impact of market concentration or consolidation on the direct outcomes for consumers. This report focuses on this important aspect.

2. Mobile mergers, quality and innovation

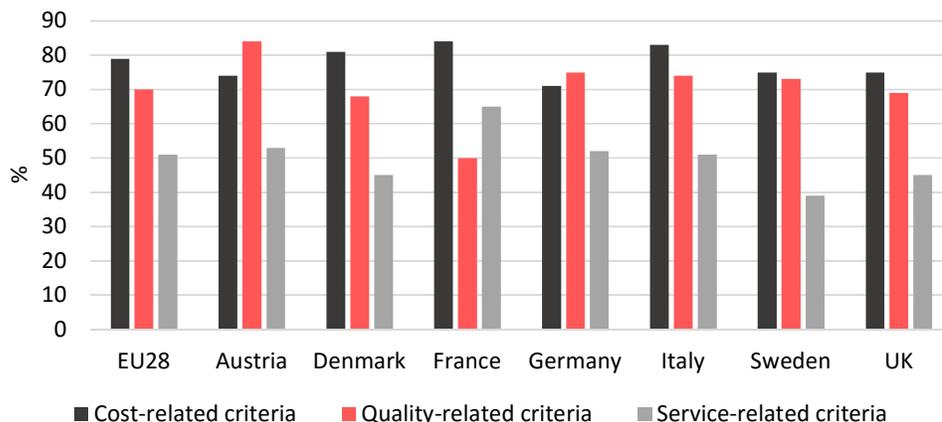
2.1 Quality, innovation and consumer welfare

Competition authorities are required to assess mergers by looking at the likely effects of the merger on consumers. These include a range of characteristics that are important to consumers, such as price, quality and innovation.

While the guidelines that authorities follow when assessing mergers acknowledge the importance of all these outcomes³, significant emphasis is put on (often short-term) prices. Many mobile mergers have heavily focused on tests of short-term price effects (e.g. upward pricing pressure calculations), which can easily trigger competition concerns in investment-intensive industries. Meanwhile, dynamic benefits and their possible effects on the quality of mobile services have often faced a strong burden of proof.⁴

This focus on short-term price effects can be a particular concern for mobile markets, where consumers may attach more importance to quality and variety than price, particularly where mobile operators offer differentiated products and services. Figure 1 summarises survey evidence for the EU28 and a selection of countries on the importance to consumers of cost, quality and service related criteria when accessing the internet. It shows that quality-related criteria are almost as important as cost-related criteria, and in some countries (for example Austria and Germany) even more so.

Figure 1: Key factors for consumers when accessing the internet



Source: E-Communications and the Digital Single Market (May 2016)

Consumers were asked "When subscribing to an internet connection, what are the main factors you consider? Firstly? And then? (Maximum 4 answers)". Numbers represent the percentage of respondents that mentioned criteria related to cost, quality and service.

The above is also consistent with survey evidence collected by GSMA Intelligence in 2016 – in Austria, 77% of mobile consumers said that network coverage was either 'the most important' or 'a very important' factor when switching operator, compared to 75% for cost and 63% for reliable data connection speeds.⁵ Consumer research carried out by Ofcom in the UK also regularly finds that consumer satisfaction with a mobile service is dependent on mobile coverage, quality of service, reliability and customer service.⁶ Going forward, these non-price

³ See EC's Horizontal Merger Guidelines

⁴ Nitsche & Wiethaus (2016)

⁵ Source: GSMA Intelligence Consumer Survey

⁶ Source: Ofcom Consumer Experience reports

factors are likely to be increasingly valued by consumers. A consultation by DG Economy and Society showed that mobile connectivity features such as download and upload speeds, latencies and reliability will significantly increase in importance by 2025.⁷

When markets are characterised by frequent cycles of technology change, the relationship between innovation and consumer welfare needs to be carefully considered. The nature of competition and technology change in mobile markets means that new mobile services are introduced regularly, as shown in Table 1: SMS and MMS in the 1G-to-2G transition; advanced internet browsing in the 2G-to-3G transition; and video streaming and conferencing in the 3G-to-4G case. Such transitions improve the quality of existing services (e.g. speeds increase and latencies fall in each cycle). Innovation also introduces cost savings in the provision of existing mobile services, allowing consumers to benefit from lower unit prices.

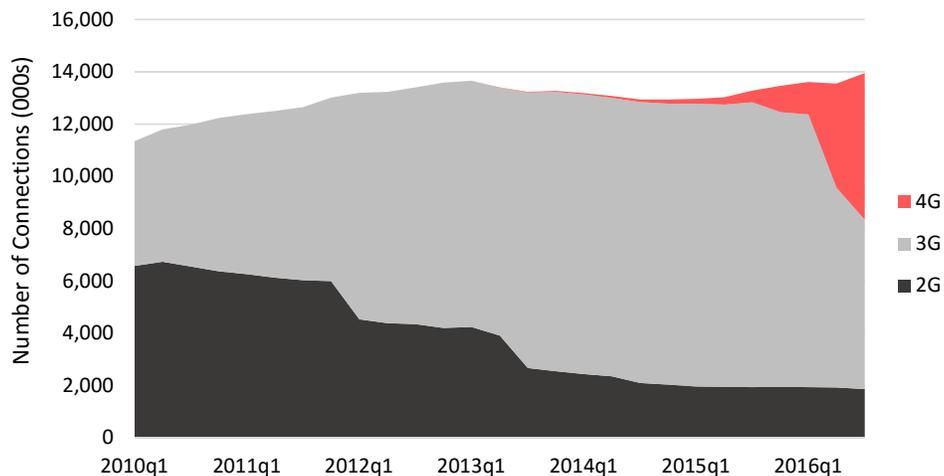
Table 1: Characteristics of mobile technology cycles

	1G	2G	3G	4G
Cycle length	1980–1990	1990–2006	2006–2011	2009–Present
Supports	Voice	Voice and data	Voice and data	Voice and data
Applications	Voice calls	Voice calls, SMS, MMS, browsing (limited)	High-speed browsing, applications	Video conferencing, mobile TV
Band type	Narrow band	Narrow band	Wide band	Ultra-wide band
Speed	2.4–14.4 kbps	14.4 kbps	3.1 Mbps	100 Mbps

Source: GSMA Intelligence

Figure 2 shows the transition across network technologies from the demand side, looking at the number of connections by technology.

Figure 2: Number of connections by technology in Austria



Source: RTR

⁷ Source: DG Economy and Society (2016), “Synopsis report of public consultation on the needs for Internet speed and quality beyond 2020”.

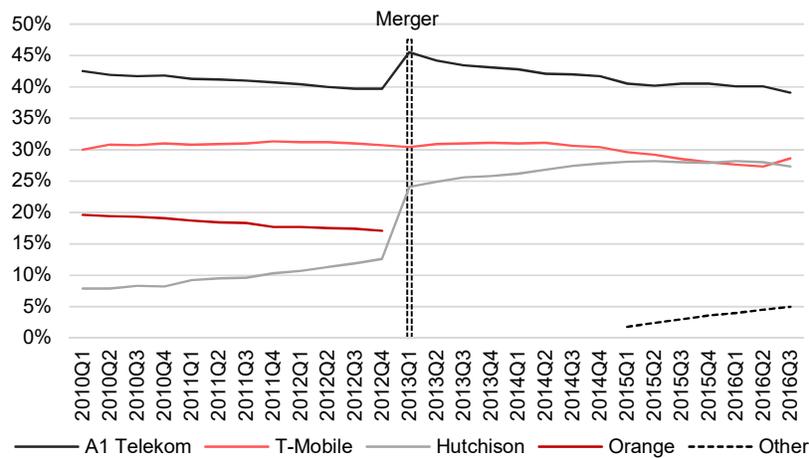
2.2 The Hutchison/Orange merger

The merger between Hutchison and Orange in Austria involved the combination of the two smallest operators in a four-player market, which included rivals A1 Telekom and T-Mobile. In its assessment, the European Commission argued that Hutchison and Orange were close competitors and Hutchison was regarded as an important competitive constraint. For this reason, the EC concluded that the merger would reduce competition and increase prices, to the detriment of consumers.

While Hutchison claimed that the merger would deliver a number of efficiencies, these did not pass the burden of proof, and eventually the merger was approved on the basis of three remedies. First, spectrum would be divested and additional rights would be provided to a potential new mobile network operator (MNO). Second, Hutchison would host up to 16 MVNOs, which would have access to up to 30% of its capacity on pay-as-you-go terms. Third, Hutchison committed not to complete the acquisition of Orange before it entered into a wholesale access agreement with one mobile virtual network operator (MVNO).

The first commitment did not become effective as no new operator entered the market following the merger. The MVNO commitment became effective following an agreement with UPC, which entered the market in December 2014. Hutchison subsequently signed three more MVNO agreements in 2015 and 2016.

Figure 3: Evolution of retail market shares in Austria⁸



Source: RTR

The merged operator initially remained the smallest operator but it has recently reached a similar market share to T-Mobile. At the same time as the merger, A1 Telekom acquired Orange's Yesss brand, increasing its market share. A1 Telekom remains the biggest operator but the market shares are more symmetric than before the merger.

⁸ The 'Other' category includes MVNOs.

2.3 The potential effect of the Austrian merger on quality and innovation

The potential effect of the merger on Hutchison

Anticipating the effect of consolidation on merged operators' quality and innovation is complex. In the case of the Hutchison/Orange merger, a number of effects were, in theory, possible.

The merger could have weakened the incentives to innovate and invest. This could happen because after the merger the remaining operators face one less competitor in the market, so there could be less of a need to improve the performance of their networks and to innovate to win and retain customers.⁹

At the same time, however, there were a number of mechanisms by which the Hutchison/Orange merger could have improved network quality and network innovation in the Austrian market. Specifically, the merger could have strengthened the ability and incentives to invest and the efficiency of investment. These all represent mechanisms by which a merger could drive dynamic efficiencies – i.e. the introduction of innovations which drive increased choice and performance and lower prices for mobile services.

First, the Hutchison/Orange merger could have affected quality and innovation outcomes by increasing profitability in the market, which should improve the *ability to invest* across all operators. Post-merger, the merged operator could have been financially well equipped to cover the costs (often sunk) and deal with the uncertainties around rolling out coverage, network upgrades or innovation more generally.¹⁰ Post-merger, Hutchison would have also enjoyed scale economies¹¹, increasing its capability to improve coverage and network quality. Additionally, bigger operators can enjoy stronger investment ability via other benefits associated with operator size – for instance, greater bargaining power in infrastructure purchases or ease of finding partnerships in related industries (e.g. mobile money, smart cars).¹²

Second, the merger could have increased the expected returns on investment, which would in turn improve the incentives to invest. After the merger, operators in the market would have been better equipped to recover the investments in their network.¹³

The merger could have also affected network quality and innovation through efficiencies. Operators often stress that the aggregation of complementary assets (particularly spectrum and sites) generates two types of efficiencies.

- Since bigger entities are able to combine spectrum and sites more efficiently,¹⁴ a merger can result in higher network quality that directly benefits consumers – i.e., a demand-side efficiency.¹⁵
- Supply-side efficiencies may arise because the combination of networks may allow a merged operator to supply mobile services at lower costs. For instance, having more

⁹ As formalised in Arrow (1962), a less competitive market structure decreases investment incentives because it involves replacing existing profits.

¹⁰ The grounds of this view were formalised in the economics literature by Schumpeter (1942)

¹¹ For example, it would have a larger customer base over which to spread fixed and common costs.

¹² WIK (2015)

¹³ Nitsche & Wiethaus (2016) noted that short-term margins provide solid investment incentives, particularly in investment-intensive industries such as telecoms.

¹⁴ As pointed out in WIK (2015): "LTE requires a minimum amount of contiguous spectrum and connection speeds can be further increased with larger blocks of spectrum. Larger operators may also be able to realise a more efficient mix of spectrum in low frequency bands (for coverage) and spectrum in high frequency bands (for capacity)".

¹⁵ See Evans & Padilla (2003)

spectrum allows operators to build capacity with fewer sites, therefore incurring lower network costs.¹⁶ Additional supply-side efficiencies may arise due to denser distribution networks and lower selling, general and administrative expenses per subscriber. These cost savings are likely to provide higher margins, in turn driving stronger ability and incentive to invest.

In the Hutchison/Orange merger, the parties argued that the merger would provide the incentives to continue the growth strategy of the merged entity and that it would increase the number of sites by approximately 50%. Hutchison argued that its customers would benefit from better mobile services via four efficiencies.

1. By combining Hutchison's and Orange's networks, the merger would increase capacity, which would allow for faster and higher quality services and would alleviate congestion in the network.
2. The combination of network assets would also allow Hutchison to roll out LTE nationwide within a short time period.
3. The coverage of the combined network would be superior to the current coverage of Hutchison's and Orange's networks.
4. The merger would reduce Hutchison's scale disadvantages, which would facilitate upcoming investments and generate cost savings that would be used to develop new services and to price more competitively.

While the EC acknowledged the possible existence of these efficiencies, they did not pass the test of verifiability (with the exception of scale advantages). The EC also said that the benefits brought by the combination of networks were not merger-specific as they could be achieved by other means, such as network sharing, though the merging parties argued this was not feasible due to incompatible network and business strategies. Lastly, the EC also argued that the efficiencies could not be verifiably translated into benefits to consumers, either in the form of improved network quality and/or lower prices.¹⁷

The potential effect of the merger on Hutchison's competitors

The Hutchison/Orange merger could have also affected the network quality of its rivals A1 Telekom and T-Mobile. On the one hand, the competitors of the merged operator may also experience lower competition intensity, so their incentives to innovate and invest may be reduced. On the other hand, competitors may expect higher expected returns on their investment and, therefore, have a stronger ability to invest, which in turn is likely to result in greater coverage and higher quality for their networks.

Separately, competitors may also strategically react to the merged operators' outcomes of coverage and network quality – or to expectations around these – just as they react to pricing. If the merged operator improves its network performance and coverage (for instance, due to network efficiencies), then rival operators would have the incentive to respond accordingly to maintain their competitive position.¹⁸ Therefore, the merger could also lead to increased competition intensity.

The dynamics of these strategic responses can be complex because changes in network quality and coverage can take time to plan and execute – unlike prices, which can be changed quickly and regularly. This particularly applies to the merged entity, which has to undergo a

¹⁶ See https://www.ofcom.org.uk/data/assets/pdf_file/0021/58314/2nd_condoc_annex_6.pdf

¹⁷ See Section 7 of Case No COMP/M.6497 – Hutchison 3G Austria/Orange Austria.

¹⁸ Investments that change quality and innovation are strategic complements in oligopolistic markets with differentiated products such as mobile markets, as shown in Athey & Schmutzler (2001).

process of network and business consolidation following the merger.¹⁹ The competitors of the merged entity may be able to achieve network quality and coverage improvements more quickly, either in direct response to the merged entity increasing quality or in the expectation that it will do so.

The evidence around market structure, quality and innovation

A number of studies have examined the relationship between market structure, innovation and investment – as measured by operators’ capital expenditure (capex). At this stage, no study has found increasing market concentration to drive lower investment per operator or lower total country investment.

A first set of studies has found that investment always increases with market concentration, suggesting that the Hutchison/Orange merger would have had a positive effect on Austrian consumers via more investment. CERRE (2015) found that, on average, a 10% increase in HHI drives a boost of 24% in merged operators’ capex. It has also been found that markets with four players have 14% lower investment per operator when compared to markets with three players – and that, more generally, an increase in the number of operators tends to decrease investment (Jeanjean & Hougbonon, 2016-b). DG Competition (2017) finds that investment per operator increased as a result of the 5-to-4 merger in the United Kingdom in 2010, although no statistically significant effect is found when analyzing investment per subscriber.

Table 2: Recent research examining market structure versus investment

Research paper	Measure of investment	Effect of an increase in HHI on investment per operator	Effect of an increase in HHI on total country investment	Scope
WIK (2015)	Capex, Capex/subs	No significant effect	No significant effect	50 MNOs, 12 markets, (2005–2013)
Frontier (2015)	Capex/subs	No significant effect	Not addressed	60+ MNOs, EU markets (2005–2013)
CERRE (2015)	Capex	Investment increases	No significant effect	33 markets (2006–2014)
Hougbonon & Jeanjean (2016-b)	Capex	Investment increases	Not addressed	100 MNOs (2005–2013)
DG Competition (2017)	Capex, Capex/subs	Total investment increases, but investment per subscriber is not affected	Not addressed	24 MNOs, 13 markets (2007-2014)
Hougbonon & Jeanjean (2016-a)	Capex	Inverted-U: investment maximised at 37–40% of margin	Not addressed	110 MNOs (2005–2012)
HSBC (2015)	Capex	Inverted-U: investment maximised at 38–44% of margin	Not addressed	66 markets (2003–2013)

Source: GSMA Intelligence

¹⁹ In this context, assessing the consequences of a merger over a short-term horizon may not lead to the best outcome in the interest of consumers.

A second set of studies (Houngbonon & Jeanjean, 2016-a; HSBC, 2015) suggests that greater market concentration increases capex per operator only when operators' profit margins are below 37–44% – with operators in most four-player markets being below this threshold, including Austrian operators before the merger. These studies suggest that the introduction of competition initially has a positive effect on investment and that, as mobile markets become less concentrated, it has a negative effect. In other words, there is an inverted-U relationship between market concentration and investment.

Other studies have found that investments do not depend on market structure (WIK, 2015; Frontier, 2015), suggesting that a mobile merger would have a neutral effect on outcomes such as network quality and coverage.²⁰

This recent wave of research represents a positive step and a first attempt to look at the effect of changes in market structure on innovation and quality. However, while the results are informative, operator investment may not be a perfect measure for network quality and innovation because it does not represent the final outcome that consumers benefit from. More specifically:

- Investment as a measure of network quality and coverage does not comprehensively capture all the mechanisms by which a merger may affect network quality and coverage. In particular, it does not take into account the efficiencies that mergers may drive, potentially leading to increased quality and innovation with similar (or lower) investment.
- Even if investment was a good measure of quality and innovation in a given market, the use of capex has a number of flaws when it comes to making comparisons across countries. The cyclical patterns of capex make it difficult to compare time series across countries and these measurements are often based on differing methodologies.²¹

This report sets out to address specifically these issues.

²⁰ Though WIK (2015) found that market structures that provide higher profit margins and larger firm scale (both enhanced by market consolidation) positively drive total country's capex.

²¹ For instance, reported capex figures often do not distinguish between investment in fixed and mobile networks and this introduces differences between convergent operators and mobile-only operators.

3. Our approach

In order to assess how the 4-to-3 merger of Hutchison and Orange in the Austrian market affected innovation and quality in mobile services, we firstly develop indicators that measure both network quality and coverage, and secondly apply quantitative techniques so that we can establish with confidence what the impact of the merger was, if any.

3.1 Measuring innovation and quality

Network innovation

Measuring innovation is challenging because it is a broad concept encompassing processes that drive cost reductions and the introduction of new products and services. In this work, we consider the impact on innovation by looking at 4G coverage, which was the most recent technology being rolled out during the period 2011–2016 (at the time of the Hutchison-Orange merger).

Our coverage data is sourced from GSMA Intelligence²², which has complete data on 4G coverage by population at the country and operator level.²³ The data is sourced directly from operators and regulators whenever they report 4G coverage metrics (e.g. in financial statements, investor presentations and regulatory filings). As the metric is generally reported based on coverage by population rather than by area, we use the former.

One limitation with this data is that operators and regulators do not always report 4G coverage in every quarter, meaning that for certain time periods the data has to be estimated.²⁴ In order to sense-check these estimates, the 4G coverage data was shared with operators in Austria. Where data was found to be inaccurate, it was updated based on feedback from operators.

Network quality

Capturing the quality of mobile services is complex. A number of parameters are regularly used to establish the quality of voice, SMS and data services, including the following:

- download speeds²⁵ (higher speeds allow consumers to download content more quickly and use data-intensive applications and content, such as video)
- upload speeds²⁶ (higher speeds enable consumers to share more content and experience better performance of services such as online gaming)
- latency²⁷ (relevant for services that require short delays such as video calls, VoIP or online gaming)
- signal strength²⁸ (which affects the overall quality of voice, SMS and data)

²² <https://gsmaintelligence.com/>

²³ There are two main ways in which 4G coverage can be measured. One is to look at the proportion of the population in a country that is in an area where 4G networks are available (network coverage by population, based on the location of households and residences). Another is to look at the proportion of a country's geography where 4G networks are available (network coverage by geographic area).

²⁴ For further details on the estimation process, see <https://www.gsmaintelligence.com/help/11/>

²⁵ Download speed is the rate of data transmission to a user's device. It is usually measured in Megabits per second (Mbps) or kilobits per second (kbps).

²⁶ Upload speed is the rate of data transmission from a user's device.

²⁷ Latencies measure the delay that happens in data communication over mobile networks (e.g., the total time it takes a data packet to travel from one node to another).

²⁸ Signal strength is the power level of mobile signals – received at a particular location – from a mobile network operator. It is usually measured in decibels.

- call reliability (i.e. dropped or blocked calls²⁹).

In this work we focus on the download and upload speeds of 4G and 3G networks.³⁰

We use data provided by Ookla's Speedtest³¹, a crowd-sourcing platform that allows mobile users to initiate a 'speed test' to measure network performance at any given time. Each time a user runs a test, they receive a measurement for download speeds and upload speeds. The test also records the consumer's location, the network operator and the technology being used at the time of the test.³² In 2016, Ookla had 427 million unique users across Speedtest applications. Using these test results, Ookla calculates the average (mean) network performance metric across all users in each quarter at both the country and operator level. This data is then disaggregated by network technology.

Bauer et al (2010) explain the complexities involved in accurately measuring broadband speeds and the importance of identifying the source of the bottlenecks, particularly as slow speeds can be caused by factors outside the network operator's control. In mobile networks, network performance is affected by many factors including the quality of the handset, the structure of the consumer's tariff plan (speeds are sometimes throttled), time of day, location, being indoors/outdoors, and weather.³³ If the number of tests in a given time period is small, then they are likely to be skewed by one or more of these factors. This makes it difficult to compare performance across countries and operators.

To avoid these biases, the network performance averages we use are based on large samples, which should average out test characteristics. The observations underlying performance averages are also subject to a sampling procedure carried out by Ookla for Speedtest Intelligence.³⁴ Table A2.3 (Annex 2) shows that the average number of tests for each country is greater than 100,000 in most quarters (the number of 4G tests is more limited in the early period due to low take-up and limited network rollout). Table A2.4 (Annex 2) presents the same statistics at the operator level. This shows that the average number of tests is greater than 10,000 in most quarters and that every operator has data based on at least 100 tests in a given quarter.

As we work with crowd-sourced data, it is arguable to what extent these sampled measures represent unbiased measures of 'average' consumer experience, due to possible self-selection – e.g. users of network performance applications may be more technologically sophisticated, or they may tend to run tests when their signal is poor. However, so long as there are no systemic biases across countries (i.e. if most users in all countries are similarly advanced in their use of technology) 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).

Overall, we consider that the network performance metrics provided from Speedtest Intelligence are reliable for both countries and operators, and appropriate for the sort of methodologies used in this study, which rely on time series comparisons. We note that many

²⁹ Blocked calls happen when the user is in an area of coverage but cannot make a call; this can be because of heavy demand on the mobile network. Dropped calls occur when a call is connected but then terminates unexpectedly; this can happen when a user moves into an area with poor or no mobile signal.

³⁰ We also analysed latencies but the assumptions required under our methodological framework did not hold. We were therefore unable to interpret the results or infer any findings from them.

³¹ <http://www.speedtest.net/mobile/>

³² Further details can be found in the Ookla's Methodology document. Available at <http://www.ookla.com/methodology/pdf>

³³ OECD (2014)

³⁴ See <http://www.ookla.com/methodology/pdf>

mobile operators use Speedtest Intelligence data when advertising their network quality and benchmarking themselves against their competitors, providing reassurance around the quality of the data. Bauer et al (2010) also found that Ookla’s Speedtest approach was the best data source for assessing the speed of broadband access services at the time of writing.³⁵

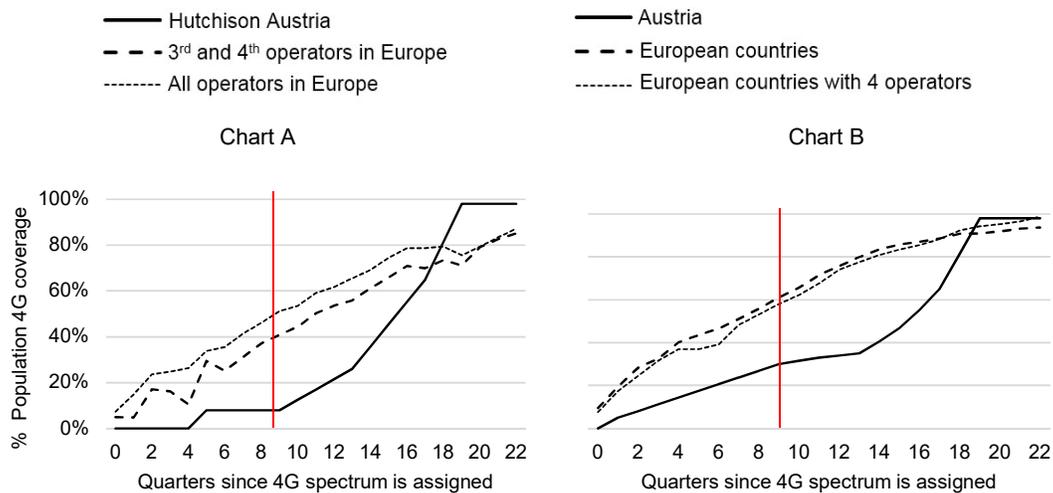
3.2 Pre and post-merger trends in innovation and quality

After the merger, Hutchison’s 4G coverage improved rapidly, leading to the merged operator overtaking its rivals A1 Telekom and T-Mobile on 4G coverage. Hutchison achieved full coverage faster than most European operators in markets that experienced no consolidation in the same period. Chart A in Figure 4 shows that Hutchison reached near universal coverage almost 5 years after 4G spectrum was assigned, while the average of other European operators was at approximately 80% at this time. Austria’s overall coverage also improved after the merger (Chart B), with the 800 MHz spectrum auction taking place in October 2013.

Looking at 4G networks (Chart C), Hutchison’s download speeds perform above the average of European operators following the merger. Austria’s overall 4G download speeds were performing close to the European averages before the merger, while after the merger this improves substantially – though this trend started before Hutchison and Orange merged (Chart D). Charts E and F suggest a similar trend in 3G network quality – i.e. after the merger, Hutchison and Austria overall appear to improve more rapidly relative to other markets.

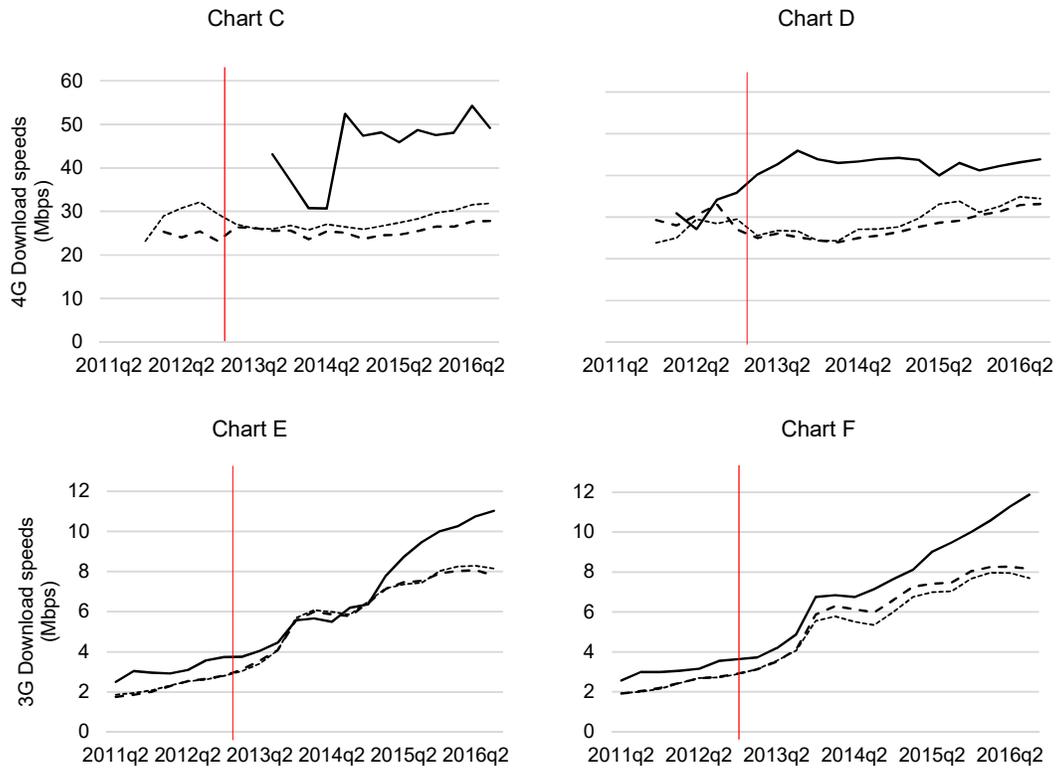
These observations however do not by themselves allow us to conclude on the impact of the merger.

Figure 4: Pre and post-merger trends in 4G coverage and network quality³⁶



³⁵ Further data sources of network quality have been developed since that paper was written but all of them are relatively recent (meaning they have insufficient data for assessing the impact of the merger in Austria).

³⁶ The average of European markets includes countries that have experienced no market structure changes (no entry, exit or mergers) in 2011–2016. The countries are: Belgium, Croatia, Czech Republic, Denmark, Greece, Hungary, Italy, Latvia, Malta, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland and the UK.

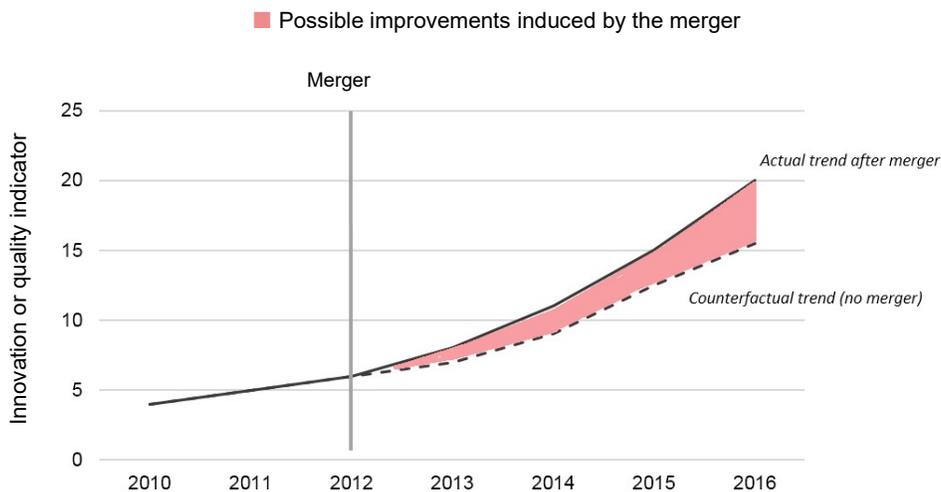


Source: Speedtest Intelligence from Ookla, GSMA Intelligence. Vertical red lines indicate the time of the merger.

3.3 Methodology

In order to determine the effect of the Austrian merger on network quality and coverage, we develop an alternative scenario that captures the likely evolution of these metrics for Hutchison and Austria had the merger not taken place. Once that alternative scenario (also known as the counterfactual) is developed, the impact of the merger can be assessed by comparing the quality and coverage levels that resulted after the merger with the quality and coverage levels in the counterfactual scenario. This is illustrated in Figure 5.

Figure 5: Illustration of counterfactual analysis



Since the counterfactual scenario cannot be observed, we simulate this with two methods that are often used in policy and programme evaluation. These approaches estimate the counterfactual for the network quality and coverage observed in a group of operators or countries that have not experienced a merger – a control group (essentially, a comparator). The approach we take is similar to DG Competition (2015), RTR (2016) and DG Competition (2017), which used the same methods to assess the effects of mobile mergers on prices.

The first method is known as a Difference-In-Difference (DD) approach³⁷. In a DD framework, the impact of the merger on quality and 4G coverage is established by comparing the observed changes in Hutchison or in Austria after the merger in 4G coverage or network quality with the changes in the control group. This comparison is carried out with econometric techniques that take into account differences in factors that may be relevant in explaining different network quality and coverage between Hutchison or Austria and the control group (see Figure 6).

The second method – the synthetic control – is a statistical, data-driven procedure to generate an artificial (“synthetic”) comparator for Hutchison or Austria³⁸. The synthetic comparator is a weighted combination of other operators or countries, with weights chosen to ensure that the relevant outcome (i.e. 4G coverage or network quality) of the comparator match Hutchison or Austria as closely as possible. The approach requires a set of variables that determine the evolution of the relevant outcome. The variables used are similar to the ones used in the first method to explain differences in network quality and coverage. This procedure is combined with cross-validation techniques to assess the statistical significance of results (see Annex 1 for a more detailed explanation).

Estimating the counterfactual

Constructing a counterfactual involves gathering data from a suitable control group of countries where there was no merger or significant change in market structure during the period of analysis (2011–2016) which therefore can be used to assess the likely trends that would have occurred in Austria in the absence of a merger. Our main control group consists of 17 European countries that did not experience entry or exit in the mobile market in 2011–2016, excluding countries that underwent a change in market structure during the period. The countries in the control group are Belgium, Croatia, Czech Republic, Denmark, Greece, Hungary, Italy, Latvia, Malta, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland and the UK.

Building an unbiased counterfactual also involves being able to isolate from the control group of countries those factors that could influence the outcomes of interest (i.e. network coverage and quality) and that are likely to be different across operators and countries, including Austria. Our simulations of the counterfactual scenario predict network quality and coverage as a function of demand and supply factors, including the change in market structure induced by the merger. We account for the fact that operators and countries may be different in a number of supply and demand factors that are relevant for network quality and coverage.

Supply factors include the differences in network quality and coverage arising from the fact that rollout costs vary across countries, depending on aspects such as the distribution of population or its geography. Other supply factors include the spectrum governments give access to, the frequencies used and the time that operators have been able to use it. Quality and coverage indicators of new technologies such as 4G are also likely to be driven by the

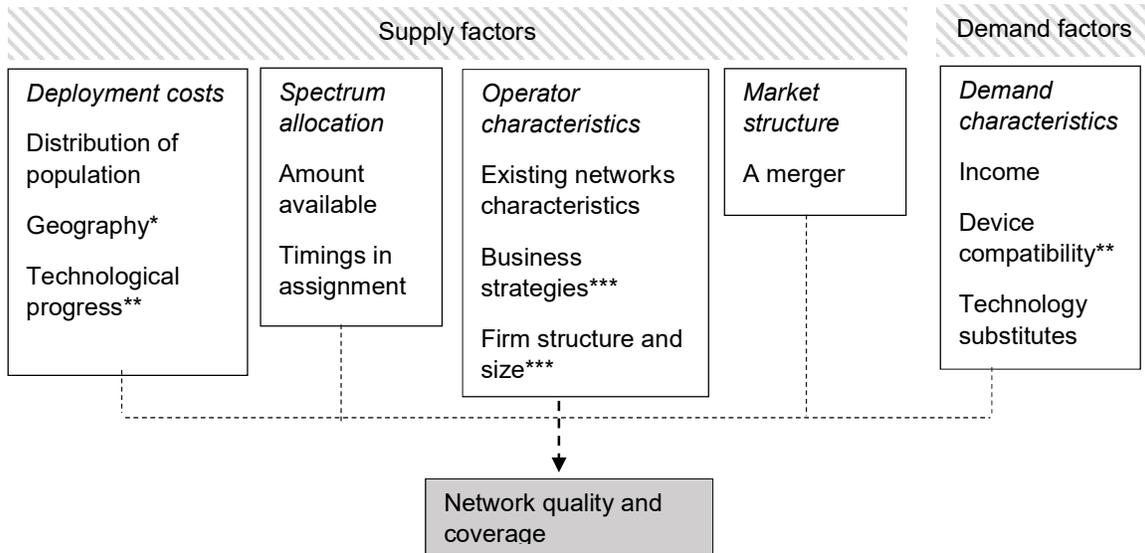
³⁷ We follow the approach defined in Angrist & Pischke (2008)

³⁸ This is based on Abadie & Gardeazabal (2003).

savings arising from the deployment of previous technologies (i.e. 3G), operators' business strategy and firm structure, etc.

Coverage and network quality also depend on demand factors. We take into account that markets vary in terms of consumers' willingness to pay, the access to mobile devices compatible with new networks or the availability of well-functioning technologies (such as advanced 3G) which could influence the demand of consumers for newer networks (i.e. technology substitutes).

Figure 6: Inputs used to simulate network quality and coverage in the counterfactual



*Only in DD models, via country fixed effects; **only in DD models, via time fixed effects; ***only in DD models, via operator fixed effects (see the econometric detail in Annex 1).

Source: GSMA Intelligence

Besides the above, in this work we have also considered accounting for other factors, including spectrum by frequency bands, network congestion, network sharing and MVNOs. These factors have not been included in the final results. See Annex A.1.2 for a full discussion of these.

The timings of merger effects

Due to competitive dynamics between operators and the fact that decisions around network quality and coverage take time to materialise, a general challenge in measuring the effects of the merger is around timings.

Operators can change network quality and coverage levels either via additional investments or due to efficiencies from combining networks. In the latter situation, the efficiencies from sharing networks involve merging infrastructures – a process that can be complex. For example, in the case of Hutchison and Orange, the consolidation of the two networks started around one year after the merger due to preparation and planning work and the selection of a network vendor. Network consolidation was finally completed in the first half of 2015. With regards to additional investments, the timings can vary; some new investments require significant planning and implementation time (for example changes to network architecture or increasing the number of sites), while others can be implemented more quickly (e.g. upgrading software and network equipment at existing cell sites and network nodes).

In order to account for these complexities, our models estimate separate merger effects by year after the merger.

Robustness checks

For the results to be regarded as robust, they must hold to three kinds of check, which are further detailed in Annex 1.

- We change the control group of operators and countries used to assess the performance of Hutchison and Austria. We do this to verify that the control group is a valid, unbiased benchmark.
- Estimations are carried out accounting for operator-specific traits such as business strategy or firm structure, which may be relevant in explaining why operators have differences in coverage or network quality.
- Models of coverage are estimated allowing for the inputs introduced in Figure 6 to have a non-linear effect (e.g., consistent with the 'S-curves' typical to coverage).

4. Results

In this section we report the main findings of the analysis with regards to the impact of the Hutchison/Orange merger on the coverage and network quality of the merged operator and the Austrian market as a whole.

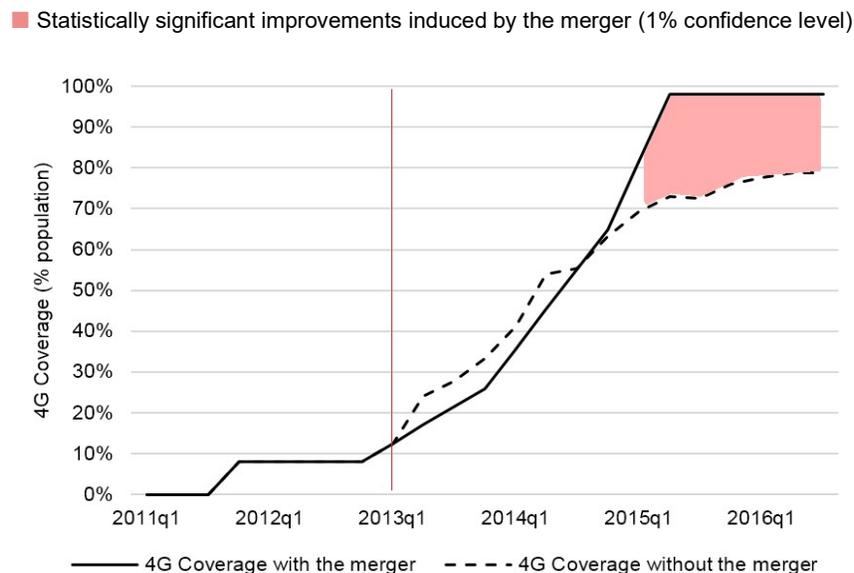
We apply both DD and synthetic control methods to 4G coverage and 3G network quality. In the case of 4G network quality since there is no pre-merger data for Hutchison the synthetic control method cannot be applied, and the DD approach is implemented using a different framework³⁹. In this section we present the estimation results of the base models. The details of the estimation process, as well as the robustness checks on the merger effects, are available in Annexes 1–3.

4.1 4G coverage

Merger effect for Hutchison

Our models show that the merger was a key factor in explaining why the rollout of Hutchison's 4G network accelerated after the merger. According to our results, the merger increased Hutchison's 4G coverage by more than 20 percentage points, as compared to the scenario without the merger. As Figure 7 shows, the effect starts to materialise from mid-2014 and fully materialises two years after the merger. These results suggest that the coverage gains that could have been driven by additional investments or by network efficiencies took time to be realised, likely due to complexities around infrastructure management and the processes of business consolidation.

Figure 7: The effect of the merger on Hutchison's 4G coverage



The section of the chart before 2015 represents differences that are not statistically significant at the 1% confidence level.

The trend of 4G coverage without the merger is based on the prediction of the Base DD model as specified in Model 7 of Table 3.

Source: GSMA Intelligence

³⁹ See Annex A.3.2.1

Table 3 presents the estimates of the base DD model of 4G coverage. No statistically significant effect is observed in either the first or the second year after the merger, but all the simulations carried out give positive and statistically significant effects two years after the merger that vary between 20 and 30 percentage points depending on the set of controls included.

The results also indicate that spectrum holdings and the timings of spectrum assignments are important drivers of 4G coverage levels. An increase in 4G spectrum holdings of 1 MHz for an operator increases its 4G coverage by 0.1 percentage points (i.e. the allocation of an additional block of 20 MHz increases coverage by 2 percentage points). Similarly, the early release of spectrum also results in sizeable benefits for consumers. For example, all things being equal, an operator that has been able to use 4G spectrum for 4–6 years will have coverage around 16 percentage points higher than another operator that has had 4G spectrum for less than one year.

Operators' 4G coverage also seems to be significantly influenced by 3G networks, as shown in Model 7 of Table 3. Operators with high 3G coverage also have higher 4G coverage – a 1 percentage point increase in 3G coverage is associated with a 0.44 percentage point increase in 4G coverage. This is expected, as having a large network infrastructure in place allows operators to achieve cost and time savings when deploying newer networks (e.g. no need to apply for planning permissions to build a new cell/tower site). However, higher 3G network quality seems to slow down 4G coverage.⁴⁰ This could be because if an operator has made significant investments in upgrading their 3G networks, they may wait some time before rolling out a large 4G network, partly to earn a return on their 3G investment and also because their customers may be less willing – or have less need – to upgrade to 4G.

Table 3: 4G coverage base DD model – merger effect for Hutchison

	(1) 4G cov.	(2) 4G cov.	(3) 4G cov.	(4) 4G cov.	(5) 4G cov.	(6) 4G cov.	(7) 4G cov.
Effect in 1 st year	-0.032	-0.0199	-0.0503	-0.053	-0.067	-0.069	-0.082
Effect in 2 nd year	0.048	0.0274	0.0357	0.026	0.012	0.016	-0.033
Effect after 2 years	0.277***	0.258***	0.241***	0.220***	0.208***	0.207***	0.214***
4G spectrum holdings		0.001***	0.001***	0.001***	0.001***	0.001**	0.001***
4G spectrum 1–2 years			0.0423	0.0470	0.049	0.060	0.051
4G spectrum 2–4 years			0.0965*	0.101*	0.107*	0.117**	0.102*
4G spectrum 4–6 years			0.157***	0.160***	0.165***	0.176***	0.161**
GDP per capita (log)				-0.480			
Rural population					0.074**		0.0268
Population density (log)						2.259*	2.832***
3G coverage							0.438**
3G download speeds							-0.031***
Observations	948	948	948	948	948	948	923
Adjusted R-squared	0.74	0.75	0.76	0.76	0.76	0.76	0.77

Significance level: *** 1%, ** 5%, * 10%.

⁴⁰ The results in Column 7 of Table 3 suggest that an increase in 3G download speeds of 1 Mbps reduces 4G coverage by 3 percentage points.

Source: GSMA Intelligence

Income (GDP per capita) and share of rural population do not provide consistently statistically significant values. This is likely due to the lack of variation of these variables over time.⁴¹ Population density in a country does however prove to be a statistically significant driver of 4G coverage levels. Overall, the signs of the effects provide reassurance about the results.

The results presented in Table 3 are consistent with several robustness checks and sensitivity tests, and are further confirmed when assessing the impact using our second method – the synthetic control (see Annex 3).

Market-wide merger effects

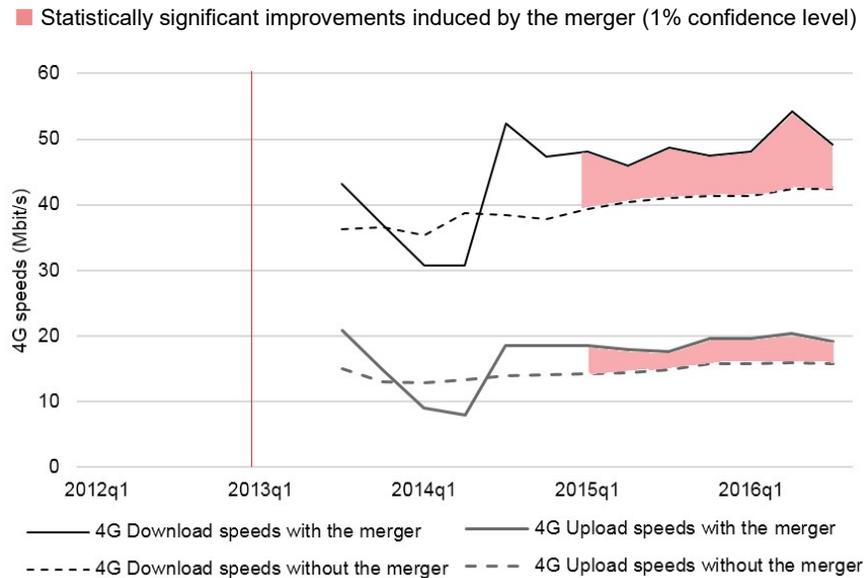
While the merger resulted in a strong and positive effect on the coverage levels of the merged entity, the results of our analysis with regards to the coverage levels of all the Austrian operators, including A1 Telekom and T-Mobile, are inconclusive. The results of the base DD model indicate a negative merger effect in the first year following the merger, though the tests we have carried out indicate that these results do not hold to alternative specifications and robustness checks do not give support to the finding of a negative effect. The second approach – the synthetic control – cannot be fully tested due to lack of data. The complete analysis is presented in Annex 3.

4.2 4G network quality

Merger effect for Hutchison

The results indicate that Hutchison’s 4G network performance as measured by download and upload speeds significantly improved after the merger, as shown in Figure 8. These effects were largely concentrated in the second year after the merger and the years thereafter, which is consistent with the timings of the finding on 4G coverage.

Figure 8: The effect of the merger on Hutchison’s 4G network quality



⁴¹ Models with country fixed effects only take into account how explanatory variables change over time within each country. Income and proportion of rural population do not change much in a country over a period of 6–7 years.

The section of the chart before 2015 represents differences that are not statistically significant at the 1% confidence level.

The trends without the merger are based on predictions of the Base model as specified in Model 1 in Table 4.

Source: GSMA Intelligence

We estimate that two years after the merger, download speeds were around 7 Mbps faster than they would have been otherwise, with this effect starting to materialise in the second year after the merger. The models reported in Table 4 also show that we identified some effects in the first year after the merger, though these did not fully pass the robustness checks.⁴² 4G upload speeds were affected positively as well, with Hutchison's speeds approximately 3 Mbps faster two years after the merger.⁴³

These results are based on the model as reported in Table 4. Due to the lack of pre-merger data on 4G performance for Hutchison Austria it is not possible to fully isolate the impact of the merger. Rather, the results indicate that following the merger (particularly after two years) Hutchison had a better quality 4G network than most other operators in the control group after controlling for other relevant factors.

Table 4: 4G network quality base model – merger effects for Hutchison

	4G download speeds			4G upload speeds		
	(1)	(2)	(3)	(1)	(2)	(3)
Effect in 1 st year	3.686**	3.381*	3.687**	3.792***	3.667***	3.793***
Effect in 2 nd year	2.705***	2.769***	2.727***	-0.0630	-0.0370	-0.0552
Effect after 2 years	7.635***	8.398***	7.673***	3.732***	4.045***	3.745***
4G spectrum holdings	0.034	0.035	0.033	0.004	0.005	0.004
Rural population		-4.632			-1.903	
Population density (log)			-0.177			-0.064
Observations	904	904	904	904	904	904
Adjusted R-squared	0.35	0.36	0.35	0.31	0.32	0.31

Significance level: *** 1%, ** 5%, * 10%. Lead Effect test and Parallel Trends tests cannot be applied due to lack of pre-merger data. We discuss the implications of this in Annex 3.

Source: GSMA Intelligence

Additionally, Table 4 shows that, as expected, spectrum holdings are positively associated with network quality and rural population has a negative effect, though neither of these are statistically significant.

Our findings pass all the standard robustness checks, which generally tend to give higher estimates of the merger effect – particularly when we account for the fact that operators may have different business strategies and firm structures (see Annex 3).

Market-wide merger effects

The analysis across all Austrian operators suggests that the market consolidation induced an improvement in A1 Telekom and T-Mobile's 4G network quality. This took place particularly

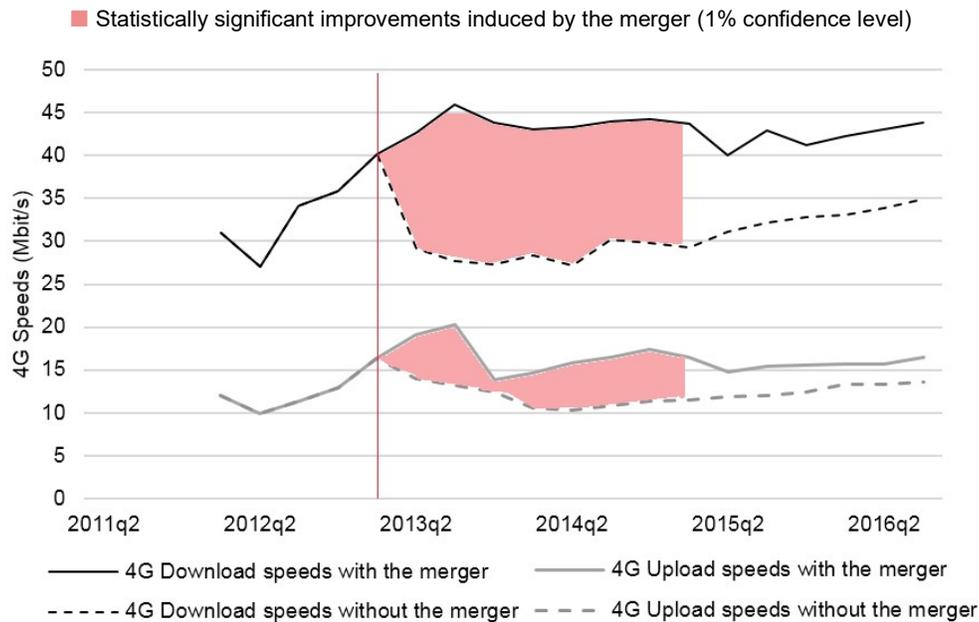
⁴² See section A3 in the Annex

⁴³ The table also suggests there was an effect on 4G upload speeds in the first year of the merger. However, since the effect dissipates in the second year after the merger, we treat it with more caution than the effect after two years.

during the first and second years after the merger⁴⁴, with the size of the impact identified being stronger as compared to what is estimated for the merged entity.

These results suggest that A1 Telekom and T-Mobile invested more in their 4G networks before Hutchison improved its 4G network, with a number of possible drivers being at play – for example the expectation that Hutchison would improve its networks (as our data shows it indeed did), putting pressure on competitors to also increase their network quality to compete effectively. Other factors potentially at play include competitors expecting greater returns on investment, or expecting to be in a stronger financial position after the consolidation of the market.

Figure 9: The effect of the merger on 4G network quality across all Austrian operators⁴⁵



The section of the chart after 2015 represents differences that are not statistically significant at the 1% confidence level.

The trends without the merger are based on predictions of the Base DD model as specified in Model 1 of Table 5. Both trends with and without the merger reflect actual and simulated averages of network quality across Hutchison, A1 Telekom and T-Mobile.

Source: GSMA Intelligence

For download speeds, the effect identified across all Austrian operators was between 13 and 16 Mbps over the first and second year. The effect of the merger on upload speeds followed the same timing, with a magnitude of approximately 4–6 Mbps. While Table 5 shows statistically significant effects two years after the merger, this is not illustrated in Figure 9 as a robust result because it was not validated in the alternative scenarios we simulated (see Annex 3).

⁴⁴ Our estimates indicate a statistically significant *average* effect over the course of the first and second year. This does not necessarily mean there was an improvement in 4G due to the merger immediately after this took place.

⁴⁵ This represents the average merger effect across Hutchison, A1 Telekom and T-Mobile.

Table 5: 4G network quality base DD model – market-wide merger effects

	4G download speeds			4G upload speeds		
	(1)	(2)	(3)	(1)	(2)	(3)
Effect in 1 st year	13.93***	15.88***	14.08***	5.075***	5.853***	5.127***
Effect in 2 nd year	13.09***	15.57***	13.28***	4.171***	5.161***	4.240***
Effect after 2 years	8.322**	11.57***	8.536**	2.587**	3.880***	2.662**
4G spectrum holdings	0.0342	0.0354	0.0336	0.00461	0.005	0.004
Rural population		-4.936			-1.969	
Population density (log)			-0.187			-0.066
Observations	827	827	827	827	827	827
Adjusted R-squared	0.46	0.46	0.46	0.42	0.42	0.42

Significance level: *** 1%, ** 5%, * 10%.

Source: GSMA Intelligence

4.3 3G network quality

Merger effect for Hutchison

Looking at Hutchison’s 3G network quality, our models conclude that the effect of the merger was neutral – the merger neither increased nor decreased network speeds. The merger effects of the base DD models do not hold to the robustness checks we rely on, and the synthetic control approach we have applied produces an artificial operator against which Hutchison cannot be reasonably compared.

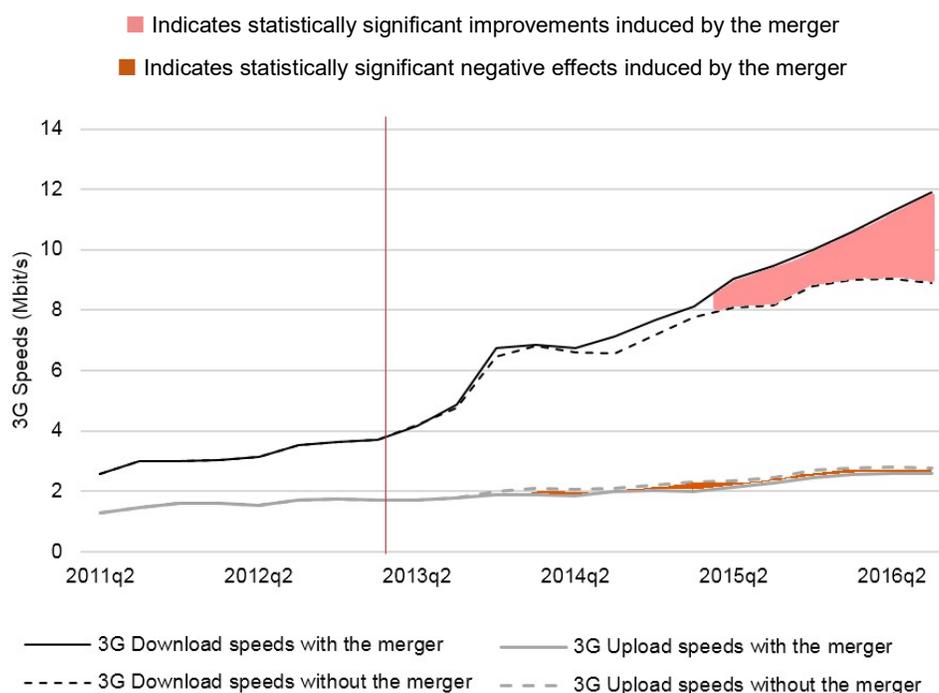
This result suggests that, after the merger, Hutchison focused on differentiating and improving its networks on the latest technology being rolled out – i.e. 4G – and that potential network efficiencies and additional investments did not affect 3G in the period covered by the analysis.

Market-wide merger effects

When we look at how the merger affected all Austrian operators, our estimates indicate that the merger induced an overall improvement in 3G network quality. As shown in Figure 10, download speeds were significantly higher than in the scenario without the merger from two years after the merger. We also identify a negative effect with regards to upload speeds, though its magnitude (both in relative and absolute terms) is more limited compared to the effect on download speeds.

Taking into account the fact that Hutchison’s 3G networks were not, according to our results, affected by the merger, this analysis across all Austrian operators implies that A1 Telekom and T-Mobile improved the performance of their 3G networks. This finding is compatible with the results on 4G networks, where Hutchison’s rivals increased their quality before the merged operator improved its networks. In the case of 3G, the improvement in network quality could be driven by an expectation that Hutchison would be able to improve its services – either due to additional investments and/or network efficiencies.

Figure 10. Effect of the merger on 3G performance across all Austrian operators



The trends without the merger are based on predictions of the Base DD model as specified in Model 2 of Table 6. Both trends with and without the merger reflect actual and simulated averages of network quality across Hutchison, A1 Telekom and T-Mobile.

Source: GSMA Intelligence

As shown in Table 6, our simulations indicate that 3G download speeds were significantly higher in the second year after the merger (0.5 Mbps) and during the period thereafter (1.5 Mbps) as compared to the scenario without the Hutchison/Orange merger. The complete analysis in Annex 3 shows that we can be particularly confident about the effect after two years.

Table 6: 3G network quality base DD model – merger effects across all Austrian operators

	3G download speeds			3G upload speeds		
	(1)	(2)	(3)	(1)	(2)	(3)
Effect in 1 st year	0.144	0.176	0.170	-0.046	-0.058	-0.047
Effect in 2 nd year	0.527*	0.579*	0.559**	-0.189***	-0.209**	-0.189***
Effect after 2 years	1.434***	1.512***	1.465***	-0.228***	-0.258**	-0.229***
3G spectrum holdings	0.023	0.023	0.0234	0.006	0.006	0.006
Rural population		-0.165			0.063	
Population density (log)			0.0887***			-0.001
Observations	1320	1320	1320	1320	1320	1320
Adjusted R-squared	0.807	0.807	0.823	0.683	0.684	0.683

Significance level: *** 1%, ** 5%, * 10%.

Source: GSMA Intelligence

We also found that the merger caused an average decrease of around 0.2 Mbps in 3G upload speeds across all Austrian operators, both in the second year and thereafter – with these impacts being robust to alternative specifications (see Annex 3). The decrease in upload speeds is lower in both absolute and relative terms than the increase in download speeds – the latter increased by almost 20% compared to the counterfactual without a merger, whereas upload speeds decreased by less than 10%.

5. Conclusions

5.1 The effect of the Hutchison/Orange merger

This study analyses the impact of the Hutchison/Orange merger in Austria on network coverage and quality. It is the first of its kind to measure the impact of a mobile merger on network quality and innovation, two important parameters for competition that are increasingly valued by consumers in Europe. We find that overall the merger had a significant positive impact for Austrian consumers in terms of network innovation and quality. In particular, the results support important conclusions on three different aspects of merger assessment in the mobile sector:

- The study shows that Hutchison was able to accelerate the coverage of its 4G network by 20–30%, with this taking effect two years after the merger. Hutchison's 4G network quality also increased rapidly and significantly, with 4G download and upload speeds increasing by 7 Mbps and 3 Mbps respectively after two years. This result is explained by a number of dynamic efficiencies at play. The merger could have driven more investment in Hutchison's 4G infrastructure, because it increased the expected returns in the market and because it improved Hutchison's scale and financial position to invest, which would altogether strengthen investment incentives and ability. At the same time, Hutchison could have also realised efficiencies by aggregating assets and scale economies, as argued by the merging parties in the merger assessment.
- We find positive effects on the quality of mobile networks in the market as a whole, with 4G download and upload speeds increasing by more than 13 Mbps and 4 Mbps respectively in the first two years after the merger and 3G download speeds increasing by 1.5 Mbps thereafter. This suggests that the merger intensified competition across all operators in quality-related aspects. These results are consistent with recent evidence showing how mobile mergers can increase investment,⁴⁶ and provide an important complement to recent studies that have reviewed the impact of mobile mergers on prices.⁴⁷
- The third conclusion concerns how Hutchison and Austria fared when compared with their peers in key European markets on innovation and quality. In Austria, a mobile market with three players after the merger, Hutchison delivered more widely available and faster 4G services than those experienced by consumers of similar operators in Europe. At the same time, Austrian consumers as a whole benefitted from faster 3G and 4G services compared to many other markets, including those with four players.

Overall, our findings show that a 4-to-3 mobile merger intensified competition in quality-related aspects and that a three-player market delivered more widely available and faster 4G services than those experienced in four-player markets. It also shows that a merger between the two smallest operators in Austria allowed them to significantly outperform other operators in Europe with a similar position in the market.

These results are important not only for Austria but also in the context of the broader debate about the impact of mobile mergers on consumer welfare. While the scope of this study is confined to network coverage and quality changes in Austria, it provides robust evidence on

⁴⁶ For example CERRE (2015); Hounghonon & Jeanjean (2016-a); Hounghonon & Jeanjean (2016-b); and HSBC (2015)

⁴⁷ For example RTR (2016); BWB (2016); and DG Competition (2015)

the magnitude and nature of dynamic efficiencies and the consequent benefits for consumers that can arise from a mobile merger.

5.2 Implications for competition policy and merger assessment

Our results show that mergers can induce significant dynamic efficiencies and realise direct benefits to consumers in mobile markets. This type of evidence should be considered in the early stages of merger reviews – in practice a substantive assessment of efficiencies only happens in later phases of merger reviews, and the burden of proof required often means efficiencies are in part or fully dismissed.⁴⁸ In particular, if we consider the three criteria used to consider efficiencies as set out in the EU Merger Regulation Guidelines, and the way that they were applied to this case⁴⁹, this analysis has important implications.

First, it shows that efficiencies and the impact they have on consumers can be measured. While this report presents a framework to model efficiencies as an ex-post evaluation, competition authorities should implement similar approaches when carrying their forward-looking analysis to anticipate merger effects. Currently such a forward-looking analysis is already carried out for prices, using tools such as the UPP test. The recent availability of data to measure quality and innovation should make it possible to develop a forward-looking analysis for estimating the impact of mergers on quality and innovation. Beyond merger assessments, these indicators could also allow for better assessments in anti-trust cases.

Second, it shows that efficiencies, and their impact on consumers, are in this case a direct result of the merger, and, hence, can be considered merger-specific. While it is in theory possible to combine two networks without a full merger occurring (i.e. through a network sharing agreement), it should not be considered as a default alternative to a mobile merger, since their ability to deliver efficiencies comparable with a merger depends on a series of factors, including the likelihood of such agreement taking place. In the Hutchison /Orange case, the EC concluded that the relevant comparison for evaluating the effects of the merger was the pre-merger status quo.

Third, the findings of this study show that efficiency effects can be significant, but they can take time to directly benefit consumers. For example, the 4G coverage results show that efficiencies started to materialize two years after the merger. For competition authorities to take into account all the relevant effects, it is important that merger control tools consider effects beyond the short-term.

Fourth, the study shows that a three-player market can outperform a four-player market in terms of innovation and quality of service.

While this study addresses an important evidence gap in the debate about mobile consolidation, it also opens new lines of investigation that will benefit from further research in the future. Since the findings of this analysis are specific to Austria, additional research should focus on the impact of other mobile mergers (e.g. Germany and Ireland) or market structure more generally on quality and coverage. This will contribute to further building evidence on which competition authorities can base their decisions when considering dynamic efficiencies and the relationship between market structure and performance in mobile markets.

Future research should also look to assess the impact of mobile mergers on overall consumer welfare. There have already been studies looking at the impact on prices and investment. This

⁴⁸ This is explained in the Competition Policy Handbook, especially in the chapter on efficiencies Key Concept 3, efficiencies in merger control (and footnote 223).

⁴⁹ See Section 7 of the published final decision by the EC, http://ec.europa.eu/competition/mergers/cases/decisions/m6497_20121212_20600_3210969_EN.pdf

paper has shown that it is possible to look at the impact on innovation and quality. The next wave of research can, therefore, bring all these outcomes together and consider the impact of mobile consolidation addressing all the key parameters that are important to consumers.

References

- Abadie, A. & Gardeazabal, J. (2003). "The Economic Costs of Conflict: A Case Study of the Basque Country", *The American Economic Review*, 93(1). Available at <<https://www.aeaweb.org/articles?id=10.1257/000282803321455188>>
- Angrist, J. & Pischke, J-S. (2008). "Mostly Harmless Econometrics: An Empiricist's Comparison". Princeton: Princeton University Press.
- Athey, S. & Schmutzler, S. (2001). "Investment and market dominance", *RAND Journal of Economics*, 32 (1). Available at <http://econpapers.repec.org/article/rjerandje/v_3a32_3ay_3a2001_3ai_3a1_3ap_3a1-26.htm>
- Bauer, S. et al (2010). "Understanding Broadband Speed Measurements", Massachusetts Institute of Technology. Available at <http://mitas.csail.mit.edu/papers/Bauer_Clark_Lehr_Broadband_Speed_Measurements.pdf>
- BWB (2016). "An Ex-post Evaluation of the Mergers H3G/Orange and TA/Yesss!". Available at <<https://www.en.bwb.gv.at/News/Seiten/BWB-und-RTR-present-reports-on-the-telecom-sector-enquiry.aspx>>
- CERRE (2015). "Evaluating market consolidation in mobile communications". Study prepared for CERRE, authored by Genakos C., Valletti T. & Verboven F. Available at <http://cerre.eu/sites/cerre/files/150915_CERRE_Mobile_Consolidation_Report_Final.pdf>
- 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. Available at <<http://ec.europa.eu/competition/publications/reports/kd0215836enn.pdf>>
- 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. Available at <<http://ec.europa.eu/competition/publications/reports/kd0417233enn.pdf>>
- Evans, D. & Padilla, J. (2003). "Demand-Side Efficiencies in Merger Control". *SSR Electronic Journal*. Available at <<http://dx.doi.org/10.2139/ssrn.390500%20>>
- Frontier (2015). "Assessing the case for in-country mobile consolidation". Study prepared for GSMA. Available at <<http://www.gsma.com/publicpolicy/wp-content/uploads/2015/02/Assessing-the-case-for-in-contry-mobile-consolidation-report.pdf>>
- Houngbonon G.V. & Jeanjean, F. (2016-b). "Optimal market structure in the wireless industry". *Information Economics and Policy*, 38, 12-22. Available at <http://econpapers.repec.org/article/eeeiepoli/v_3a38_3ay_3a2017_3ai_3ac_3ap_3a12-22.htm>
- Houngbonon, G.V. & Jeanjean, F. (2016-a). "What level of competition intensity maximises investment in the wireless industry?", *Telecommunications Policy*, 40(8), 774-790. Available at <<http://dl.acm.org/citation.cfm?id=2983042>>
- HSBC (2015). "Supersonic: European telecoms mergers will boost capex, driving prices lower and speeds higher". Available at <<http://www.orange.com/fr/content/download/33263/1086075/version/2/file/Supersonic+13.04.15.pdf>>

Nitsche, R. & Wiethaus, L. (2016). "Efficiency defence in telecom mergers and other investment intensive industries", *European Competition Law Review*, 7(13).

OECD (2014). "Access network speed tests", *OECD Digital Economy Papers*, No. 237, OECD Publishing. Available at <<http://dx.doi.org/10.1787/5jz2m5mr66f5-en>>

RTR (2016). "Ex-post analysis of the merger between H3G Austria and Orange Austria". Available at <https://www.rtr.at/en/inf/Analysis_merger_H3G_Orange/Ex_post_analysis_merger_H3G_Orange_RTR.pdf>

WIK (2015). "Competition & Investment: An analysis of the drivers of investment and consumer welfare in mobile communications". Study prepared for Ofcom, authored by Elixmann D., et al., Available at <http://stakeholders.ofcom.org.uk/binaries/consultations/dcr_discussion/annexes/Competition_and_investment_mobile.pdf>

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Annex

A1. Methodology

A1.1 General counterfactual considerations

When assessing the effects of the Hutchison/Orange merger in Austria, the EC used the pre-merger status quo as the counterfactual scenario. As expressed by the EC, “the relevant comparison for evaluating the effects of the merger is constituted by the competitive conditions existing at the time of the merger as set out in paragraph 9 of the Horizontal Guidelines, namely that Orange would remain a comparably relevant competitor in the Austrian market for mobile telecommunications services to end customers as it has been to date”⁵⁰.

Being consistent with the above, the counterfactual scenario in this study is based on a market that consists of four separate mobile networks in Austria after 2012 (as was the case before the merger). In its assessment, the EC suggested that a network sharing agreement could achieve some of the efficiencies claimed by Hutchison. However, there is no certainty about whether this would have happened absent of the merger; for example Hutchison argued that a network sharing agreement was not realistic due to different strategies around network design, concerns about losing a competitive edge over a competitor and confidentiality issues. It is beyond the scope of this study to consider a wide range of counterfactual scenarios (of which network sharing is only one).

A1.2 Difference-In-Difference

A1.2.1 Base model

In our Base model (Equation 1 below), we implement the DD approach using an OLS fixed-effects regression. In this basic DD framework the counterfactual evolution of the outcomes for treated units is the post-merger evolution in the control set of operators. This Base model controls for all time invariant factors at the country level and time-specific events. The model is estimated at the operator level, in a multi-period setting, and allows for the identification of dynamic merger effects.

$$(1) y_{i,j,t} = \alpha + \delta D_i + \sum_t \lambda_t T_t + \rho^{Y1}(D_i * T_{i,t}^{Y1}) + \rho^{Y2}(D_i * T_{i,t}^{Y2}) + \rho^{Y3+}(D_i * T_{i,t}^{Y3+}) + \sum_j \gamma_j C_j + \sum_{k=1}^K \mu_k X_{i,j,t,k} + \varepsilon_{i,j,t}$$

where $y_{i,j,t}$ is one of the outcomes for operator i in country j at time t . The outcomes we look at are 4G coverage, download speeds (3G and 4G) and upload speeds (3G and 4G).

The DD has three main variables:

D_i is a treatment dummy, taking value 1 if operator i is in the treatment group. In the merged entity analysis, Hutchison is the only operator being treated, while in the market-wide effects A1 Telekom and T-Mobile are included in the treatment group as well. This variable captures fixed unobserved factors of the treated operator(s) that can be relevant for the outcome (i.e., business strategy, resources, firm structure and management).

⁵⁰ See paragraph 401 of the EC decision on the Hutchison/Orange merger.

T_t are quarterly time dummies⁵¹, which account for time-specific events common to all operators that may impact some of the outcomes. Examples include the launch of handsets that are compatible with 4G spectrum bands, which could drive 4G take-up (and is therefore likely to impact 4G rollout and the measures of quality).

ρ^{Y1} , ρ^{Y2} and ρ^{Y3+} are the merger effects. These result from the inclusion of interaction terms between the treatment dummy D_i and three post-treatment period dummies ($T_{i,t}^{Y1}$, $T_{i,t}^{Y2}$ and $T_{i,t}^{Y3+}$). The latter identify three time periods: first year (2013), second year (2014) and more than two years after the merger (2015 and 2016). This approach to capturing merger effects is consistent with DG Competition (2015) and RTR (2016).

Besides the main variables above, we add a number of controls. C_j are country dummies to account for time invariant characteristics of a country that will affect 4G coverage and network quality (geography, climate, regulation⁵², etc.) We also include a set of controls X with K variables ($\sum_{k=1}^K X_{i,j,t,k}$) likely to shape coverage and network quality, which vary within each country over time.

The *mobile-specific controls* we include are as follows:

$4Gspectrum_{i,j,t}$ and $3Gspectrum_{i,j,t}$ are the amount of 4G or 3G-relevant spectrum held by operator i in country j at time t . We consider 800, 1800⁵³ and 2600 MHz bands to be 4G-dedicated, and 2100 and 900 MHz to be for 3G technologies. Spectrum holdings have been aggregated into '4G' and '3G' bands to increase variability of the data.⁵⁴ The inclusion of spectrum controls for biases that would arise from differences in coverage that are attributed to variation in spectrum holdings in both treated and control operators (i.e. via auctions or trading).

$4Gspectrum_{i,j,t}^{T0 < t < T1}$ are three spectrum dummies that represent the number of quarters that spectrum for 4G networks has been available for operator i in country j at time t . We include three dummies, taking value 1 if time t is 1-2 years, 2-4 years or 4-6 years since the first assignment of 4G spectrum to the operator.⁵⁵ The rationale of their inclusion is that the more time an operator has had spectrum available, the more coverage and network quality it should have rolled out.

⁵¹ Each time period in the data has its own dummy variable. For example in the case of 2012q1, there is a dummy variable that takes the value 1 where the observation is for 2012q1 and 0 otherwise

⁵² The country fixed effect will control for country-specific regulatory frameworks but it will not control for changes in regulation over time. The time fixed effect dummy will control for new regulations that impact all countries in the analysis (for example, those that are made at the European level, such as on roaming). However, with the exception of spectrum assignments, in-country changes in regulation over time are not included in the model. We are not aware of any specific regulatory policy in Austria in this period that could potentially bias our estimate of the merger effects.

⁵³ 1800 MHz spectrum is included after it has been refarmed for 4G or made technology-neutral by the national regulatory authority.

⁵⁴ Given the different properties of the spectrum bands, in particular the fact that 800 MHz is better suited for achieving wide coverage, and spectrum above 1 GHz is better suited to high capacity rates, it would be preferable to have separate spectrum variables by band. However, as our base model is a fixed effects regression, it is driven by variation within each country. Spectrum holdings do not exhibit significant variation at this level – once it is assigned, it does not change unless there is a merger or spectrum is re-auctioned or re-assigned (neither of which is relevant for the vast majority of operators in our dataset). We therefore aggregate spectrum holdings into '4G' and '3G' bands to increase the variability of the data.

⁵⁵ The baseline (or omitted variable) is the first year after 4G spectrum is assigned to the operator. The coefficients can therefore be interpreted as the impact of having spectrum for these three time periods compared to the first year in which it was assigned to operators.

Only for 4G coverage models, we include the following:

coverage3G_{i,j,t} is the 3G coverage of operator *i* in country *j* at time *t*. This is potentially relevant to 4G coverage because an operator with a large 3G network is likely to incur lower 4G rollout costs than another operator with a small 3G network (all else being equal) as they already have some of the key network elements in place (backhaul and core, cell sites etc).

downloadspeeds3G_{i,j,t} is the average download speed of operator *i*'s 3G network in country *j* at time *t*. We include this because if an operator has made significant investments in upgrading its 3G network, it may wait some time before rolling out a large 4G network, partly to earn a return on the 3G investment and also because its customers may be less willing – or have less need – to upgrade to 4G.

Aside from the above, there are five mobile-specific factors that we have not included in our model, which may stand out at first glance.

First, spectrum holdings would ideally be estimated in separate frequency bands since they have different propagation and capacity properties that may have a bearing on the resulting coverage and network performance. While this approach should improve the precision of estimates, separating spectrum holdings substantially decreases variability in the dataset. We carried out a sensitivity check based on such an approach which showed that the overall results of the analysis in regards to the merger effects remain unchanged. However, the lack of variability across and within operators means that the estimated parameters for spectrum variables with separate frequency bands do not appear to be strong predictors of 4G coverage or network performance.

Second, in the case of network performance models, there could be differences in quality across operators driven by network congestion effects. This could be controlled by including the number of connections in a 3G or 4G network (more users on a network will mean higher network congestion). However, we do not include these in our main results as it might introduce endogeneity problems.⁵⁶ As a sensitivity check, we have run the models including the connections variables and our findings for network quality do not change.

Third, due to lack of data, we are not able to account for network sharing agreements, which we would expect to positively affect 4G coverage and network performance. In the period of study there were no network sharing agreements between operators in the Austrian market. However, some operators from other countries in the control group did share networks. Since some control operators and markets have this enhancing factor that we do not account for, the merger effect is likely to be underestimated via this mechanism.

Lastly, we do not model the MVNO remedy associated with the Hutchison/Orange merger because its impact on quality and innovation is unlikely to be material. MVNOs entered late in our period of study⁵⁷ and with a limited impact in terms of market share⁵⁸ – their impact on competition was likely to be limited in the period of our analysis. Furthermore, MVNOs are unlikely to directly exert competition in terms of network quality and coverage, since they rely on the infrastructure of the host MNO. In fact, the impact of MVNOs might be negative on host

⁵⁶ There may be simultaneity between connections and network quality in that, while connections may drive network quality through network congestion, an increase in connections on a given technology may also be due to better network quality.

⁵⁷ The first MVNO agreement Hutchison finalised based on the reference offer was with UPC in December 2014. Another was signed in May 2015 and two more in May 2016.

⁵⁸ See Figure 3 in main report

MNO investment, since they can create investment hold-up problems (Foros et al., 2002; Dwenter & Haucap, 2006).⁵⁹ Consequently, the absence of the MVNO remedy in our simulations is likely to underestimate the merger effects on Hutchison.

We also add a number of *non-mobile-specific factors* that could affect the outcomes of interest, though we note that these do not exhibit as much variation within countries during our time period:

$\log(\text{popdense}_{j,t})$ is the population density in country j at time t . More densely populated countries should have lower costs of 4G rollout, meaning that any given network investment should more easily increase coverage. For the same reason, we would expect higher population density to impact network quality in the same direction.

$\text{ruralpop}_{j,t}$ is the proportion of population in country j at time t that live in rural areas. Over time, a fall in the proportion of population living in rural areas should mean that investment becomes more efficient in achieving coverage and network quality. Consequently, rural population should have a negative effect on both outcomes.

$\log(\text{GDPcapita}_{j,t})$ is the GDP per capita in country j at time t . This is used as a proxy for income, which could capture willingness to take up 4G services (which may drive rollout, i.e. as a demand factor).

A1.2.2 Trend model

After including the set of observed controls presented above, the unbiasedness of the merger effect estimate in the Base model relies on Austria and the group of control countries being subject to the same unobservable effects. The latter is not testable but it is likely to hold if the treatment and control group have similar pre-merger trends. Besides graphically inspecting these, we assess the Parallel Trends assumption statistically with two approaches. It is important to assess this assumption statistically because graphical inspection does not take into account the fact that the Base model has a set of factors that controls for some of the key determinants of 4G coverage and network quality.

We apply a formal test of the Parallel Trends assumption based on the approach proposed in Angrist & Pischke (2008), which in turn is based on the Granger causality test and which was also implemented in DG Competition (2015). The test substitutes the merger dummy in Equation 1 with one dummy variable per quarter for the treated operator (Hutchison). If the pre-merger slope of these linear dummies is statistically different from zero, then this suggests that the Parallel Trends assumption does not hold between the treatment and control.⁶⁰

Additionally, we estimate the Base model with a 'lead' dummy. The 'lead' dummy takes value 1 in the four quarters prior to the merger if the operator is Hutchison or, where we test for market-wide effects, if the operator is Austrian. If the coefficient of the 'lead' is insignificant, this gives us reassurance that the post-merger dummies are likely capturing merger effects and are not being confounded by other unobservable factors. For each model where we report results, 'lead' dummies are included in separate regressions (with outputs table reporting the result of the test – i.e. a 'Pass' or 'Fail' at the 5% level of confidence).

⁵⁹ MNOs' investment efforts may not be fully internalised, especially when access prices do not accurately reflect these. In this context, host MNOs may lose the incentives to differentiate in terms of network quality and coverage, since their efforts also spill downstream (Foros et al., 2002; Dwenter & Haucap, 2006).

⁶⁰ Similar tests to the Parallel Trends assumptions have been applied in related literature about market structure in the mobile market, such as Hounghonon (2015) and HSBC (2015).

Where the Parallel Trends assumption is not passed (i.e. 4G coverage and network quality is affected by unobserved factors that we cannot fully control for), we modify the DD framework suggested in Equation 1 and introduce a different linear trend for the treatment country. This is presented in Equation 2 below.⁶¹

$$(2) y_{i,j,t} = \alpha + \delta D_i + \sum_t \lambda_t T_t + \sum_{t>TM} \rho_{it} (D_i * T_t^{t>TM}) + \sum_j \theta_j (C_j * T) + \sum_j \gamma_j C_j + \sum_{k=1}^K \mu_k X_{i,j,t,k} + \varepsilon_{i,j,t}$$

In this equation θ_j represents a country-specific linear trend coefficient. The trend is constructed by interacting the country fixed effect dummy with the time variable T . For control units, this means that the coefficient θ_j picks up a linear trend based on the entire period. For the treated units, the coefficient θ_{ct} is a country-specific linear trend based on pre-merger outcomes only. This is because we introduce an interaction between the treatment dummy D_i and multiple time dummies $T_t^{t>TM}$ for each of the post-treatment periods.

The identification of merger effects in Equation 2 relies on the assumption that without the merger, the outcome (be it 4G coverage or network quality) would have followed the same trend that existed before the merger (after controlling for the other explanatory variables). As explained in Angrist & Pischke (2008) “DD estimation with state-specific trends is likely to be more robust and convincing when the pre-treatment data establish a clear trend that can be extrapolated into the post-treatment period”.

In the case of 4G coverage, the linear trend assumption may not be reasonable as the rollout of new technologies often follows a logistical function or ‘S-curve’. As discussed below, we also run two non-linear models as sensitivity tests. Furthermore, we do not rely solely on a trend model to make a robust finding.

A1.2.3 Robustness checks

Robustness checks of merger effects on Hutchison

We implement a set of robustness checks detailed below. For results to be regarded as robust, merger effects have to be significant in the majority of relevant checks (i.e. those where the underlying assumption of the model is validated – for the Base DD model, we look at specifications where there are common trends).

Robustness checks are carried out on models where the underlying assumptions hold (i.e. in the case of Base DD, pre-merger parallel trends). We also take into account the specification that incorporates explanatory variables that turn out significant.

a. Restrictions to the control group

In order to avoid biased estimates, our full sample only includes European countries that experienced no significant entry, exit or merger in the period of the study. The countries in the control group are Belgium, Croatia, Czech Republic, Denmark, Greece, Hungary, Italy, Latvia, Malta, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland and the UK.⁶² However, this may not be enough to avoid having

⁶¹ This approach was proposed in Angrist (2008) and implemented in DG Competition (2015)

⁶² We exclude markets with significant market structure changes (e.g. Germany and Ireland) because this would violate the assumption behind the Base model – i.e. we would not be able to say that the trends in the control group reflect the outcomes that would have occurred in Austria (as they will be affected by changes to market structure).

biased estimates. In order to further control for unobserved factors, we implement our models on three additional sub-samples:

- i. Markets with four players, which may provide a more direct comparison between a market that went from four to three operators with those that have four players only. These are Denmark, Italy, Latvia, Poland, Romania, Spain, Sweden and the UK.
- ii. Third and fourth operators in the sample, as given by their market shares for connections. These may represent better comparators for Hutchison and will determine whether there is a merger effect relative to other smaller operators (though at the expense of reducing data and variation).
- iii. Close markets to Austria, in terms of an index we construct based on Mahalanobis distance.⁶³ This index summarises closeness in terms of GDP per capita, subscribers, population density, rural population and country elevation. Based on these calculations, the closest countries to Austria just before the merger were Romania, Italy, Poland, Denmark, Czech Republic, Sweden, Portugal and Spain.

b. MNO fixed effects

As an additional sensitivity check, we estimate the Base and Trend models with MNO fixed effects. We do so because there may be unobservable factors that need to be controlled with regards to operators within each country. For instance, it may be the case that operators differ in business strategies, resources, firm structure, size and management. These factors may have some effect on the degree of innovation and/or quality of each operator.

c. Non-linear functional forms (4G coverage only)

There are two outstanding issues in the OLS framework behind the Base and Trend models when modelling 4G coverage. First, OLS assumes a linear relationship between the variables, but this may not be correct in variables that follow diffusion or S-type curves such as 4G coverage.⁶⁴ OLS estimates may particularly fail in predicting the bottom and top 'tails'. Secondly, coverage values are bounded between 0 and 1 (as the dependent variable is a proportion of total population), but standard OLS results can give predictions outside this range.

To address the issue of the linearity in OLS, the Base and Trend models described previously are only applied to the period of actual 4G rollout by each operator. This means that repeated observations of 0% or 100% were dropped. Additionally, we carry out two non-linear models as robustness checks: a log-linear model, where the dependent variable is expressed in logarithms; and fractional regression⁶⁵, which performs a logistic transformation of the dependent variable (keeping all predictions within the 0–1 range and assuming a non-linear relationship).

⁶³ Mahalanobis distance is calculated as $D^2 = (x-m)^T C^{-1}(x-m)$ where D^2 is Mahalanobis distance, x is a vector of data (e.g. GDP per capita, population density etc), m is a vector of mean values of independent variables, C^{-1} is the inverse covariance matrix of independent variables and T indicates that the vector should be transposed.

⁶⁴ It is important to note however that due to the inclusion of time fixed effects and controls for the amount of time that spectrum has been assigned to the operator, the OLS model does *not* assume a linear trend in 4G coverage over time.

⁶⁵ Implemented in Stata using the command 'fracreg'.

d. Normalised time (4G coverage only)

To address the issue around S-curves discussed above, we also estimate 4G coverage models by synchronising the timelines of operators in the sample. We do so by setting time 0 as the year and quarter where the operator had spectrum that could be used for the rollout of 4G. Once this transformation of the time variable has been implemented, we estimate models with both OLS and the non-linear models presented above.

Robustness checks of market-wide effects

In addition to the checks above, in the analysis for market-wide effects (i.e. where all Austrian operators are considered as treated) we also run the models with a country-level dataset (i.e., the units are countries rather than operators) where Austria itself is considered as a treated unit.

Standard errors and inference

In order to account for the existence of heteroskedasticity and serial correlation in our models, we use a cluster-robust estimator with clustering at the country level. We also carried out sensitivity checks using clustering at the operator level and found all the results still held.

A1.3 Synthetic control

A1.3.1 Framework

In order to provide reassurance that the results from Base and Trend models are valid we also apply the synthetic control method. The synthetic control approach constructs a counterfactual for Hutchison by assigning weights to each operator in the control group, based on how they resemble the treated unit on a set of predictors. It has some advantages with respect to the Base and Trend DD models:

- i. It is robust to having a limited pool of control units with characteristics that do not fully match. In other words, the synthetic control can work when there is no control unit that individually resembles the treated unit – i.e. when the Parallel Trends assumption is not accomplished.
- ii. Whereas the DD method assumes that unobserved effects affecting the outcome are constant in time (controlled for using the fixed effect), the synthetic control allows the effects of confounding unobserved characteristics to vary with time (Abadie, 2010).
- iii. By giving different unequal weights to control observations, the synthetic control can better deal with biases arising from comparisons based on average observed characteristics and their statistical distribution. This is in contrast with the DD approach, where all units have equal weights in a standard OLS framework.

The synthetic control requires three sets of inputs: a vector of ‘predictor’ variables used to estimate the outcome of interest; a matrix of ‘predictor weights’ to reflect the importance of each predictor with respect to the outcome; and a vector of ‘operator weights’ to reflect the importance given to each control group operator (or country) in the synthetic Hutchison (or Austria). This basic framework is complemented with cross-validation procedures geared at the selection of the set of predictors and at the application of placebo tests to assert the robustness of results (Abadie, Diamond & Hainmueller, 2003 and 2010).

We follow the original framework of Abadie & Gardeazabal (2003) where operator and predictor weights are assigned to minimise prediction errors of the outcome in the pre-

intervention period.⁶⁶ This is because if the synthetic control closely matches the development of the outcome in the treated country before the intervention, then post-treatment it may follow a trend similar to what would have happened in the treated country had there not been an intervention.

In this study, the variables used as predictors are chosen based on which group provides the lowest RMSPE for the outcome in the pre-intervention period. To provide further reassurance, we also look at the Difference-In-Difference results (i.e. the variables that consistently appear to be relevant). We test the following as potential predictor variables for 4G coverage and network quality in our approach to the synthetic control:

- average of outcome (4G coverage or network quality measures) in the pre-merger period
- value of the outcome at the start of the period
- value of the outcome just before the merger (2012q4)
- time that 800 MHz, 1800 MHz and 2600 MHz had been available just before the merger
- average 3G/4G spectrum holdings before the merger
- average population in the pre-merger period
- average rural population in the pre-merger period
- 3G coverage just before the merger (where the outcome is 4G coverage)
- average proportion of 3G and 4G connections in the pre-merger period (where outcomes are network quality).

Having derived weights for predictors and operators, the outcome for the synthetic control can be estimated – the trend in the post-merger period represents the counterfactual of what would have happened to the outcome in the treated country absent the merger.

A1.3.2 Robustness checks

Statistical significance

To assess the statistical significance of the merger effect⁶⁷, we implement the “placebo approach” proposed by Abadie et al. (2010 and 2015). This applies the synthetic control method to every country in the control group (as if they experienced a merger at the same time as Austria). We then compute the post-merger RMSPE to the pre-merger RMSPE⁶⁸ ratio for each country. A higher ratio indicates a larger merger effect; if it is higher in Austria than other countries, then it is likely that the impact was driven by the merger and not by random effects. The rank of the treated country can be translated into the probability of finding a RMSPE ratio which is not below the RMSPE ratio observed in the treated country (the smaller

⁶⁶ More recently, Abadie et al. (2015) applied a different approach by dividing the pre-intervention period into a ‘training period’ and a ‘validation period’. Predictor weights are computed based on the former and chosen to minimise prediction errors in the latter. This approach is well-suited if the pre-intervention period sample is large, allowing it to be divided into two groups. However, our study does not have sufficient data for this. We also note Klossner et al. (2016) found that the cross-validation approach used in Abadie et al. (2015) did not have a unique solution to defining predictor weights, resulting in ambiguity in the results. They instead recommended the standard synthetic control method.

⁶⁷ Large sample inferential techniques (of the kind used in regression analysis) are not well suited to comparative case studies when the number of units in the comparison group is small. See Abadie et al. (2010).

⁶⁸ This is the magnitude of the gap in the outcome variable between each country and its synthetic control. It is calculated as the root of the average squared difference between outcomes in the treated country and the synthetic control.

the probability of finding a RMSPE ratio which is larger than the RSMPE ratio of the treated country, the more likely that there was an effect of the merger).

However, given the relatively small number of observations in the control group, we follow the approach in DG Competition (2015) whereby if the RSMPE ratio is higher than the placebos, then the effect of the merger is assumed to be significant.

The pool of placebo studies we use for statistical inference is restricted to the synthetic operators or countries where the pre-merger MSPE is less than five times that of Hutchison or Austria. This is consistent with the approach taken in Abadie et al. (2010).

A2. Data

Our complete panel dataset covers 63 operators and 18 European countries: Austria, Belgium, Croatia, Czech Republic, Denmark, Greece, Hungary, Italy, Latvia, Malta, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland and the UK (see Annex A1). Some of the robustness checks we carry out include restrictions to this sample (markets with four players⁶⁹, close markets⁷⁰ and third and fourth operators before the merger).

The datasets for the 4G coverage analysis run from 2009q4 to 2016q3, while in the case of quality the time series covers 2011q2 to 2016q3. Both the DD and Synthetic control are implemented using the same panel datasets.

A2.1. Data sources

Table A2.1: Additional data

Model notation	Variable name	Description	Source	Scope
$4Gspectrum_{i,j,t}$	4G spectrum	Amount of spectrum holdings in 800, 1800 and 2600 MHz bands.	GSMA Intelligence	Quarterly (2010–2016)
$4Gspectrum_{i,j,t}^{T0 < t < T1}$	4G spectrum X-Y Years	Dummy variable indicating whether 4G spectrum has been available between X and Y years.	GSMA Intelligence	Quarterly (2010–2016)
$connections4G_{i,j,t}$	4G connections	Number of connections based on 4G technologies	GSMA Intelligence	Quarterly (2010–2016)
$conn_pen4G_{i,j,t}$	4G connections penetration	Share of connections based on 4G technologies among all types of connections	GSMA Intelligence	Quarterly (2010–2016)
$3Gspectrum_{i,j,t}$	3G spectrum	Amount of spectrum holdings in 900 and 2100 MHz bands.	GSMA Intelligence	Quarterly (2010–2016)
$connections3G_{i,j,t}$	3G connections	Number of connections based on 3G technologies	GSMA Intelligence	Quarterly (2010–2016)
$conn_pen3G_{i,j,t}$	3G connections penetration	Share of connections based on 3G technologies among all types of connections	GSMA Intelligence	Quarterly (2010–2016)
$coverage3G_{i,j,t}$	3G coverage	3G coverage (based on proportion of population covered)	GSMA Intelligence	Quarterly (2010–2016)
$GDPcapita_{j,t}$	GDP per capita	GDP per capita in 2010 euros	Eurostat	Quarterly (2010–2016)
$ruralpop_{j,t}$	Rural population	Percentage of population living in rural areas	World Bank and UN	Quarterly ⁷¹ (2010–2016)
$popdense_{j,t}$	Population density	Population per square km of land	World Bank and UN	Quarterly ⁷² (2010–2016)

Source: GSMA Intelligence

⁶⁹ Four-player markets include Denmark, Italy, Latvia, Poland, Romania, Spain, Sweden and the UK.

⁷⁰ The closest countries are Romania, Italy, Poland, Denmark, Czech Republic, Sweden, Portugal and Spain.

⁷¹ The original data is annual. We have used linear interpolation to obtain quarterly estimates.

⁷² The original data is annual. We have used linear interpolation to obtain quarterly estimates.

A2.2 List of operators included in study

Table A2.2: Operators and countries included in the sample

<u>Country</u>	<u>Operator</u>	<u>Country</u>	<u>Operator</u>
Austria	A1 Telekom	Malta	Go
Austria	Hutchison	Malta	Melita Mobile
Austria	Orange	Malta	Vodafone
Austria	T-Mobile	Poland	Orange
Belgium	BASE (Telenet)	Poland	Play
Belgium	Mobistar (Orange)	Poland	Plus
Belgium	Proximus	Poland	T-Mobile
Croatia	Hrvatski Telekom	Portugal	MEO
Croatia	Tele2	Portugal	NOS
Croatia	Vipnet	Portugal	Vodafone
Czech Republic	O2	Romania	DigiMobil
Czech Republic	T-Mobile	Romania	Orange
Czech Republic	Vodafone	Romania	Telekom Romania
Denmark	Hutchison	Romania	Vodafone
Denmark	TDC	Slovenia	Si.Mobil
Denmark	Telenor	Slovenia	T-2
Denmark	Telia	Slovenia	Telekom Slovenije
Greece	Cosmote	Slovenia	Telemach Mobil
Greece	Vodafone	Spain	Movistar
Greece	WIND	Spain	Vodafone
Hungary	Magyar Telekom	Spain	Yoigo
Hungary	Telenor	Sweden	Hutchison
Hungary	Vodafone	Sweden	Tele2
Italy	Hutchison	Sweden	Telenor
Italy	TIM	Sweden	Telia
Italy	Vodafone	Switzerland	Salt
Italy	WIND	Switzerland	Sunrise
Latvia	Bite	Switzerland	Swisscom
Latvia	LMT	United Kingdom	EE
Latvia	Tele2	United Kingdom	Hutchison
Latvia	Triatel	United Kingdom	O2
		United Kingdom	Vodafone

Source: GSMA Intelligence

A2.3. Network quality test statistics

Table A2.3: Number of speed tests at the country level

Time	All tests			3G			4G		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2011q2	41,263	497	215,340	36,709	473	193,600	-	-	-
2012q2	99,290	3,647	497,764	89,525	3,533	469,980	1,904	173	8,925
2013q2	129,983	1,301	620,765	99,428	1,195	523,651	19,928	107	91,636
2014q2	209,030	2,237	1,417,000	107,276	1,289	622,394	94,617	879	768,363
2015q2	356,293	4,490	1,835,329	169,044	2,786	1,018,824	183,426	1,627	929,013
2016q2	413,055	5,296	2,500,959	149,987	2,044	1,065,400	260,050	3,215	1,422,100

Source: Ookla

Table A2.4: Number of speed tests at the operator level

Time	All tests			3G			4G		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2011q2	12,379	155	75,945	11,013	140	67,526	-	-	-
2012q2	29,787	1,417	231,697	26,857	493	231,696	1,178	111	7,439
2013q2	38,995	549	256,662	30,333	215	256,623	8,458	107	85,625
2014q2	63,456	596	600,196	32,621	571	285,783	32,518	147	314,412
2015q2	106,856	1,506	651,135	50,704	1,154	353,819	55,937	324	321,309
2016q2	123,887	2,415	760,765	44,990	911	324,523	77,992	1,488	505,416

Source: Ookla

A3. Results

A3.1 4G coverage

A.3.1.1 Merger effects on Hutchison

a. Difference-In-Difference (DD) approach

The Base DD model in Table A3.1 approximates the merger effect by building a counterfactual for Hutchison based on the post-merger trend of control operators.

Differences between treated and control operators seem to be to a certain extent captured by statistically significant country and time fixed effects, population density, and 3G network factors, with signs as expected in Annex A1. The significance of spectrum variables both in terms of overall holdings and in timings suggests that merger effect estimates are not biased due to changes in spectrum across the sample either.

Table A3.1: 4G coverage base DD model – merger effect for Hutchison

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	4G cov.	4G cov.	4G cov.	4G cov.	4G cov.	4G cov.	4G cov.
Effect in 1 st year	-0.032	-0.0199	-0.0503	-0.053	-0.067	-0.010	-0.082
Effect in 2 nd year	0.048	0.0274	0.0357	0.026	0.012	0.016	-0.033
Effect after 2 years	0.277***	0.258***	0.241***	0.220***	0.208***	0.207***	0.214***
Treated unit dummy	-0.084***	-0.080***	-0.063***	-0.055**	-0.048**	-0.045**	-0.070*
4G spectrum holdings		0.001***	0.001***	0.001***	0.001***	0.001**	0.001***
4G spectrum 1–2 years			0.0423	0.0470	0.049	0.060	0.051
4G spectrum 2–4 years			0.0965*	0.101*	0.107*	0.117**	0.102*
4G spectrum 4–6 years			0.157***	0.160***	0.165***	0.176***	0.161**
GDP per capita (log)				-0.480			
Rural population					0.074**		0.0268
Population density (log)						2.259*	2.832***
3G coverage							0.438**
3G download speeds							-0.031***
Observations	948	948	948	948	948	948	923
Adjusted R-squared	0.74	0.75	0.76	0.76	0.76	0.76	0.77
Lead Effect test	Fail	Pass	Pass	Pass	Pass	Pass	Pass
Parallel Trends test	Fail	Fail	Fail	Fail	Fail	Fail	Pass
Country and time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Significance level: *** 1%, ** 5%, * 10%. Standard errors are clustered at country level. Lead Effect test is given as 'Pass' if estimating the Base model with a lead coefficient produces an insignificant effect at the 5% level. Parallel Trends test is given as 'Pass' if passed at the 5% level. There are fewer observations for Model 7 because of unavailable 3G network performance data for two operators.

Source: GSMA Intelligence

The tests we carry out to inspect if the Base DD satisfies the condition of pre-merger trends pass in Model 7. This specification proves to pass the common trends tests specifically due to the inclusion of 3G coverage and 3G download speeds (with the former enhancing 4G rollout via cost savings in existing infrastructure, and the latter having a negative impact due to operators investing in 3G upgrades and technology substitutability). Altogether, the model

specification Model 7 suggests that post-merger changes observed in the control group of operators can be used to approximate Hutchison's counterfactual without incurring biases.

The long-term merger effects found in the Base DD in an OLS framework are confirmed in the sensitivities with restrictions to the sample (Table A3.2).⁷³ Only the OLS simulations with normalised time and with MNO fixed effects identify a negative effect in the first year, but none of these results pass the two tests for pre-merger common trends required for unbiased DD results. Separately, taking into account the S-diffusion type of curve, as discussed in Annex A1, special weight should be given to non-linear functional forms and normalised time results. Effects after two years are confirmed by the non-linear functions.

Table A3.2: 4G coverage robustness checks on Base DD model – merger effect for Hutchison

(7) 4G coverage									
Model	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg
Check	All sample			Four-players sample			Close markets sample		
Effect in 1 st year	-0.082	0.295*	0.010	-0.064	0.449**	0.032	-0.118	0.209	0.014
Effect in 2 nd year	-0.033	0.639***	0.011	0.017	0.795**	0.065	-0.054	0.367	0.025
Effect after 2 years	0.214***	1.037***	0.288***	0.254***	1.182***	0.347***	0.200***	0.747**	0.305***
Lead Effect test	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Parallel Trends test	Pass	Fail	N/A	Pass	Fail	N/A	Pass	Pass	N/A
Model	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg
Check	MNO fixed effects			Third and fourth MNOs sample			Normalised time		
Effect in 1 st year	-0.103***	0.303***	-0.015	-0.093	0.452**	0.055	-0.146***	0.270**	-0.027
Effect in 2 nd year	-0.035	0.739***	-0.004	0.013	1.014***	0.064	-0.089**	0.808***	-0.007
Effect after 2 years	0.171***	1.111***	0.217***	0.220***	1.397***	0.285***	0.135**	1.154***	0.201***
Lead Effect test	Fail	Pass	Pass	Fail	Pass	Pass	Fail	Fail	Pass
Parallel Trends test	Pass	Pass	N/A	Pass	Pass	N/A	Pass	Fail	N/A

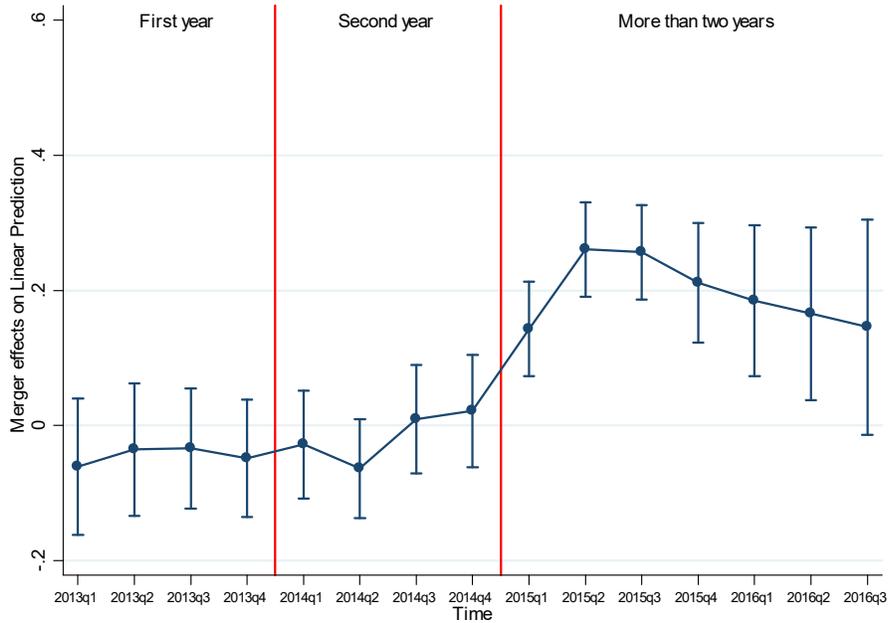
Significance level: *** 1%, ** 5%, *10%. Fractional regression coefficients represent marginal effects. Robustness checks carried out with the model specification as defined in Model 7 of Table A3.1. Lead Effect test is given as 'Pass' if estimating the Base model with a lead coefficient produces an insignificant effect at the 5% level. Parallel Trends test is given as 'Pass' if passed at the 5% level.

Source: GSMA Intelligence

We note that Model 7 of Table A3.1 passes the tests for pre-merger common trends. While we already consider this – together with the checks described above – the basis of a robust result, we have run Trend DD models for completion. Looking at the results of the Trend DD model (Figure A3.1) merger effects are still significant two years after the merger. These results have also proven to hold in the same set of checks as in Table A3.2.

⁷³ Robustness checks are carried out with Model 7 of Table A3.1 as this passes the underlying assumption of Base DD.

Figure A3.1: 4G coverage trend DD model – merger effect for Hutchison



Merger effect coefficients (as given by each post-merger time dummies for Hutchison) and 95% confidence intervals. Estimates based on Model 7 of Table A3.1.

Source: GSMA Intelligence

We note that the Trend DD may raise issues around whether the pre-merger rollout observed on Hutchison is a useful basis for the post-merger counterfactual. Particularly, the pre-merger rollout for Hutchison is in the left tail of the S curve, so the extent to which this trend can be used as counterfactual could be questioned. As discussed in Annex A1, we have addressed this issue by estimating merger effects from Trend DD models with non-linear functional forms, with the positive impact after two years confirmed.⁷⁴

b. Synthetic control approach

Given the synthetic control requires pre-merger data in coverage and in the set of predictors, we have restricted the sample to operators that had launched 4G networks at least four quarters before the merger (in our full sample, this leads to 13 “donor” operators). The variables used to predict 4G coverage are the ones that provide the lowest RSMPE pre-merger, and are also consistent with the DD results. The weights given to each predictor shown in Table A3.3 are broadly consistent with the results derived from the inclusion of additional variables (e.g. rural population, elevation).

⁷⁴ A second aspect to take into account is that one difference between the pre- and post-merger period in the Austrian market is the 800 MHz spectrum auction, which took place in the post-merger period. While we control for spectrum holdings, Hutchison in any case did not obtain 800 MHz spectrum, so this cannot bias the merger effect

Table A3.3: 4G coverage synthetic control operator key parameters

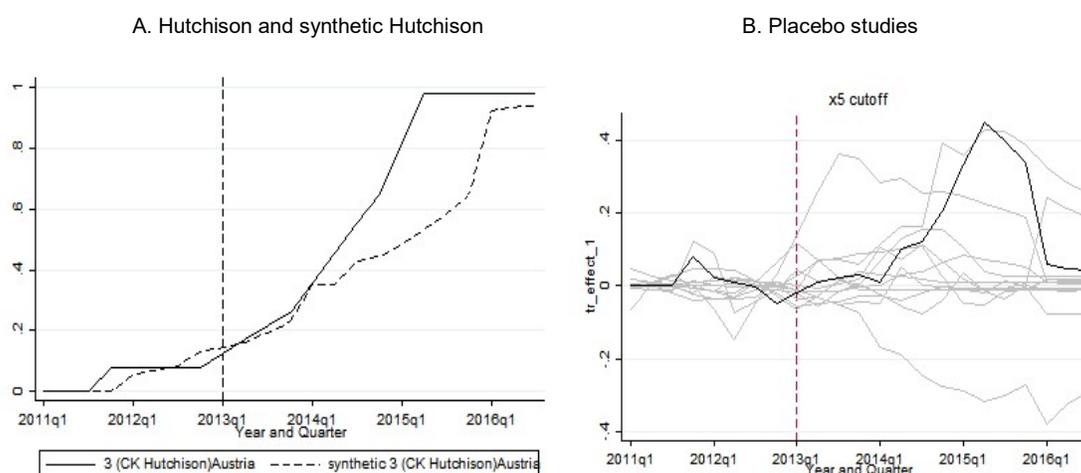
Operator	Weight	Predictor	Predictor balance		Predictor weight ⁷⁵
			Hutchison	Synthetic	
Hrvatski Telekom (Croatia)	0.952	4G cov. (pre-merger mean)	0.066	0.061	0.6720
Vipnet (Croatia)	0.048	4G cov. (2011q4)	0	0	0.1002
		4G cov. (2012q4)	0.08	0.130	0.2244
		4G count (2012q4)	9	3	0.0027
		4G spectrum (pre-merger mean)	65	22	0.0006

The pool of donor operators is restricted to operators that had active 4G networks (i.e., 4G coverage values above 0) at least four quarters before the merger and that receive a positive weight in the synthetic Hutchison.

Source: GSMA Intelligence

The resulting synthetic operator (Table A3.3) appears to be reasonably well balanced, with predictor values being very close to Hutchison in terms of 4G coverage, though the 4G count and 4G spectrum holdings are not as balanced. The overall post-/pre-merger MSPE ratio ranking in the placebo analysis is 4/14 while the ranking after two years is 3/14. With only 14 placebo studies (Chart B in Figure A3.2) the synthetic control provides little evidence as a standalone exercise, though it gives some reassurance of the results found in the DD framework as there is a noticeable difference between the actual and synthetic result around two years following the merger (in 2015).

Figure A3.2: 4G coverage synthetic control operator



Placebo studies in Chart B show treatment effects for operators that had active 4G networks before the Austrian merger and where the pre-merger MSPE is less than five times that of Hutchison.

Source: GSMA Intelligence

A.3.1.2 Market-wide effects

a. Difference-In-Difference (DD) approach

If we assign all Austrian operators to the treatment group, we find no conclusive effects. Base and Trend DD give contradictory results, with the former not passing tests for pre-merger

⁷⁵ Predictor weights may not sum to 1 due to rounding.

common trends and the latter reporting estimates that are not robust across alternative models.

The Base DD specifications in Table A3.4 find negative effects in the first two years after the merger and, in some models, a positive effect after two years. While the parallel trends test is passed in each model, the fact that the lead effect is significant when included in the separate regressions makes it unclear whether it was the merger that caused a reduction in 4G coverage or something else. One possible candidate behind the significance of the lead effect (and potentially the negative effect in the first year after the merger, i.e. 2013) could be the delay in the 800 MHz auction in Austria.⁷⁶ In any case, the significant lead effects suggest that control operators may not offer a good counterfactual for all Austrian operators due to some factors remaining unobserved.

Table A3.4: 4G coverage Base DD model – market-wide merger effects

	(1) 4G cov.	(2) 4G cov.	(3) 4G cov.	(4) 4G cov.	(5) 4G cov.	(6) 4G cov.	(7) 4G cov.
Effect in 1 st year	-0.094**	-0.085**	-0.099*	-0.100*	-0.119**	-0.102**	-0.082*
Effect in 2 nd year	-0.058*	-0.089**	-0.079*	-0.089*	-0.107**	-0.093**	-0.085**
Effect after 2 years	0.089***	0.051*	0.074**	0.052	0.036	0.046	0.091**
4G spectrum holdings		0.001***	0.001***	0.001**	0.001***	0.001***	0.001***
4G spectrum 0–2 years			0.043	0.046	0.048	0.059	0.0529
4G spectrum 2–4 years			0.105*	0.107*	0.113**	0.122**	0.111**
4G spectrum 4–6 years			0.166***	0.167***	0.172***	0.184***	0.172***
GDP per capita (log)				-0.475			
Rural population					0.079**		0.027
Population density (log)						2.294*	2.803***
3G coverage							0.431**
3G download speeds							-0.031***
Observations	948	948	948	948	948	948	923
Adjusted R-squared	0.74	0.75	0.74	0.74	0.75	0.75	0.76
Lead Effect test	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Parallel Trends test	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Country and time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Significance level: *** 1%, ** 5%, *10%. Standard errors are clustered at country level. The ‘Treated unit dummy’ is not reported in market-level analyses because it is, in effect, a country fixed effect. Lead Effect test is given as ‘Pass’ if estimating the Base model with a lead coefficient produces an insignificant effect at the 5% level. Parallel Trends test is given as ‘Pass’ if passed at the 5% level.

Source: GSMA Intelligence

We have estimated the same models with the usual set of alternative specifications, using Model 7.⁷⁷ Table A3.5 below shows that the Log-Lin model is the only specification appropriate

⁷⁶ The 800 MHz auction in Austria was planned to take place in 2012 but was delayed until after the merger decision. It is possible that because operators would have been uncertain as to how much 800 MHz spectrum that would obtain, they delayed rollout of their 4G networks in the first year following the merger.

⁷⁷ Robustness checks are carried out with Model 7 of Table A3.4 because it incorporates the additional explanatory factors of 3G coverage and 3G download speeds, which prove to be significant drivers of 4G rollout.

when applied to four-player countries, in the close markets and in the MNO fixed effects framework, as well as the OLS model with normalised time. The other models do not fully pass pre-merger trends tests. Even though most of the valid models point towards a positive impact of the merger, these results alone do not provide sufficient evidence considering the opposite impact that the OLS with normalised time suggests. With regards to the negative effects in the latter model, as discussed above it is possible that the delay in the 800 MHz auction could also be a factor in slowing down rollout in the first year or two after the merger, making it difficult to isolate the impact of the merger.

Table A3.5: 4G coverage robustness checks on Base DD model – market-wide effects

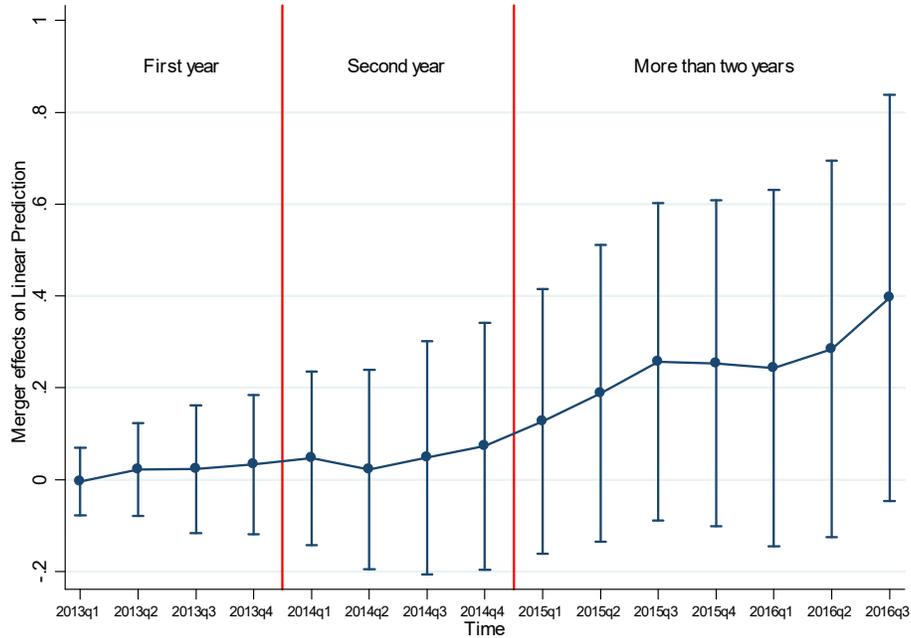
(7) 4G coverage									
Model	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg
Control	All sample			Four-player markets			Close markets		
Effect in 1 st year	-0.082*	0.339**	-0.043	-0.072	0.492**	-0.020	-0.109	0.310	-0.003
Effect in 2 nd year	-0.085**	0.626***	-0.112*	-0.046	0.804***	-0.067	-0.074	0.488	-0.039
Effect after 2 years	0.091**	0.941***	-0.020	0.126*	1.131***	0.019	0.111**	0.740**	0.032
Lead Effect test	Fail	Fail	Pass	Fail	Pass	Pass	Fail	Pass	Pass
Parallel Trends test	Pass	Pass	N/A	Pass	Pass	N/A	Pass	Pass	N/A
Model	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg	OLS	Log-Lin	Fracreg
Control	MNO fixed effects			Normalised Time			Country-level		
Effect in 1 st year	-0.129***	0.272*	-0.098**	-0.095**	0.339**	-0.098***	-0.169***	-0.121	-0.173***
Effect in 2 nd year	-0.121**	0.643*	-0.163**	-0.126***	0.626***	-0.195***	-0.223***	-0.161	-0.275***
Effect after 2 years	0.0117	0.916**	-0.148	-0.002	0.941***	-0.148*	-0.0835	0.242	-0.155**
Lead Effect test	Fail	Pass	Fail	Pass	Fail	Pass	Pass	Fail	Fail
Parallel Trends test	Pass	Pass	N/A	Pass	Pass	N/A	Fail	Pass	N/A

Significance level: *** 1%, ** 5%, *10%. Fractional regression coefficients represent marginal effects. Robustness checks carried out with the model specification as defined in Model 7 of Table A3.4. Lead Effect test is given as 'Pass' if estimating the Base model with a lead coefficient produces an insignificant effect at the 5% level. Parallel Trends test is given as 'Pass' if passed at the 5% level.

Source: GSMA Intelligence

With the underlying assumption in Base DD not being accomplished across the majority of simulations, we also present the result of the Trend DD model. This suggests insignificant impacts (Figure A3.3). Running alternative Trend DD models results in mixed findings (some positive and some negative) – hence, we cannot conclude if there was a merger effect at the market level in Austria.

Figure A3.3: 4G coverage trend DD model – market-wide merger effects



Merger effect coefficients (as given by each post-merger time dummies for Austrian operators) and 95% confidence intervals. Estimates based on the Trend DD application following the Base DD set-up in Model 7 of Table A3.4.

Source: GSMA Intelligence

b. Synthetic control approach

Aside from Austria, in our sample there are only seven other countries with 4G networks in place for more than one year before the merger. The synthetic control is, consequently, of limited use – the pool of ‘donor’ countries is reduced and, moreover, the number of placebo studies to determine the significance of the results makes it difficult to draw any conclusions from the analysis. Hence, we conclude that based on the data available to us, it is not possible to say what impact the merger had (if any) at the market level.

A3.2 4G network quality

A.3.2.1 Merger effects on Hutchison

a. Regression-based approach

Due to the lack of pre-merger data on 4G performance for Hutchison, the only model that we can estimate is the Base specification, for which the Parallel Trends assumption cannot be directly inspected. In this case, the DD framework cannot be estimated using the standard approach, since the double difference cannot be calculated.

The estimates in Table A3.6 point to a significant positive merger effect across all years after the merger for download speeds, while the second year effect is not significant in upload speeds. These merger coefficients represent, in effect, an operator fixed effect for Hutchison. These capture whether the merged entity had better or worse network performance than would have been expected by assessing other operators' network performance and controlling for other distinctive factors between the treatment and the control. In this case, the factors that turn out significant are the country and time fixed effects.

Table A3.6: 4G network quality Base model – merger effects for Hutchison

	4G download speeds			4G upload speeds		
	(1)	(2)	(3)	(1)	(2)	(3)
Effect in 1 st year	3.686**	3.381*	3.687**	3.792***	3.667***	3.793***
Effect in 2 nd year	2.705***	2.769***	2.727***	-0.0630	-0.0370	-0.0552
Effect after two years	7.635***	8.398***	7.673***	3.732***	4.045***	3.745***
4G spectrum holdings	0.0337	0.0353	0.0331	0.00441	0.00507	0.00422
Rural population		-4.632			-1.903	
Population density (log)			-0.177			-0.0643
Observations	904	904	904	904	904	904
Adjusted R-squared	0.35	0.36	0.35	0.31	0.32	0.31
Country and time FE	Yes	Yes	Yes	Yes	Yes	Yes
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes

Significance level: *** 1%, ** 5%, * 10%. Standard errors are clustered at country level. Lead Effect test and Parallel Trends tests cannot be applied due to lack of pre-merger data.

Source: GSMA Intelligence

Considering the limitations above, the alternative specifications we can carry out provide some useful insights (we use Model 1 of Table A3.6 as Models 2 and 3 add explanatory factors without significance).

By limiting the sample to operators and markets with closer characteristics to Hutchison, these estimates should limit the sources for unobserved factors that could confound the merger effect. Separately, the MNO fixed effects model should be able to control for unobserved structural differences across operators that could be biasing merger effects.

In terms of download speeds, the models reported in Table A3.6 appear to confirm both the effect after two years (which remains significant on all checks) and the effect in the second year (which only dilutes in the third/fourth operator sample) – with both effects intensified when controlling for operator fixed effects. Considering upload speeds, most alternative models suggest coefficients similar in significance and magnitude for the first year after the merger

and two years after. We treat the former with caution given it seems to dilute in the second year after the merger, suggesting that it could be driven by something other than the merger.

Table A3.7: 4G network quality Base model robustness checks – merger effect for Hutchison

	4G download speeds				4G upload speeds			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Effect in 1 st year	11.68***	4.076	1.959	5.390*	3.518***	4.529***	1.739	5.304***
Effect in 2 nd year	11.13***	2.523**	1.583	1.858*	0.053	-0.277	-2.124	-0.709*
Effect after two years	15.80***	7.209***	8.094**	7.328***	3.787***	3.508***	1.623	3.373***
Check	MNO FE	Four-player sample	Third/fourth operator sample	Close markets sample	MNO FE	Four-player sample	Third/fourth operator sample	Close markets sample

Significance level: *** 1%, ** 5%, *10%. Robustness checks carried out with the model specification as defined in Model 1 in Table A3.6. Lead Effect test and Parallel Trends tests cannot be applied due to lack of pre-merger data.

Source: GSMA Intelligence

This analysis cannot be complemented with estimates from Trend models given the lack of pre-merger data.

b. Synthetic control approach

The synthetic control approach cannot be applied in this case either, since there is no 4G network quality pre-merger data on which we can generate optimal weights.

A.3.2.2 Market-wide merger effects

a. Difference-In-Difference (DD) approach

When assigning all Austrian operators to the treatment group, the only treated operator with pre-merger data on 4G network quality is A1 Telekom and this only exists for four quarters prior to the merger. Therefore, although we have pre-merger data on which to carry out a parallel trends test, this should be treated with some caution.

Table A3.8: 4G network quality Base DD robustness checks – market-wide effects

	4G download speeds			4G upload speeds		
	(1)	(2)	(3)	(1)	(2)	(3)
Effect in 1 st year	13.93***	15.88***	14.08***	5.075***	5.853***	5.127***
Effect in 2 nd year	13.09***	15.57***	13.28***	4.171***	5.161***	4.240***
Effect after two years	8.322**	11.57***	8.536**	2.587**	3.880***	2.662**
4G spectrum holdings	0.0342	0.0354	0.0336	0.00461	0.005	0.004
Rural population		-4.936			-1.969	
Population density (log)			-0.187			-0.066
Observations	827	827	827	827	827	827

Adjusted R-squared	0.46	0.46	0.46	0.42	0.42	0.42
Parallel trends test	Pass	Pass	Pass	Pass	Pass	Pass
Country and time FE	Yes	Yes	Yes	Yes	Yes	Yes
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes

Significance level: *** 1%, ** 5%, * 10%. Standard errors are clustered at country level. Lead Effect test cannot be applied due to lack of pre-merger data. Parallel Trends test results are presented but should be treated with some caution as there is only data for four quarters pre-merger and this is primarily based on the network performance of A1 Telekom. The 'Treated unit dummy' is not reported in market-level analyses because it is, in effect, a country fixed effect.

Source: GSMA Intelligence

Due to the limited amount of pre-merger data, the alternative models that can be carried out are particularly important, especially the checks done with the market-level dataset – where Austria as a whole is the relevant unit of treatment and where we have pre-merger data. Using the specification of Model 1 in Table A3.8⁷⁸, Table A3.9 shows that the country-level model passes the two tests of pre-merger trends, and the size and significance of the merger effects are along the lines of that found in Table A3.8 across the three post-merger periods.

The other alternative models (restrictions to sample and MNO fixed effects) provide results in the same general direction. In almost all specifications, the effects in the first two years after the merger are statistically significant. However, in some of the simulations the significance of the merger effect two years after the merger is diluted. Due to the limited length of pre-merger data, we prefer to have a statistically significant result in the majority of alternative models in order to be confident of a finding. Given this is not the case for the effect after two years, we conclude that the results found after two years are inconclusive.

Table A3.9: 4G network quality Base DD robustness checks – market-wide merger effects

	4G download speeds				4G upload speeds			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Effect in 1 st year	15.31***	12.45***	14.89***	15.42***	5.255***	5.025***	5.531***	5.709***
Effect in 2 nd year	15.30***	10.97**	10.82**	15.19***	4.783***	3.144*	2.038	4.996***
Effect after two years	10.35**	5.465	5.861	8.756**	3.211**	1.267	0.268	2.343**
Parallel trends test	Fail	Fail	Pass	Pass	Fail	Fail	Fail	Pass
Check	MNO FE	Four-player sample	Close markets sample	Market-level dataset	MNO FE	Four-player sample	Close markets sample	Market-level dataset

Significance level: *** 1%, ** 5%, *10%. Robustness checks carried out with the model specification as defined in Model 1 in Table A3.8. Lead Effect test cannot be applied due to limited pre-merger data.

Source: GSMA Intelligence

⁷⁸ Checks are carried out using Model 1 in Table A3.8 because the inclusion of variables in the other simulations does not seem to add substantial explanatory power.

b. Synthetic control approach

The synthetic control approach cannot be applied in this case, since there is not enough 4G network quality pre-merger data on which we can generate optimal weights.

A3.3 3G Network quality

A.3.3.1 Merger effects on Hutchison

a. Difference-In-Difference (DD) approach

With respect to 3G download speeds, the Base DD model reported in Table A3.10 suggests that the merger had a negative impact in the first two years after the merger, disappearing thereafter. The Base DD comfortably passes the parallel trends test and the Lead Effect test in Model 2, meaning that this is an appropriate specification to use.

Table A3.10: 3G network quality Base DD – merger effect for Hutchison

	3G download speeds			3G upload speeds		
	(1)	(2)	(3)	(1)	(2)	(3)
Effect in 1 st year	-0.730**	-0.713**	-0.704**	-0.184*	-0.194*	-0.185*
Effect in 2 nd year	-1.388***	-1.360**	-1.356***	-0.313**	-0.328**	-0.313**
Effect after two years	0.513	0.554	0.544	-0.301	-0.325	-0.302
Treated unit dummy	0.244	0.223	0.221	0.641**	0.653**	0.642**
3G spectrum holdings	0.024	0.024	0.024	0.008	0.008	0.008
Rural population		-0.092			0.053	
Population density (log)			0.088***			-0.001
Observations	1,320	1,320	1,320	1,320	1,320	1,320
Adjusted R-squared	0.81	0.81	0.82	0.68	0.68	0.68
Lead Effect test	Fail	Pass	Fail	Fail	Fail	Fail
Parallel trends test	Pass	Pass	Pass	Fail	Fail	Fail
Country and time FE	Yes	Yes	Yes	Yes	Yes	Yes
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes

Significance level: *** 1%, ** 5%, * 10%. Standard errors are clustered at country level. Lead Effect test is given as 'Pass' if estimating the Base model with a lead coefficient produces an insignificant effect at the 5% level. Parallel Trends test is given as 'Pass' if passed at the 5% level.

Source: GSMA Intelligence

Nevertheless, the sensitivity tests on Model 2 for 3G download speeds do not fully support negative impacts in the first two years after the merger⁷⁹ (see Table A3.11). While the 'close markets' sample does report negative merger effects in the first and second year as well, the two other sample restrictions report insignificant estimates. Additionally, the MNO fixed effects model produces inconsistent estimates, with a negative effect in the second year and a positive effect after two years. With these inconsistencies, we cannot determine with confidence that there was an impact on this metric.

Regarding 3G upload speeds, Table A3.10 shows some negative merger effects in the first and second year, but these models do not pass any of the tests for common trends. Given

⁷⁹ Sensitivities are carried out with Model 2 because this specification is robust to common pre-merger trends. Model 3 includes population density, which proves to be significant, but this leads to the specification not passing both tests on pre-merger trends.

Base DD estimates are not appropriate, we run Trend DD simulations. Figure A3.4 reports the merger coefficients that result from the Trend DD version of the Base DD application in Model 1 of Table A3.10.⁸⁰ This suggests the merger effect was insignificant for the entire post-merger period.

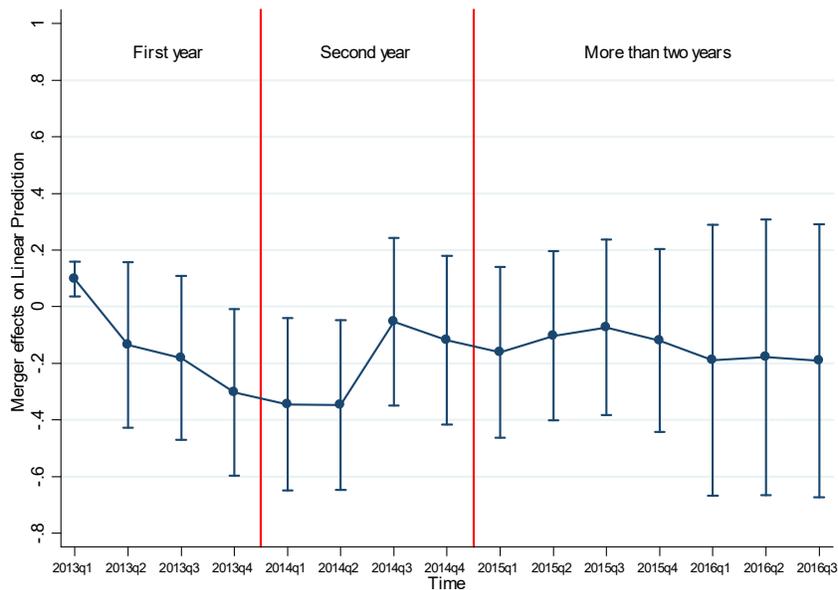
Table A3.11: 3G network quality Base DD robustness checks – merger effect for Hutchison

	3G download speeds			
	(1)	(2)	(3)	(4)
Effect in 1 st year	-0.394	-0.799	-0.382	-1.564**
Effect in 2 nd year	-0.937*	-1.248	-0.782	-2.548***
Effect after two years	1.070*	0.628	1.288	-0.890
Lead Effect test	Pass	Pass	Pass	Pass
Parallel trends test	Pass	Pass	Pass	Pass
Check	MNO FE	Four-player sample	Third/fourth operator sample	Close markets sample

Significance level: *** 1%, ** 5%, *10%. Robustness checks carried out with the model specification as defined in Model 2 of Table A3.10 for download speeds. Lead Effect test is given as ‘Pass’ if estimating the Base model with a lead coefficient produces an insignificant effect at the 5% level. Parallel Trends test is given as ‘Pass’ if passed at the 5% level.

Source: GSMA Intelligence

Figure A3.4: 3G upload speeds trend DD model – merger effect for Hutchison



⁸⁰ We carry the Trend DD application of Model 1 because the additional explanatory variables in Models 2 and 3 lack significance.

Merger effect coefficients (as given by each post-merger time dummy for Hutchison) and 95% confidence intervals. Estimates based on the Trend DD application following the Base DD set-up in Model 1 of Table A3.10.

Source: GSMA Intelligence

b. Synthetic control approach

The synthetic part of the analysis for 3G download and upload speeds does not appear to provide a good framework to determine whether the merger induced significant effects at the merged entity level. We find that the combination of data across operators in the dataset does not generate a synthetic control that can be feasibly compared against Hutchison.

The predictors that we have included (pre-merger mean of the outcomes, as well as the values in 2011q2 and 2012q4, 3G spectrum and connections penetration) give the lowest pre-merger MSPE and generally prove to be relevant in the DD models. The synthetic Hutchison takes values from operators in the full sample, with the results shown in Table A3.12. For both upload and download speeds, the predictor balance indicates that Hutchison and its synthetic counterpart are close in terms of observed characteristics (with the exception of 3G connections penetration in upload speeds).

Table A3.12: 3G Network quality synthetic control operator key parameters

Download speeds

Operator	Weight	Predictor	Predictor balance		Predictor weight ⁸¹
			Hutchison	Synthetic	
Hutchison (Denmark)	0.817	3G down. (pre-merger mean)	3.20	3.20	0.7192
Hutchison (Sweden)	0.023	3G down. (2011q2)	2.50	2.48	0.0942
Tele2 (Croatia)	0.161	3G down. (2012q4)	3.74	3.73	0.1858
		3G spect. (pre-merger mean)	36.20	45.20	0.0004
		3G conn. penetration (pre-merger mean)	0.98	0.88	0.0001

Upload speeds

Operator	Weight	Predictor	Predictor balance		Predictor weight ⁸²
			Hutchison	Synthetic	
Vodafone (Czech Republic)	0.855	3G up. (pre-merger mean)	1.65	1.63	0.7391
Vodafone (Malta)	0.145	3G up. (2011q2)	1.23	1.20	0.1160
		3G up. (2012q4)	1.88	1.67	0.1446
		3G spect. (pre-merger mean)	36.20	66.05	0.0001
		3G conn. penetration (pre-merger mean)	0.98	0.33	0.0002

The pool of donor operators includes all operators in the sample. Only those operators with positive weights are listed in the operator weights vector.

Source: GSMA Intelligence

Charts A and B in Figure A3.5, however, indicate that the resulting predictions of download and upload speeds do not match Hutchison's values during the pre-merger period. Hence, the resulting synthetic control does not prove to be useful. This could indicate that the variables chosen to predict download and upload speeds do not work well because of their *static* nature (i.e. average and snapshot values do not capture the dynamics on a time series); and/or that

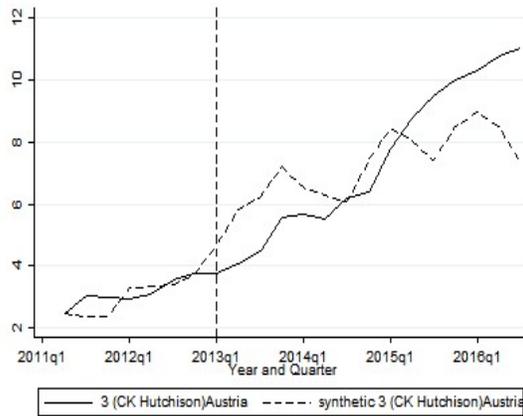
⁸¹ Predictor weights may not sum to 1 due to rounding.

⁸² Predictor weights may not sum to 1 due to rounding.

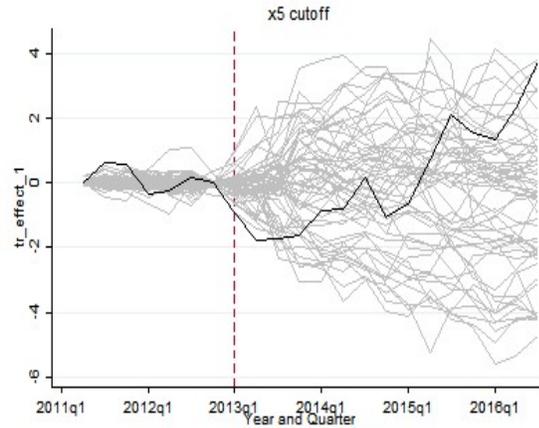
the operator dataset simply does not provide an *efficient* combination of firms in terms of synthetic control.

Figure A3.5: 3G network quality synthetic control operator

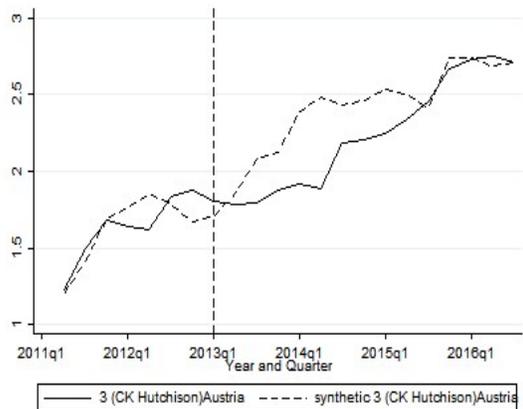
A. Hutchison and Synthetic Hutchison (download speeds)



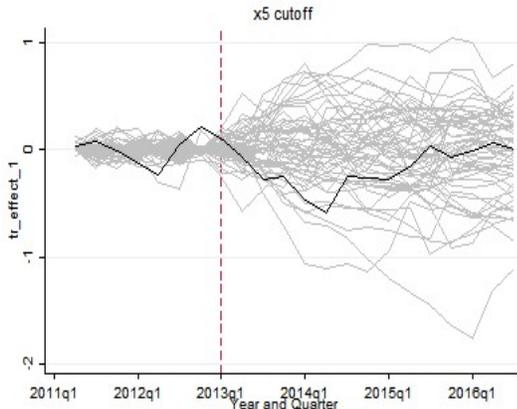
B. Placebo studies (download speeds)



A. Hutchison and Synthetic Hutchison (upload speeds)



B. Placebo studies (upload speeds)



Placebo studies in Charts B show treatment effects based on synthetic operators whose pre-merger MSPE is less than five times that of Hutchison.

Source: GSMA Intelligence

A.3.3.2 Market-wide merger effects

a. Difference-In-Difference (DD) approach

For both 3G download and upload speeds we rely on the results from the Base DD model. Model 2 of Table A3.13 passes the tests for common pre-merger trends, reporting significant merger effects in the second year and after two years (positive for download and negative for upload speeds). The other models do not pass both tests for common trends.

Table A3.13: 3G network quality Base DD model – merger effects across all Austrian operators

	3G download speeds			3G upload speeds		
	(1)	(2)	(3)	(1)	(2)	(3)
Effect in 1 st year	0.144	0.176	0.170	-0.046	-0.0583	-0.047
Effect in 2 nd year	0.527*	0.579*	0.559**	-0.189***	-0.209**	-0.189***
Effect after two years	1.434***	1.512***	1.465***	-0.228***	-0.258**	-0.229***
3G spectrum holdings	0.023	0.023	0.0234	0.006	0.006	0.006
Rural population		-0.165			0.063	
Population density (log)			0.0887***			-0.001
Observations	1320	1320	1320	1320	1320	1320
Adjusted R-squared	0.81	0.81	0.82	0.68	0.68	0.68
Lead Effect test	Pass	Pass	Pass	Pass	Pass	Pass
Parallel trends test	Fail	Pass	Fail	Fail	Pass	Fail
Country and time FE	Yes	Yes	Yes	Yes	Yes	Yes
Robust SE	Yes	Yes	Yes	Yes	Yes	Yes

Significance level: *** 1%, ** 5%, * 10%. Standard errors are clustered at country level. Lead Effect test is given as 'Pass' if estimating the Base model with a lead coefficient produces an insignificant effect at the 5% level. Parallel Trends test is given as 'Pass' if passed at the 5% level. The 'Treated unit dummy' is not reported in market-level analyses because it is, in effect, a country fixed effect.

Source: GSMA Intelligence

The effect on download speeds after two years from Model 2 in Table A3.13 holds to MNO fixed effects, the four-player sample and the exercises with the market-level dataset where we test the treatment for Austria as a whole. Meanwhile, the checks on the negative effects on upload speeds indicate that the impact appears in both the second year and after two years in the majority of alternative models, including the market-level dataset. In both metrics we have only one of the robustness checks where estimates are insignificant, so we are confident overall about the key findings (i.e., a significant effect on download speeds two years after the merger and a negative effect on upload speeds in the second year and thereafter).

Table A3.14: 3G network quality Base DD robustness checks, market-wide merger effects

	3G download speeds				3G upload speeds			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Effect in 1 st year	0.284	0.241	-0.0698	-0.140	0.007	-0.0634	-0.138*	-0.127**
Effect in 2 nd year	0.721	0.936**	0.222	0.053	-0.123	-0.203**	-0.364***	-0.276***
Effect after two years	1.658**	1.901***	1.130	1.355**	-0.170	-0.270**	-0.446**	-0.317***
Lead Effect test	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Parallel trends test	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Check	MNO FE	Four-player sample	Close markets sample	Market-level dataset	MNO FE	Four-player sample	Close markets sample	Market-level dataset

Significance level: *** 1%, ** 5%, *10%. Robustness checks carried out with the model specification as defined in Model 2 of Table A3.13.

Source: GSMA Intelligence

b. Synthetic control approach

As with the synthetic control at the operator level, the analysis for 3G download and upload speeds does not appear to provide a good framework to determine whether the merger induced significant effects at the market level. We find that the combination of data across countries in the dataset does not generate a synthetic control that can be feasibly compared against Austria.

The predictors that we have included (pre-merger mean of the outcomes, as well as the values in 2011q2 and 2012q4, 3G spectrum and connections penetration) give the lowest pre-merger MSPE. The synthetic Austria takes values from countries in the full sample, with the results reported in Table A3.15. For both upload and download speeds, the predictor balance indicates that Hutchison and its synthetic counterpart are close in terms of observed characteristics (with the exception of 3G connections penetration in upload speeds).

Table A3.15: 3G Network quality synthetic market key parameters

Download speeds

Country	Weight	Predictor	Predictor balance		Predictor weight ⁸³
			Hutchison	Synthetic	
		3G down. (pre-merger mean)	3.20	3.22	0.7233
Croatia	0.112	3G down. (2011q4)	2.57	2.44	0.0754
Slovenia	0.087	3G down. (2012q4)	3.63	3.61	0.1998
Sweden	0.801	3G spect. (pre-merger mean)	216.45	201.42	0.0002
		3G conn. penetration (pre-merger mean)	0.63	0.68	0.0013

Upload speeds

Country	Weight	Predictor	Predictor balance		Predictor weight ⁸⁴
			Hutchison	Synthetic	
		3G up. (pre-merger mean)	1.59	1.34	0.7454
		3G up. (2011q4)	1.28	1.07	0.1056
		3G up. (2012q4)	1.75	1.47	0.1472
		3G spect. (pre-merger mean)	216.45	203.8	0.0003
		3G conn. penetration (pre-merger mean)	0.63	0.76	0.0015

Source: GSMA Intelligence

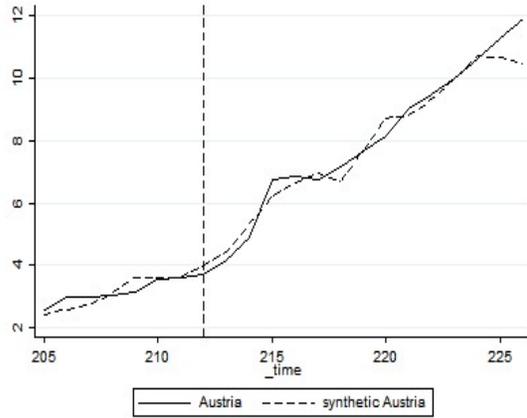
Charts A and B in Figure A3.6, however, indicate that the resulting predictions of download and upload speeds do not match Austria's values during the pre-merger period, meaning that the synthetic control is not useful to confirm or verify the findings of the DD analysis.

⁸³ Predictor weights may not sum to 1 due to rounding.

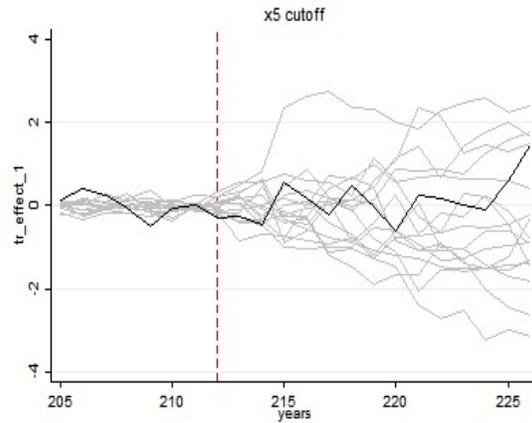
⁸⁴ Predictor weights may not sum to 1 due to rounding.

Figure A3.6: 3G network quality synthetic control market

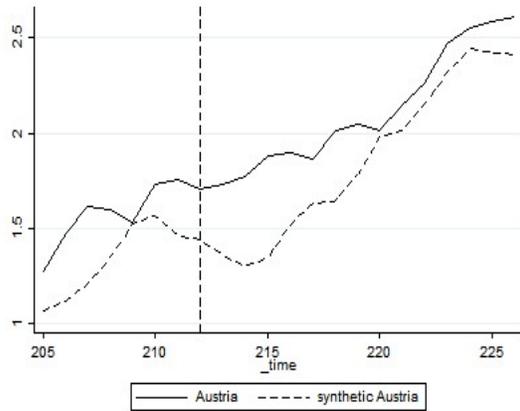
A. Hutchison and Synthetic Austria (download speeds)



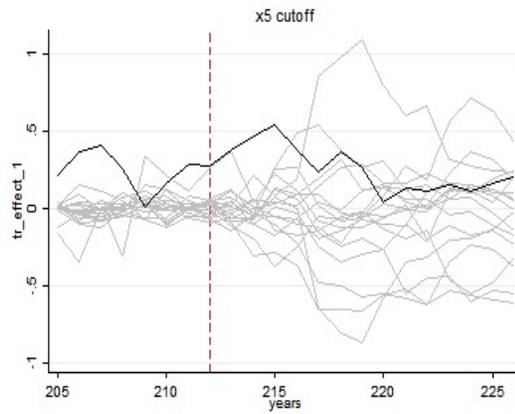
B. Placebo studies (download speeds)



A. Hutchison and Synthetic Austria (upload speeds)



B. Placebo studies (upload speeds)



Placebo studies in Charts B show treatment effects based on synthetic operators whose pre-merger MSPE is less than five times that of Hutchison.

Source: GSMA Intelligence

A4. Annex references

- Abadie, A. & Gardeazabal, J. (2003). "The Economic Costs of Conflict: A Case Study of the Basque Country", *The American Economic Review*, 93(1). Available at <<https://www.aeaweb.org/articles?id=10.1257/000282803321455188>>
- Angrist, J. & Pischke, J-S. (2008). "Mostly Harmless Econometrics: An Empiricist's Comparison". Princeton: Princeton University Press.
- Athey, S. & Schmutzler, S. (2001). "Investment and market dominance", *RAND Journal of Economics*, 32 (1). Available at <http://econpapers.repec.org/article/rjerandje/v_3a32_3ay_3a2001_3ai_3a1_3ap_3a1-26.htm>
- Bauer, S. et al (2010). "Understanding Broadband Speed Measurements", Massachusetts Institute of Technology. Available at <http://mitas.csail.mit.edu/papers/Bauer_Clark_Lehr_Broadband_Speed_Measurements.pdf>
- BWB (2016). "An Ex-post Evaluation of the Mergers H3G/Orange and TA/Yesss!". Available at <<https://www.en.bwb.gv.at/News/Seiten/BWB-und-RTR-present-reports-on-the-telecom-sector-enquiry.aspx>>
- CERRE (2015). "Evaluating market consolidation in mobile communications". Study prepared for CERRE, authored by Genakos C., Valletti T. & Verboven F. Available at <http://cerre.eu/sites/cerre/files/150915_CERRE_Mobile_Consolidation_Report_Final.pdf>
- 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. Available at <<http://ec.europa.eu/competition/publications/reports/kd0215836enn.pdf>>
- 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. Available at <<http://ec.europa.eu/competition/publications/reports/kd0417233enn.pdf>>
- Evans, D. & Padilla, J. (2003). "Demand-Side Efficiencies in Merger Control". *SSR Electronic Journal*. Available at <<http://dx.doi.org/10.2139/ssrn.390500%20>>
- Frontier (2015). "Assessing the case for in-country mobile consolidation". Study prepared for GSMA. Available at <<http://www.gsma.com/publicpolicy/wp-content/uploads/2015/02/Assessing-the-case-for-in-contry-mobile-consolidation-report.pdf>>
- Houngbonon G.V. & Jeanjean, F. (2016-b). "Optimal market structure in the wireless industry". *Information Economics and Policy*, 38, 12-22. Available at <http://econpapers.repec.org/article/eeeiepoli/v_3a38_3ay_3a2017_3ai_3ac_3ap_3a12-22.htm>
- Houngbonon, G.V. & Jeanjean, F. (2016-a). "What level of competition intensity maximises investment in the wireless industry?", *Telecommunications Policy*, 40(8), 774-790. Available at <<http://dl.acm.org/citation.cfm?id=2983042>>
- HSBC (2015). "Supersonic: European telecoms mergers will boost capex, driving prices lower and speeds higher". Available at <<http://www.orange.com/fr/content/download/33263/1086075/version/2/file/Supersonic+13.04.15.pdf>>

Nitsche, R. & Wiethaus, L. (2016). "Efficiency defence in telecom mergers and other investment intensive industries", *European Competition Law Review*, 7(13).

OECD (2014). "Access network speed tests", *OECD Digital Economy Papers*, No. 237, OECD Publishing. Available at <<http://dx.doi.org/10.1787/5jz2m5mr66f5-en>>

RTR (2016). "Ex-post analysis of the merger between H3G Austria and Orange Austria". Available at <https://www.rtr.at/en/inf/Analysis_merger_H3G_Orange/Ex_post_analysis_merger_H3G_Orange_RTR.pdf>

WIK (2015). "Competition & Investment: An analysis of the drivers of investment and consumer welfare in mobile communications". Study prepared for Ofcom, authored by Elixmann D., et al., Available at <http://stakeholders.ofcom.org.uk/binaries/consultations/dcr_discussion/annexes/Competition_and_investment_mobile.pdf>