

Competition & investment:

An analysis of the drivers of
investment and consumer welfare
in mobile telecommunications

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Executive summary

Main findings

The aim of this study is to provide evidence-based analysis of the effect of competition on investment and consumer outcomes in the mobile sector. It explores the hypothesis as to whether there is a 'virtuous circle' between competition and investment, or whether, as has been claimed, more intense competition may undermine investment, harming consumer outcomes in the long term. Our assessment is based on empirical analysis from 12 countries, eight of which are European (besides the UK: Austria, France, Germany, Ireland, Italy, Netherlands, Spain) and four are non-European (Australia, Japan, South Korea and the U.S.).

This study aims to provide insights that may be relevant to competition and spectrum policy at European level, as well as providing an input to Ofcom's Strategic Review of Digital Communications which specifically considers competition and investment in converged communications infrastructure.

On the basis of our analysis including econometric assessments, we have found no linkage between consolidation or higher concentration in mobile markets and an increase in investment. Investment tends to follow long-term investment cycles which appear to be largely unrelated to developments in market structure in the countries assessed.

The evidence also does not confirm that consolidation and higher concentration in mobile markets is linked to an improvement in consumer outcomes. The major potential drivers of better consumer outcomes - notably higher connection speeds, higher mobile penetration and higher data usage - can be found on the demand side. Higher connection speeds are linked to higher smartphone penetration. Both higher mobile penetration and higher data usage are linked to higher mobile video usage. Demand factors thus seem to have a major role in explaining better consumer outcomes.

Our analysis also does not confirm the hypothesis that the UK falls behind major non-European countries such as the U.S., Australia, Japan and South Korea. While the non-European countries have a higher investment in the period assessed, the UK fares well in terms of consumer outcomes. There has been an initial delay in the licensing of 4G spectrum and the subsequent roll-out of 4G networks (not just in the UK, but generally within Europe), which however has been substantially reduced over time.

Although there has been a trend towards approval of consolidation in Europe, we note that in the US the competition authority has sought to maintain a 4 player market, while in Korea the Government is considering reserving spectrum for a 4th mobile entrant in an upcoming auction.

Background

The effect of competition on investment and consumer outcomes in mobile networks has been subject to intense debate. Some mobile operators and analysts have put forward an argument that in the mobile sector there is a virtuous circle between less intense competition, higher operator profitability, and increased investment, which has resulted in better consumer outcomes. The US is often presented as an example of this dynamic. In contrast, they claim that in the EU, mobile network operators make lower returns on capital because of intense competition and stringent regulation, which in turn has led to lower investment and relatively poor consumer outcomes. Meanwhile, some smaller operators, regulators and competition authorities have voiced concerns that consolidation will harm consumers without delivering substantial investment gains. These questions are especially relevant in Europe, because there is currently a trend towards consolidation that has led to a reduction in the number of mobile operators from 4 to 3 in several countries.

A key focus of the study is to understand the main drivers of investment and consumer outcomes, whether the UK and Europe are 'falling behind' other regions internationally and what role competition policy (and especially measures to promote market entry or permit consolidation) might play, in relation to other factors, in determining consumer outcomes.

Do consolidated markets lead to increased investment?

Economic theory suggests ambiguous effects of competition on investment. One theory suggests that competition may stimulate investment as operators seek to leapfrog each other in order to gain competitive advantage. On the other hand, the Schumpeterian view holds that there may be greater incentives to invest and innovate if operators can maintain the resulting returns in a concentrated market. A further perspective combining both theories is that there is 'turning point' (inverted U-shaped curve) within which it is possible to identify an 'optimal' level of competition in order to spur investment.

Various studies have used econometric techniques to assess whether there is a link between mobile market structure and investment, and to highlight what they view as the implications for policies concerning market entry and merger control. A 2015 study by Frontier for the GSMA (2015) suggests that the level of competition (measured through HHI or number of operators) does not have a clear influence on investment (capex per subscriber). On the other hand, a report by HSBC (2015) claims to have found an inverted U-shaped relationship between investment and competition, in which the optimal level of competition is found to correspond to an EBITDA margin of 38%.

On the basis of our own analysis including econometric assessments, similarly to Frontier, we have found no linkage between consolidation or higher concentration in

mobile markets and an increase in investment¹. We also find no compelling evidence that consolidation or a higher HHI impacts on investment through higher profitability, thus casting some doubt on whether assessments based on profitability measures can reliably be used to draw conclusions around consolidation.

Rather, our analysis suggests that investment levels in mobile markets may depend on a range of – often nationally specific – factors, which might for example include demand factors such as mobile video usage, cost drivers such as a high rural population or potentially auction dates and coverage obligations. E.g. investment in the U.S. is higher than in the UK, while the extent of concentration as measured by the HHI is similar to the UK. Possible factors that could explain the higher US investment are earlier assignment of 4G spectrum, higher network deployment costs (lower user density in covered areas) and higher demand for video services.

We also note that, while econometric analysis can provide more comprehensive insights than “simple” (one-dimensional) comparisons between operators or countries on the basis of descriptive statistics, it is rarely definitive. The specific datasets and the operators/countries as well as the time periods observed do matter, and could miss specific features which may explain results in particular markets. A thorough market-by-market investigation is therefore needed for assessing the effects of consolidation and new entry in any particular country.

Do consumer outcomes in mobile markets increase with less competition?

Economic theory predicts that there is a certain level of competition which is best for consumer outcomes in industries characterized by economies of scale and innovation such as the mobile industry. There is thus unlikely to be a single ‘optimal’ market structure in terms of number of mobile network operators and market concentration that is best for consumer outcomes. Rather each national market needs to be examined in the light of local characteristics.

The qualitative evidence does not confirm that consolidation and higher concentration in mobile markets is linked to an improvement in consumer outcomes. However, neither does it show a clear link between increased competition and consumer outcomes.² The reason may be that any effects from competition are outweighed by effects from other factors.

The major linkages to consumer outcomes - notably connection speeds, mobile penetration and data usage - can be found on the demand side. Higher connection speeds are linked to higher smartphone penetration. Both higher mobile penetration

¹ Neither a decrease in the number of MNOs nor an increase in the Hirschman-Herfindahl Index (HHI) is linked to higher CAPEX/revenue or higher CAPEX per subscriber.

² We found no statistical linkage between number of MNOs or HHI and CAPEX/revenue (or CAPEX per subscriber).

and higher data usage are linked to higher mobile video usage. Demand factors thus seem to have a major role in explaining better consumer outcomes.

This is also demonstrated by Table A, which ranks the countries by

- Consumer outcomes (average of all consumer outcome variables, with equal weights attached to each outcome)³,
- Investment (CAPEX/revenue),
- Competition (Hirschman-Herfindahl Index - HHI),
- Deployment costs (we use share of rural population as a proxy), and
- Demand factors (GDP per capita, smartphone penetration, mobile video usage).

Table A: Country rankings for consumer outcomes, competition, investment and other factors, 2013

	Consumer outcomes	Investment CAPEX/revenue	Competition - HHI	Costs - share of rural population	Demand - GDP per capita	Demand - Smartphone penetration	Demand - mobile video usage
South Korea	1	4	10	4	12	1	1
Australia	2	na	11	2	1	4	4
UK	3	10	2	5	8	3	5
US	4	2	4	6	2	7	2
Japan	5	1	9	1	9	12	3
France	6	9	6	7	7	11	8
Austria	7	7	7	11	4	8	na
Netherlands	8	3	8	3	3	6	na
Ireland	9	na	na	12	5	5	na
Italy	10	5	3	10	10	9	7
Spain	11	8	5	8	11	2	6
Germany	12	6	1	9	6	10	9

³ Consumer outcomes include broadband outcomes (3G and 4G availability, connection speed, prices of mobile baskets including mobile Internet, mobile broadband and 4G penetration, data usage) and voice outcomes (prices of mobile baskets including voice, mobile subscriber penetration and voice usage).

Two of the countries doing best in consumer outcomes are among the least concentrated countries (US and UK), while the other two are among the highest concentrated (South Korea and Australia). This example also illustrates that the relationship between competition (HHI) and consumer outcomes is not clear-cut.

It is however clearly visible that the good consumer outcomes of the top-4 countries are associated with demand factors. The countries performing best in consumer outcomes rank higher in smartphone penetration and mobile video usage (resulting in higher demand for broadband services).

It should be noted that different metrics, a different list of consumer outcomes, and/or other weightings can result in a lower rank for the UK, but would not put in question the overall positive picture for the UK.

An analysis of this kind also highlights that it is simplistic to characterize US mobile markets as 'lacking competition'. Rather the US compares in the level of mobile competition with many 4 player European markets if competition is measured by the HHI.

Case studies

The countries covered in case studies are characterised by four-to-three consolidation: Netherlands in 2007, Austria in 2010, Ireland and Germany in 2014. The market consolidation led to the removal of the most disruptive operators, and – notably in the latter three countries - to more symmetric market shares of the leading MNOs, structures which might in theory provide fewer incentives for 'disruptive' competition.

In the more recent mergers in Austria, Ireland and Germany, the Commission tried to avoid the deterioration of competition by making the mergers subject to MVNO access and spectrum divestiture commitments. Although the design of new mobile 'bitstream' remedies in Ireland and Germany with high upfront commitments are interesting, given the recent occurrence of the mergers, it is too early to draw definitive conclusions as regards how these remedies will affect competition and consumer outcomes. In general, there are doubts whether the MVNO access arrangements can compensate for the removal of competitors with a maverick role. It is also doubtful whether the MVNOs that benefit from the commitments will ultimately develop into MNOs and acquire or lease the spectrum provided for in the commitments.

In the Dutch case, the earlier merger was not subject to similar commitments. However, Tele2 which operated as an MVNO on commercially negotiated terms, became a fourth operator in 2013 using spectrum acquired in the 2010 and 2012 auctions, following policies by the Dutch Government to reserve spectrum for a new entrant. The market impact of Tele2 as new entrant MNO, however, is to date small.

Implications for competition policy

As regards questions over the approach towards merger control, our analysis suggests that a benign merger control approach which generally welcomes three-to-four consolidation in mobile markets would not be grounded on empirical facts.

UK consumers have benefited from generally positive outcomes, for which the competitive market structure may have been a contributing factor. It is important not to jeopardize the existing positive outcomes by taking decisions which change the market structure without a thorough analysis which focuses on specific factors affecting the UK.

Countries which are ahead of the UK in terms of 4G deployment have benefited from earlier licensing of 4G spectrum. Deployment also has been stimulated in many of those countries by a higher demand for data-intensive mobile services. Meanwhile the UK has caught up with 4G rates reaching 84% in 2014.

Competition policy should take account of the particular national circumstances of the UK mobile market. Previous commitments by merging parties in other jurisdictions would have to be carefully scrutinized as to whether they would be effective in a UK environment. It is not clear that they would be able to substitute for the current amount of network competition in the UK. It should also be noted that 4 to 3 consolidations are difficult to reverse und the merger commitments, while striving to keep markets open, do not appear to be effective in this respect.

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1 Introduction

1.1 Context

Mobile network operators (“MNOs”) across Europe have put forward the argument that they are hampered by the degree of competition in their markets, chiefly because the high level of competition leads to lower levels of investment. Less investment, the argument runs, slows down the roll-out of new networks and prevents better consumer outcomes in terms of availability, choice, price and speed. Specifically, there is an argument sometimes put forward that in the US mobile sector there is a virtuous circle between less intense competition, higher operator profitability, and increased investment, which has resulted in better consumer outcomes. The contrasting position sometimes put forward is that in the EU, mobile network operators make lower returns on capital because of intense competition and stringent regulation, which in turn has led to lower investment and relatively poorer consumer outcomes.

This study provides evidence-based analysis of the effect of competition on investment and consumer outcomes in the mobile sector. It explores the hypothesis as to whether there is a ‘virtuous circle’ of competition and investment in mobile markets, and the conditions under which there may be potential conflict between the two policy objectives of promoting competition and investment.

In doing so, we have assessed evidence from 12 countries, eight of which are European (besides the UK: Austria, France, Germany, Ireland, Italy, Netherlands, Spain) and four are non-European (Australia, Japan, South Korea and the U.S.). The data available at the time of the study mostly relate to 2013.

This study aims to provide insights that may be relevant to competition and spectrum policy at European level, as well as providing an input to Ofcom’s Strategic Review of Digital Communications which specifically considers competition and investment in converged communications infrastructure.

1.2 Structure of report

The report is structured as follows:

Section 2 assesses consumer outcomes in mobile markets by means of rankings regarding availability, connection speed, price, take-up and usage, and draws insights as to the UK’s positioning versus other EU and non-EU countries.

Section 3 assesses investment in mobile markets by means of CAPEX rankings and looks at the UK’s positioning.

Section 4 identifies the factors that drive investment. It assesses the empirical evidence as to whether more concentrated markets with three players lead to higher investment

than less concentrated markets with four players. It also identifies the important role that other factors play for investment.

Section 5 looks at the factors which explain consumer outcomes. A major question is whether more concentrated markets with three players lead to better consumer outcomes. The answer critically hinges on the relationship between competition and investment. Again, as the study shows, other factors exert an important role.

Section 6 presents case studies of four countries where consolidation has taken place as a result of mergers and looks at the impact of consolidation in these countries. Countries assessed are Austria, Germany, Ireland and the Netherlands.

Section 7 summarises the conclusions on the existence of a virtuous circle between less intense competition, higher operator profitability, and increased investment, and good consumer outcomes.

The Annex shows country rankings based on alternative consumer outcomes and metrics for connection speeds. It also provides an overview of econometric studies on the relationship between competition and investment, respectively consumer outcomes.

2 How do consumer outcomes in mobile markets compare?

2.1 Metrics

Consumer outcomes include the availability of mobile voice and broadband services, connection speeds and price. Availability, connection speed and price are major determinants of two other consumer outcomes which are the take-up (or penetration) of the services and their usage intensity (Figure 1).

Figure 1: Consumer outcomes

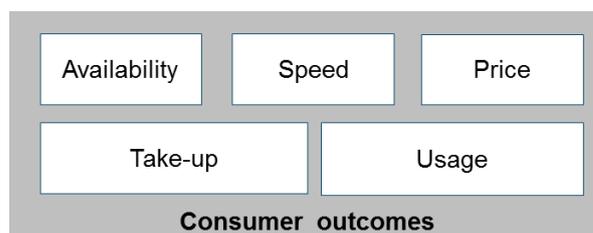


Table 1 shows the metrics and data sources we have used in the empirical analysis. While we have also included voice outcomes, the emphasis of the analysis is on broadband outcomes.

Table 1: Consumer outcomes: Metrics and sources of data used

Consumer outcome	Metric used	Source
Availability	3G population coverage 4G population coverage	Point Topic, HIS/VVA, DAE scorecard; OECD; various others for non-EU countries
Speed	Average connection speed Maximum download speed	Akamai Ookla
Price	Average monthly price of various baskets <ul style="list-style-type: none"> • 30 calls/100MB • 300 calls/1GB • 900 calls/2GB • 500MB laptop use • 2GB laptop use • 10GB laptop use • 30 calls • 100 calls • 300 calls • 900 calls • 40 prepaid calls • 400 prepaid SMS 	OECD/Teligen
Take-up (penetration)	Mobile subscriber penetration (pop) Mobile broadband penetration (pop) 4G penetration (pop)	New Street; OECD; statista.com; various others
Usage intensity	Average minutes per user, Average traffic (GB) per user	New Street; Cisco VNI Forecast Widget

Availability

As 2G services are generally available throughout the countries studied, we focus on availability of 3G and 4G services. Availability is measured by the percentage of the population to which 3G and 4G services are available as measured by HIS/VVA (2014) for the European Commission. According to the definition a household has 4G coverage if it is in the stated coverage area for at least one 4G mobile network

It should be noted that the metric cannot provide a full picture. First, as HIS/VVA states, “definitions are not designed to be rigorous definitions from an engineering point of view, but rather are intended to reflect practical definitions used by NRAs and ISPs.” Second, it does not capture the extent to which locations outside inhabited areas are covered, e.g. roads, ports and waterways, which are also important to users. Population coverage is however a better measure than overall territorial coverage, notably if countries are included which comprise large parts of remote and uninhabited areas where mobile networks are not rolled out (cf. Australia). Third, the metric only considers outdoor coverage. Equally important, notably for 3G/4G, is indoor coverage.

Connection speed

For measuring connection speeds, we use data from software-based tests of end users’ connections provided by Akamai and Ookla.

- Akamai estimates users’ average connection speed for a large number of countries from the time taken to deliver content of a known size from Akamai’s platform.
- Ookla provides users with applications, which they can download for testing their connection speed. The results are collated by Ookla into estimates of average speeds in a country.

We use Akamai and Ookla, because results are publicly available for a number of years for all countries selected in our study. We note however that the results should be treated with caution as it is difficult to control the environment in which software testing takes place.⁴ It would be more appropriate to use equipment-based testing using the same methodologies in all countries compared. Data based on equipment-based testing was however not available for the set of countries selected for this study.

Speeds measured by Ookla are considerably higher than those measured by Akamai. However, this should not matter for analytical purposes if the ranking of countries is similar for both measures. In practice, there is a weak correlation between Akamai and

⁴ See Ofcom (2014, p. 37-38) about its reservations with regard to software-based testing of fixed-line broadband speeds.

Ookla on mobile.⁵ Given differences in the ranking for the UK, we have shown how the results would differ if different sources were used.⁶

Price

Price is measured by the monthly average expenditure incurred by users of predefined baskets of mobile services. We have used the widely cited OECD/Teligen data, which provide prices for mixed voice/data baskets, baskets for laptop-only use and voice/SMS-only baskets.

A problem with predefined price plans is that the plans selected may not be representative, at least not for all countries compared. The large number of baskets defined by OECD/Teligen however largely mitigates this potential problem.

For consolidating the pricing information we have calculated simple averages of prices for bundles that include voice calls and for bundles that include broadband Internet. Weighted averages would have been more appropriate, but the lack of the relevant subscriber weights did not allow us to do so.

Basket-based prices are more likely to offer a direct comparison between services than ARPU, which may be affected by volumes and types of services consumed.

Take-up

Take-up or penetration is measured by the percentage of the population that has subscribed to a mobile service ('mobile penetration'), a mobile broadband service ('mobile broadband penetration') or specifically a 4G service ('4G penetration'). Mobile broadband penetration is usually higher than LTE penetration as it also takes into account 3G-only use.

The penetration of the population is a widely used measure of take-up. It may however not reveal the „unsubscribed“ portion of the population because multi-SIM usage drives penetration rates above the “true” population penetration. This may distort rankings that include both countries where most mobile connections are pre-pay and characterised by high levels of multi-SIM usage (i.e. Italy) and countries where connections are mainly post-pay and there is lower multi-SIM use (i.e. U.S.).

Usage

Usage intensity for a service is measured by the average monthly usage per subscriber.

⁵ The correlation coefficient is 0.6 for mobile. There are stronger ranking correlations for fixed broadband speeds.

⁶ See Annex on alternative rankings (Section 7.1).

For mobile voice services, we use average monthly number of minutes per user as reported by New Street.

For mobile broadband services, we use the average monthly traffic (measured in GByte) per user. Usage of bandwidth is an important indicator as to the extent to which consumers and business make use of broadband connections in practice. Bandwidth usage per subscriber per month, can be measured by operators directly (but is often not published), collected by applications installed on end-user equipment or predicted by equipment manufacturers. In this study, we use estimates of bandwidth usage from Cisco Visual Networking Index (VNI).

2.2 Countries compared

2.2.1 Availability

3G services are now widely available in developed countries. All countries in our comparison, except Ireland and Germany have 3G coverage of more than 97%. With 3G coverage of almost 99%, UK is among the best covered countries. 7 other countries have only marginally higher coverage than the UK.

4G networks are still rolled-out in most countries depending on the date of licensing of new 4G spectrum and refarming of existing spectrum. In 2013, the UK had not yet caught up with other countries, some of which have licensed 4G spectrum much earlier. The picture had already changed by the end of 2014, when the most extensive network operated by EE already covered 81% of UK premises.⁷ As part of the 800MHz license terms, Telefonica O2 has an obligation to deliver at least 98 per cent indoor reception nationwide by the end of 2017 (expected to cover at least 99% when outdoors). The Commission’s recent Implementation Report notes an LTE coverage of 84% for 2014.⁸

Figure 2: Coverage of 3G and 4G services



Source: IHS/VVA/DAE scorecard; OECD; various others for non-EU countries

⁷ See Ofcom (2015, p. 61), which regularly measures mobile broadband performance.

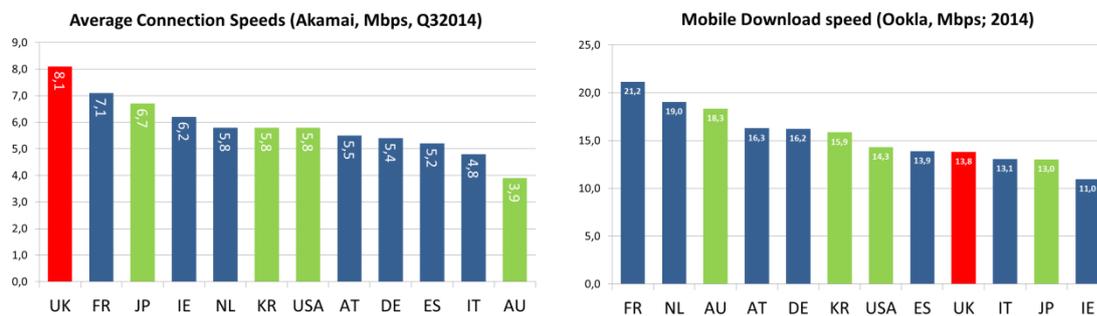
⁸ European Commission (2014), p. 313.

2.2.2 Speed

The lower roll-out of 4G networks is not reflected in lower UK connection speeds if Akamai data is used. In fact, average connection speed in 2014, as measured by Akamai, is higher in the UK than in any other EU or non-EU country.

There are however substantial differences between the Ookla and Akamai ranking as Figure 3 shows, which affect the UK's relative position. While we report this metric, we therefore treat it with some caution – and refer to both sources.

Figure 3: Connection speed of mobile broadband services



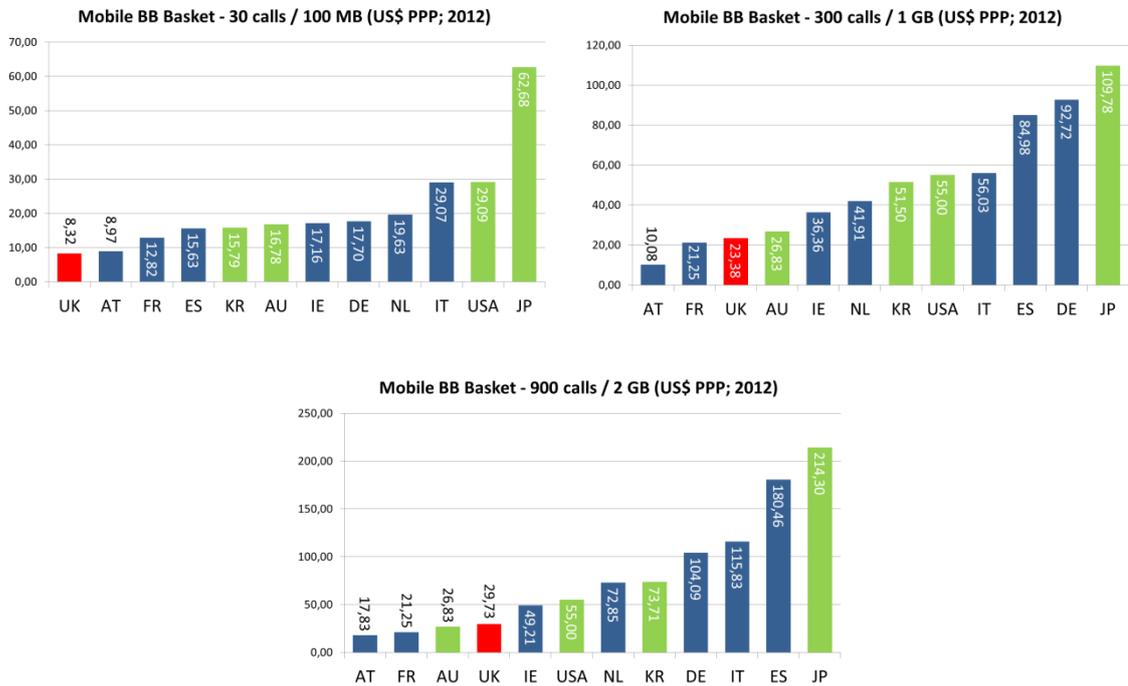
Source: Akamai, Ookla

2.2.3 Prices

UK consumers get a particularly good deal in terms of prices. The OECD pricing data shows that, across the whole range of mobile baskets, the UK fares particularly well, whether compared to EU or non-EU countries. For all mobile baskets – mixed calls/data baskets, data-only baskets and calls/SMS-only baskets – the UK is among the top countries and in many cases the most advantageous for consumers. This is shown by Figure 4 (mixed calls/data bundles), Figure 5 (laptop use) and Figure 6 (calls/SMS only). The favorable position of the UK among the EU countries included in this study is confirmed by recent Digital Agenda Scoreboard data.⁹

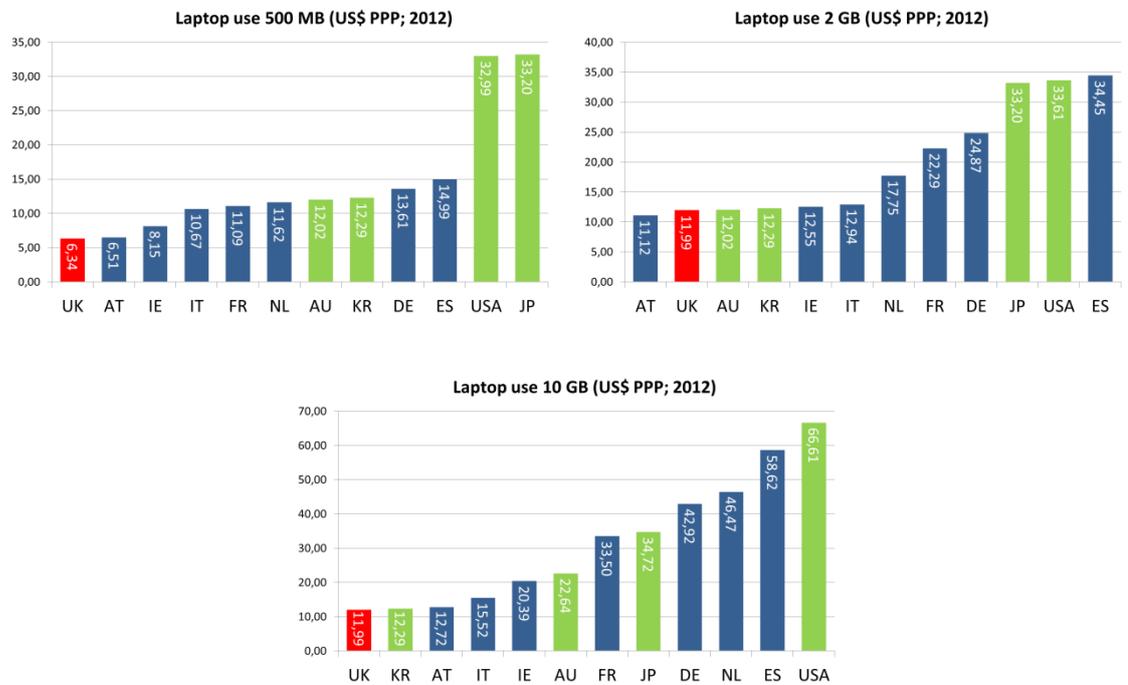
⁹ See European Commission (2015c), p. 35-36. The pricing data have been collated by van Dijk.

Figure 4: Prices of mixed calls/broadband baskets



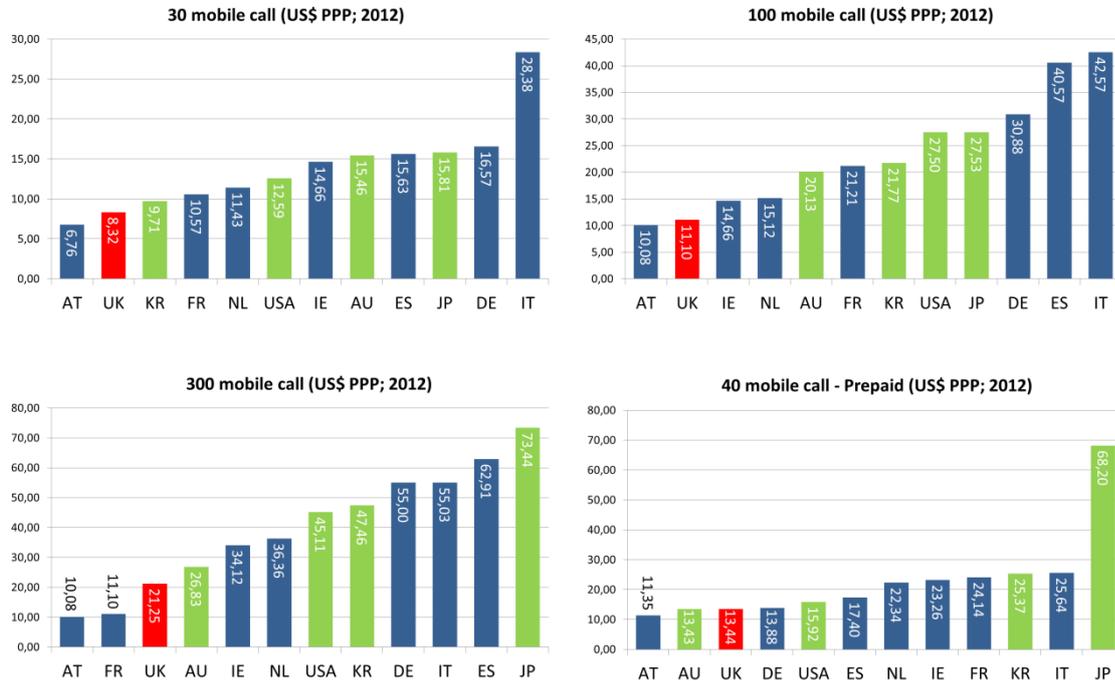
Source: OECD

Figure 5: Prices of broadband-only baskets (laptop use)



Source: OECD

Figure 6: Prices of calls-only baskets



Note: The UK is equally well ranked for very large bundles of minutes (900 minutes) and SMS (400 SMS), which are not shown in the Figure.

Source: OECD

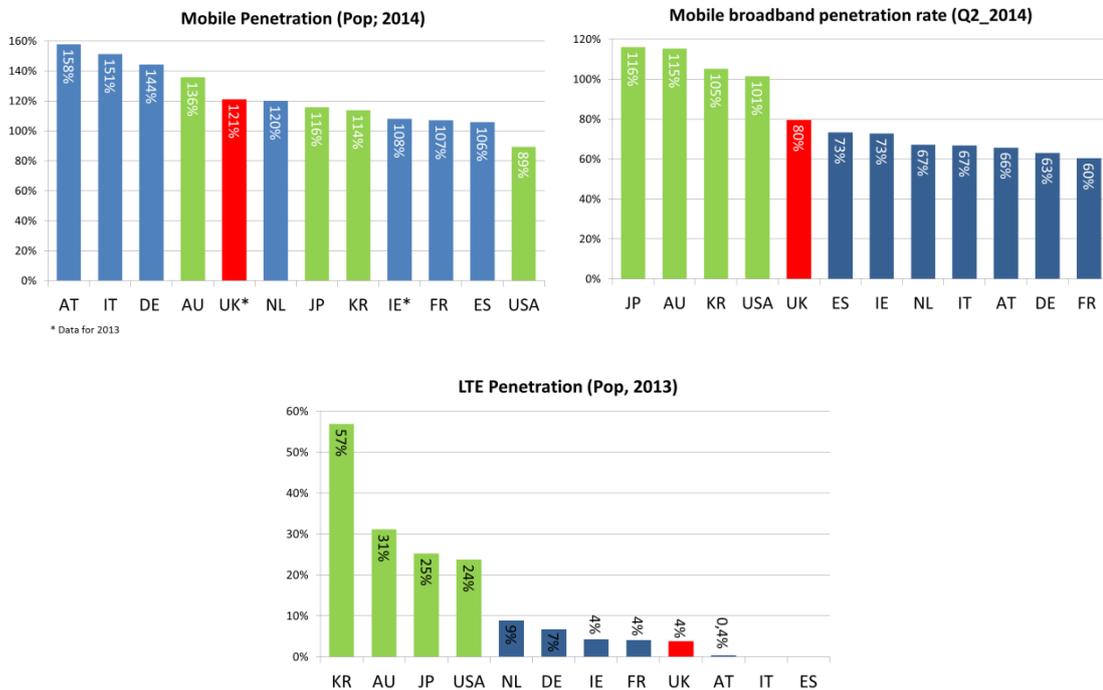
2.2.4 Penetration

The UK is well penetrated with mobile services as Figure 7 shows. Because of multi-SIM usage the mobile penetration rate stands at 121%. The UK has a middle place in the EU, and – if compared to non-EU countries - is only passed by Australia.

The picture with regard to mobile broadband services is mixed. With a mobile broadband penetration of 80% in Q2/2014, the UK was clearly ahead of other EU countries, but behind the assessed non-EU countries.

Because of the relatively late licensing of new 4G spectrum, the UK encountered an initial delay compared to non-EU and other EU countries. With 4G penetration of 4%, the UK was number 5 among the EU countries, and behind the non-EU countries.

Figure 7: Penetration with mobile subscriptions, mobile broadband services and 4G services



Source: New Street; OECD; statista.com; various others

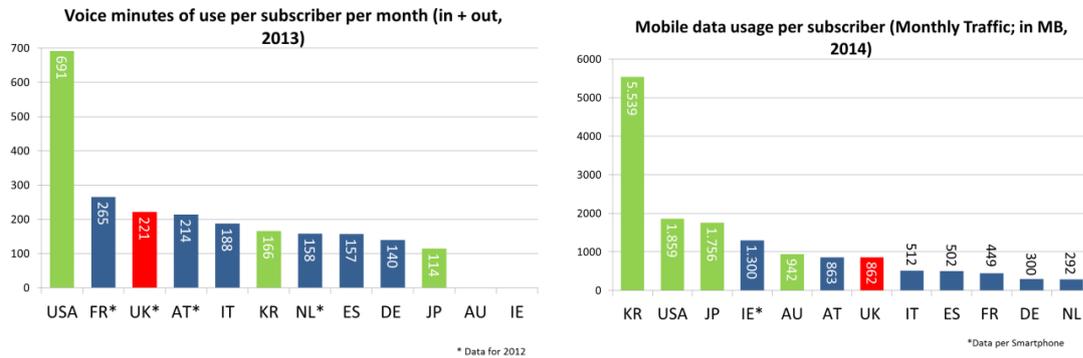
2.2.5 Usage

Good consumer outcomes in the UK in terms of availability, prices and connection speeds should promote usage of mobile services. In fact, the UK is among the top-3 countries in terms of mobile voice usage: With 221 minutes per subscriber, the UK is 2nd placed in the EU (behind France) and also 2nd if compared with non-EU countries (behind the U.S.) as Figure 8 shows.

In turn, good prices and high connection speeds are not yet reflected in a top UK rank for mobile data usage. With 862 MB per subscriber, the UK is 3rd among EU countries, but well behind data usage in most non-EU countries.

Mobile data usage is to a large degree driven by mobile video. The countries that have the highest data usage – Korea, USA and Japan – are also those with the highest mobile video usage, as we will discuss in Section 4.2.2.

Figure 8: Usage intensity of voice and broadband



Source: New Street; Cisco VNI Forecast Widget

2.2.6 Linkages between consumer outcomes

Table 2 shows the linkages between consumer outcome variables: 4G coverage, connection speed, price of mobile baskets, mobile broadband penetration, and usage. The Table indicates strong correlations (if the correlation coefficient is 0.7 or higher, it is marked in green with “++”) and weak correlations (if the correlation coefficient is between 0.5 and 0.7, it is marked in yellow with “+”).

Table 2: Correlations between consumer outcomes

	4G coverage	Connection speed (Akamai)	Connection speed (Ookla)	Price for mobile basket including calls	Price for mobile including Internet	Mobile broadband penetration	Voice usage	Data usage
4G coverage								
Connection speed (Akamai)								
Download speed (Ookla)	++	+						
Price for basket including calls								
Price for baskets including Internet				++				
Mobile broadband penetration	+							
Voice usage								
Data usage	+					+	++	

Note: Green (++) if correlation coefficient is above 0.7. Yellow (+) if correlation coefficient is between 0.5 and 0.7.

To measure speed, price and usage, we have used two variables in each case. It is interesting to note how the variables are correlated:

- Speed is measured by Akamai or Ookla. Both variables are positively correlated, though the correlation is weak as measurement approaches of Akamai and Ookla are different.
- Prices are measured for (i) baskets that include calls and for (ii) baskets that include mobile Internet. There is a strong correlation between both price measurements. The reason is that mixed baskets that include both calls and Internet enter into both price measurements.
- Usage intensity is measured for voice and data. There is a strong positive correlation between data usage and voice usage.

Regarding the linkages between the five consumer outcomes - availability, speed, price, penetration and usage, the following correlations exist:

- 4G coverage has a strong positive linkage with download speeds measured by Ookla. This linkage, however, does not exist between 4G coverage and connection speeds measured by Akamai.
- There is a weak positive linkage between 4G coverage and mobile broadband penetration. This may be explained by availability of fast mobile broadband connections being a necessary condition for users to subscribe to mobile broadband accesses.
- There is a weak positive linkage between 4G coverage and mobile data usage. Again this may be easily explained: availability of fast mobile broadband connections is a necessary condition for subscribers to use data-intensive services.
- Finally, there is a weak positive linkage between mobile broadband penetration and data usage. The availability of, and demand for, data-intensive services may provide an incentive for users to connect to a mobile broadband network.

2.2.7 Rankings

2.2.7.1 UK versus all other countries

Compared to 11 other countries, UK customers overall get a good deal. The UK ranks high in two voice outcomes (average minutes of use and price of baskets including voice) and two broadband outcomes (average connection speed and price of baskets including Internet). Note that, for 3G coverage, the difference between the UK and the leading countries is very small, such that 3G coverage in the UK is comparable to the top countries.

In many other consumer outcomes, the UK has a medium rank. This includes mobile penetration, mobile broadband penetration and data usage. The exception is 4G

coverage and 4G penetration, where the delay in licensing of new 4G spectrum is the prime reason why the UK was placed behind in 2013. It should be noted that 4G coverage has increased since then and likely improved the UK rank.

Table 3: UK versus all other countries - Ranking

	Broadband outcomes							Voice outcomes		
	3G Coverage	4G Coverage	Average connection speed (Akamai)	Average Price of mobile baskets with internet	Mobile BB penetration	LTE penetration	Data usage	Average Price of mobile baskets with calls	Mobile penetration	Voice usage
UK	8	8	1	2	5	9	6	2	5	3
France	2	6	2	4	11	8	10	3	11	2
Germany	12	5	9	10	12	6	11	9	3	9
Italy	10	10	11	8	8	na	9	10	2	5
Spain	3	9	10	11	7	na	8	11	7	8
Austria	9	12	8	1	9	10	7	1	1	4
Ireland	11	11	4	5	6	7	4	5	10	na
Netherlands	3	3	5	6	10	5	12	7	6	7
Australia	3	7	12	3	1	2	5	4	4	na
Japan	1	3	3	12	2	3	2	12	8	10
South Korea	3	1	5	7	3	1	1	6	9	6
US	7	2	5	9	4	4	3	8	12	1

2.2.7.2 UK versus other EU countries

If the UK is compared to other EU countries, UK consumers mostly get a very good deal. In many respects, consumers are better served in the UK than in other EU countries: The UK ranks 1st or 2nd in two voice outcomes (price and average minutes of use) and four broadband outcomes (mobile broadband penetration, average connection speed, price and data usage). For all other consumer outcomes, the UK has a medium rank, except for LTE penetration, where in 2013 it still lagged behind.

Table 4: UK versus other EU countries – Ranking

	Broadband outcomes							Voice outcomes		
	3G Coverage	4G Coverage	Average connection speed (Akamai)	Average Price of mobile baskets with calls	Mobile BB penetration	LTE penetration	Data usage	Average Price of mobile baskets with internet	Mobile penetration	Voice usage
UK	4	4	1	2	1	5	2	2	4	2
France	1	3	2	3	7	4	6	3	8	1
Germany	8	2	6	6	8	2	7	7	3	7
Italy	6	6	8	7	4	na	5	6	2	4
Spain	2	5	7	8	3	na	4	8	6	6
Austria	5	8	5	1	5	6	3	1	1	3
Ireland	7	7	3	4	2	3	1	4	7	na
Netherlands	2	1	4	5	6	1	8	5	5	5

2.2.7.3 UK versus non-EU countries

While comparisons between the EU, the U.S. and Asia have often placed Europe behind the other regions, a direct comparison of the UK with major non-EU countries provides positive results. The UK ranks 1st or 2nd in three voice outcomes (price, mobile penetration and voice usage) and two broadband outcomes (price and average connection speed as measured by Akamai). The 3G coverage difference to the leading non-EU countries is negligible.

A gap exists with regard to other broadband outcomes, namely 4G coverage, mobile broadband penetration, 4G penetration, and data usage.

Table 5: UK versus non- EU countries - Ranking

	Broadband outcomes							Voice outcomes		
	3G Coverage	4G Coverage	Average connection speed (Akamai)	Average Price of mobile baskets with calls	Mobile BB penetration	LTE penetration	Data usage	Average Price of mobile baskets with internet	Mobile penetration	Voice usage
UK	5	5	1	1	5	5	5	1	2	2
Australia	2	4	5	2	1	2	4	2	1	na
Japan	1	3	2	5	2	3	2	5	3	4
South Korea	2	1	3	3	3	1	1	3	4	3
US	4	2	3	4	4	4	3	4	5	1

2.2.7.4 Overall ranking with equal weighting of consumer outcomes

Table 6 provides an overall ranking on the basis of an equal weighting of all consumer outcomes for purely illustrative purposes. Based on an equal weighting of all consumer outcome parameters used, the top-4 performers comprise South Korea, Australia, UK and the US. The good performance of the UK reflects its low price level and high connection speed (as measured by Akamai).

It should be noted that different metrics, a different list of consumer outcomes, and/or other weightings can result in a lower rank for the UK.

- Using connection speed measurements by Ookla does not affect the UK rank (see Annex/Section 7.1).
- Considering only broadband outcomes (either with Akamai or Ookla measurements of connection speeds) moves the UK to the middle group of countries (see Annex/Section 7.1 for alternative rankings).
- It is debatable whether attaching equal weights to all consumer outcomes reflects consumer preferences. Reasonable alternative weightings, however, are unlikely to change the overall positive picture for the UK.

Table 6: Overall ranking with equal weighting of consumer outcomes

	Broadband outcomes							Voice outcomes			Number of observations	Average rank value	Overall rank
	3G Coverage	4G Coverage	Average connection speed (Akamai)	Average Price of mobile baskets with internet	Mobile BB penetration	LTE penetration	Data usage	Average Price of mobile baskets with calls	Mobile penetration	Voice usage			
South Korea	3	1	5	7	3	1	1	6	9	6	10	4,2	1
Australia	3	7	12	3	1	2	5	4	4	na	9	4,6	2
UK	8	8	1	2	5	9	6	2	5	3	10	4,9	3
US	7	2	5	9	4	4	3	8	12	1	10	5,5	4
Japan	1	3	3	12	2	3	2	12	8	10	10	5,6	5
France	2	6	2	4	11	8	10	3	11	2	10	5,9	6
Austria	9	12	8	1	9	10	7	1	1	4	10	6,2	7
Netherlands	3	3	5	6	10	5	12	7	6	7	10	6,4	8
Ireland	11	11	4	5	6	7	4	5	10	na	9	7,0	9
Italy	10	10	11	8	8	na	9	10	2	5	9	8,1	10
Spain	3	9	10	11	7	na	8	11	7	8	9	8,2	11
Germany	12	5	9	10	12	6	11	9	3	9	10	8,6	12

Conclusions

The UK's performance in context:

The UK mobile industry generally performs well and UK customers get a good deal:

- Mobile voice services are ubiquitously available in the UK at a low price. Mobile subscriber penetration and voice usage is high.
- Mobile broadband services are widely available in the UK as far as 3G is

concerned. In contrast, availability of 4G services in 2013 was behind most other countries due to the delay in licensing of 4G spectrum, but this has subsequently changed. Average connection speeds (as measured by Akamai) and prices are very favorable. The UK must however further catch up in terms of 4G penetration and data usage.

- Based on a simple average of all consumer outcome parameters, including broadband and voice outcomes, the UK is placed among the top-4 countries. Different metrics, list of consumer outcomes and/or weightings can change the rankings, but do not to affect the overall positive picture for the UK.

Is Europe 'falling behind'?

While comparisons between the EU, the U.S. and Asia have often placed Europe behind the other regions, this is not generally confirmed by our analysis. Many European countries fare well in terms of 3G coverage, connections speeds and prices as well as mobile subscriber penetration and voice usage. However, many European countries also have to catch up in 4G outcomes. Europe, as a whole, certainly has to further improve 4G coverage, mobile broadband penetration (notably 4G penetration) and data usage (which is driven by 4G).

Overall, all consumer outcomes taken together, the UK leads the European countries. The direct comparison of the UK with major non-EU countries also suggests that the UK is not behind. The UK ranks generally high in voice outcomes and also performs well in three broadband outcomes (3G coverage, average connection speed and price). There is however a gap in terms of 4G coverage (which has subsequently narrowed down), 4G penetration and data usage which is visible if the UK is compared with non-European countries. The later 4G spectrum auction may be one cause of this difference.

3 Does competitive intensity reduce investment?

In this section we assess the hypothesis that competition may hamper investment, and discuss other factors that may explain differing investment levels in different countries. Our main focus is whether a reduction of the number of MNOs and an increase in market concentration influences investment. *Section 3.1* first summarises theoretical arguments on the relationship between competition and investment. *Section 3.2* sets out the empirical evidence in qualitative and econometric terms.

3.1 Theoretical arguments

The impact of consolidation on investment is complex as different effects overlap. In a market with a few larger players, operators may be better able to achieve efficiencies. Three efficiencies have been considered as relevant for mobile markets:¹⁰

- Larger operators are able to spread fixed network and spectrum costs over a larger customer base and realise lower unit costs (economies of scale). At lower unit costs, it may become profitable to further roll out 3G/4G networks into areas that cannot be profitably served by smaller operators. Thus there may be a positive effect on investment.
- Larger operators which have more spectrum can more easily aggregate spectrum assets into technically and economically efficient packages. LTE requires a minimum amount of contiguous spectrum and connection speeds can be further increased with larger blocks of spectrum.¹¹ 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). Finally, the relative amount of spectrum required for maintaining continuity of 2G services will be smaller in a 3-player market than in a, say, 4-player market.
- Larger operators can more easily develop commercial partnerships to deploy innovative services, e.g. mobile banking or 'smart car' technologies. The chances of finding a partner in the financial or car sector to deploy an innovative service may be higher for a mobile operator with a large customer base than for a small operator.

It should be noted that some, if not all, of the mentioned benefits could also be realised under certain cooperative or regulatory arrangements. The efficiencies that a large operator may achieve over smaller operators are less pronounced or largely evaporate if the following alternative approaches are considered:

¹⁰ See e.g. Frontier (2015).

¹¹ E.g., 2x10MHz is generally considered necessary for 800MHz spectrum and 2x20MHz for 1800MHz spectrum.

- Economies of scale could also be achieved through network sharing agreements. Mobile operators could strike network sharing arrangements for lower density areas in order to share the cost of network deployment.
- Efficient spectrum aggregation could be promoted by appropriate spectrum management policies. In fact, when new spectrum is auctioned, regulators pay much attention to safeguarding that bidders can realise efficient blocks of contiguous spectrum. Regulators may also make refarming of spectrum bands subject to a reallocation of spectrum if this is required to ensure efficient block sizes or avoid competitive distortions. Finally, spectrum trading may play an important role in fine-tuning spectrum assignments.
- Commercial partnerships of MNOs with the banking and car industry could be arranged in a cooperative approach. In fact, it may be preferable to have common arrangements agreed upon by MNOs provided that new players and/or MVNOs can enter into such arrangements on a non-discriminatory basis.

Moreover, it is debatable whether the efficiencies claimed to occur in consolidated markets are fully exploited by the larger entities. Consolidated markets may be characterised by less competition and more market power. Market power gives operators discretion over prices and quality. They may choose not to lower prices or not to improve services, or delay price decrease and service innovations if such strategy preserves profit margins.

The impact of market power on investment in technologically progressive industries is however more complex:

- With an increase in market concentration, firms will have a weaker incentive to leapfrog their rivals by investing in new technologies to gain higher profits, since firms can generate higher profits without investing. Higher concentration levels in this context reduce the incentive of operators to 'escape competition'.
- This is counter-balanced by what has been termed the Schumpeterian effect. With increasing market power, firms can expect higher future profitability when investing (which is an important investment incentive). With less competition, it becomes less likely that profits from an investment will be competed away. It is hypothesized that this Schumpeterian effect would increase in a concentrated market with market power.¹²

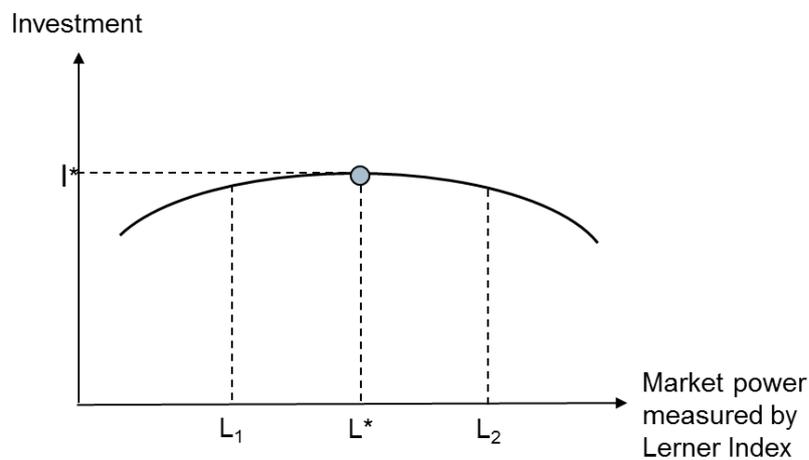
Another theory, incorporating both the 'escape-competition' and Schumpeterian effect, is offered by Houngbonon and Jeanjean (2014).¹³ They have constructed a model for the mobile industry that yields an inverted-U shaped relationship between market power and investment as depicted in Figure 9. It should be noted that the model equates

¹² Industry representatives also attribute a positive effect to market power, because current profitability may facilitate funding of investment.

¹³ See also the seminal paper of Aghion et al. (2002).

market power with the profit margin and not with the number of MNOs or a market concentration measure¹⁴. The model predicts that, at low levels of market power, investment can be increased through consolidation and the resulting increase in market power. The inverted U-shaped relationship between market power and investment is created by the specific modelling assumptions. Note that the model relates firm investment to market power as perceived by the firm. It does not allow to conclude that a 4 to 3 consolidation would increase aggregate industry investment.

Figure 9: U-shaped theory – posited relationship between market power and investment



Conclusions

On the theoretical relationship between investment and competition:

The impact of consolidation on investment is complex as different effects overlap:

- Consolidation is more likely to decrease investment of individual firms if the “escape-competition” effect dominates: The escape-competition effect predicts that, with a decrease in competition intensity, firms will have a weaker incentive to leapfrog their rivals, since market power will already generate profits in the absence of investments.
- Consolidation is more likely to increase investment of individual firms if the Schumpeterian effect dominates: The Schumpeterian effect postulates that, as consolidation decreases competition intensity, firms can expect higher future profitability (which creates an incentive to invest) and also achieve higher

¹⁴ Houongbonon and Jeanjean (2014) use the Lerner Index as a measure of monopoly power. The Lerner Index is the difference between price and marginal cost over price. [1-Lerner Index] serves as the measure of competition intensity.

current profitability (which may facilitate funding of investment).

There are theoretical models that predict an inverted U-shaped relationship between competition intensity as perceived by individual firms (measured by profit margins) and investment. Thus market consolidation may result in an increase or decrease of investment of firms. Ultimately, the precise nature of the relationship between consolidation and investment can only be established on the basis of an empirical analysis. It should also be noted that consolidation may reduce *aggregate* investment in the mobile market even though each of the remaining players may invest more than prior to consolidation.

3.2 Empirical evidence

3.2.1 Metrics

The relevant factors potentially driving investment are depicted in Figure 10. Besides competition, there are a variety of other factors that may impact on investment and therefore might explain differences in investment in international comparisons.

Figure 10: Factors potentially driving investment

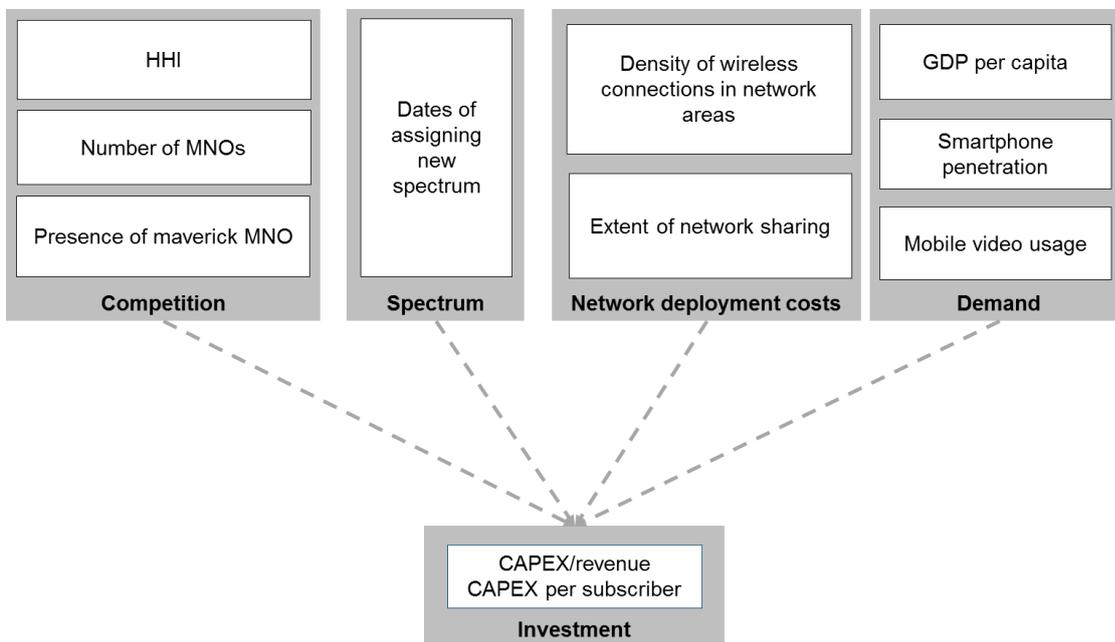


Table 7 lists the metrics and data sources we have used. The metrics are discussed thereafter.

Table 7: Investment and factors driving investment: Metrics and sources of data used

Indicator	Metric used	Source
Investment	CAPEX-revenue ratio , CAPEX per subscriber	New Street
Profitability	EBITDA/revenue margin , ROCE (return on capital employed)	New Street
Competition	HHI based on revenues or subscribers	New Street
	Number of MNOs	WIK
	Presence of maverick MNO	WIK
Dates of assigning new spectrum and refarming existing spectrum	Year of first 3G/2000MHz and 4G/700-800MHz auction	WIK WIK
Network deployment costs	Share of rural population	Worldbank, OECD
	Form of network sharing (site/mast sharing, RAN sharing, national roaming)	GSMA, Frontier, other sources
Demand	GDP per capita	Worldbank
	Smartphone penetration	Cisco VNI Forecast Widget; New Street
	Use of mobile video	Cisco VNI Forecast Widget; New Street

Investment

Investment is measured by the CAPEX/revenue ratio and CAPEX per subscriber as reported by New Street. CAPEX figures must be interpreted with care.

- First, CAPEX measurements in different countries may be based on different methodologies, in particular as regards the treatment of spectrum acquisitions.
- Second, CAPEX comparisons between MNOs or between countries may be misleading if limited to a single year. CAPEX follows a cyclical pattern, since technological change is implemented in successive generations of technologies. CAPEX is closely correlated to periods in which there are network deployments and technology upgrades.
- Third, it is useful to relate CAPEX to subscribers or revenue, in order to adjust for different market sizes in international comparisons. We prefer to use the CAPEX to revenue ratio, as CAPEX per subscriber, if used in international comparisons, is sensitive to exchange rate changes.

Profitability

Profitability is measured by the EBITDA to revenues ratio (EBITDA margin) as reported by New Street and defined as follows:

$EBITDA\ margin = \frac{EBITDA}{Revenues}$, where

EBITDA = Earnings before Interest, Tax, Depreciation and Amortisation

Revenues = Retail and wholesale revenues, incl. from sales of terminal equipment

An alternative measure is post-tax ROCE (Return on Capital Employed):

$ROCE = \frac{FCF}{Capital\ Employed}$, where

FCF = Operating Free Cashflow tax = EBITDA – CAPEX

Capital Employed = 5 year rolling sum of CAPEX plus a fair value of spectrum holdings (5 years' CAPEX implies a ten year average asset life, half depreciated).

A core difference between the measures is that EBITDA margins do not reflect expenditure on spectrum, while typically the measure of 'capital employed' used in the context of ROCE includes spectrum costs. In its assessment of ROCE, New Street uses what it deems a 'fair value' for spectrum costs.¹⁵ In markets where spectrum is allocated without spectrum charges, such as in Japan, New Street uses zero for capital employed in spectrum.

In Europe, New Street has also calculated an 'adjusted FCF' based on a normalised capex figure (a five year average), with the aim of smoothing spikes.

Competition

Competition between MNOs is measured by the Hirschman-Herfindal Index (the sum of the squared percentage market shares, which may take a value of up to 10.000 in case of a monopoly) and the number of MNOs. While HHI and number of MNOs are often used as proxies, they are incomplete measures of competition intensity. In a multi-country study they are however the best available indicators. We also use them as we are primarily interested in the impact of consolidation – as reflected in number of operators and market concentration - on investment and consumer outcomes.

¹⁵ With regard to the 'fair value' for spectrum, New Street uses certain base valuations. Where there have been auctions at prices that are materially higher than the base case valuations, New Street uses the higher figure for one year, and then tapers back to the base case valuation over the following four years. For example this applies to the expensive EU 3G auctions in 2000 and to the Austrian and Dutch multiband auctions more recently.

The HHI is calculated on the basis of subscriber numbers as well as revenues reported by New Street. The revenue-based HHI may be more appropriate for competition analysis. However, as shown below, correlation is strong between both indices such that they can be considered substitutes. As we measure infrastructure competition, customers of MVNOs are included in the host network operators' market shares.

Maverick MNOs are identified as smaller MNOs, which actively try to win market share by undercutting prices of the larger operators, and/or by offering service innovations. Mavericks are usually latecomers or new entrants. More concretely, mavericks are characterized by a commercial strategy to increase market share given their (i) limited scale and subscriber base and (ii) low costs of acquiring additional customers due to available spare capacity which provide strong incentive to grow by competing vigorously.¹⁶

Dates of assigning new spectrum and refarming existing spectrum

Deploying new generation networks requires the prior assignment of new spectrum and/or the refarming of existing spectrum.¹⁷ It is clear that a late auction date delays investment into new networks. The auctioning of spectrum for 3G, and subsequently 4G, triggered new investment cycles. There should be a close relationship between date of auctioning and investment, because spectrum license conditions usually contain roll-out obligations and firms usually roll out networks once they have won spectrum. We focus on the two most important dates for 3G and 4G spectrum assignments: the date when new 3G/2000MHz spectrum has been licensed (this was at the beginning of the 2000s) and the date when new 4G/700 or 800MHz spectrum has been licensed (this was at the beginning of the 2010).

Network deployment costs

Countries may substantially differ in terms of deployment costs. Geographical coverage area and the distribution of population in coverage area have an important influence on the cost of network deployment, both in terms of investment for coverage and capacity. A larger geographical area requires more investment into coverage.¹⁸ Moreover, the parts of the coverage area that are densely populated require additional investment into capacity.

Wireless connections per sqm of network area would be a good proxy for network deployment cost, for which however data was not available for the countries compared. Inhabitants per sqkm of national territory is also often used. However, as totally

¹⁶ See the Commission's characterisation of Three in Ireland before its merger with Telefónica. European Commission (2014), summary.

¹⁷ 3G networks operate in the 2.1GHz band (new spectrum). The new 4G networks operate in the 700/800MHz and 2.6GHz bands (new spectrum) as well as 1800MHz band (refarmed spectrum).

¹⁸ A certain minimum amount of population coverage and sometimes territorial coverage is often required by spectrum license conditions.

unpopulated remote areas may not be covered by networks (see Australia), inhabitants per sq km would provide a distorted picture of network density. We therefore used the share of rural population as it may be a better proxy for deployment costs than population density.

Network deployment costs can be reduced with network sharing, and countries may differ with regard to the use of sharing.¹⁹ Different grades of network sharing lead to different cost savings. We measured the extent of network sharing by the following scale:

1. Countries where operators use site/mast sharing, RAN sharing, and (usually limited to a new entrant and an established operator) national roaming; this generates the largest cost savings;
2. Countries, where operators use site/mast sharing and national roaming;
3. Countries where operators use site/mast sharing and RAN sharing;
4. Countries where operators only use site/mast sharing; this produces the lowest cost savings.

We have placed “category 2” with national roaming ahead of “category 3” with RAN sharing. This is however a very crude categorization. It depends on the scope and efficacy of the two infrastructure sharing measures taken in the particular countries. The categorization is therefore to be treated with caution.

Demand factors

Investments may be related to GDP per capita, if higher average income enables greater expenditure on high value telecommunications services such as data. Moreover, a high penetration of smartphones and a high usage of OTT services such as mobile video streaming is likely to promote demand for mobile broadband and drive investment in higher network capacity.

Smartphone penetration is measured by the percentage of inhabitants that use a smartphone.

Mobile video usage is measured by the percentage of mobile subscribers which once a day (or once a week) watch videos on their smartphone.

3.2.2 Quantitative evidence

In this section we explore the quantitative evidence on whether more investment has a linkage to markets with fewer players and higher concentration. We first describe how countries compare in terms of investment and then look at the qualitative evidence that may point at a direct linkage between investment and competition, respectively

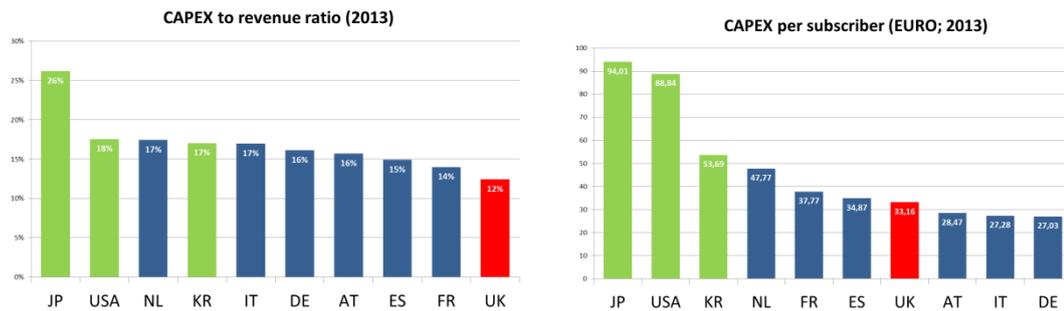
¹⁹ See e.g. OECD (2015a), p. 58-70.

profitability and specific supply and demand factors. The econometric evidence is set out in the section 3.2.3 thereafter.

3.2.2.1 Investment: Countries compared

Investment varies widely between countries. In 2013, the leading countries in both measures were Japan and the U.S. The UK is ranked 4th and 7th among EU countries, but well behind non-EU countries (Figure 11).

Figure 11: CAPEX to revenue ratio and CAPEX per subscriber

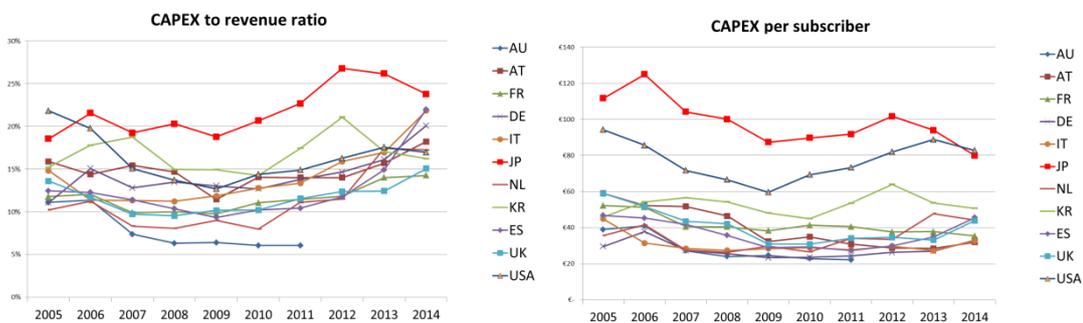


Source: New Street

CAPEX to revenue ratio and CAPEX per subscriber are correlated measures. If CAPEX/revenue and CAPEX per subscriber are measured on an aggregate country basis, as in Figure 11, the correlation coefficient is 0.71. On an operator basis, the correlation between CAPEX/revenue and CAPEX per subscriber is 0.68.

Viewed over a longer term, the CAPEX rankings frequently change, presumably depending on investment cycles; this is shown in Figure 12.

Figure 12: CAPEX trends



Source: New Street

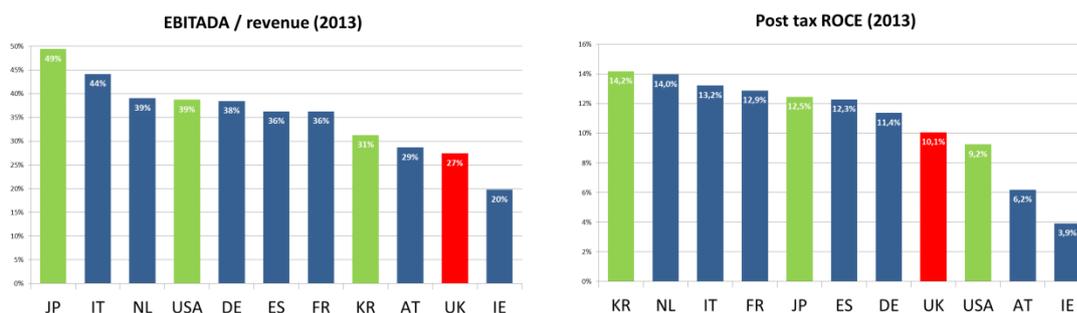
The CAPEX trends also suggest that investment follows cyclical patterns. In fact, both CAPEX/revenue and CAPEX per subscriber are strongly linked to investment values in the previous year. The correlation coefficient is 0.79 for CAPEX/revenue and 0.86 for CAPEX per subscriber if calculated on the basis of operator numbers. It is 0.67 for CAPEX/revenue and 0.93 for CAPEX per subscriber if calculated on the basis of aggregate country averages.

3.2.2.2 Possible factors driving investment: Profitability

A factor widely claimed by the mobile industry to be central for investment is profitability. While investments certainly require a positive expected return, the controversial issue is whether higher profitability *per se* is associated with more investment.

In 2013, profitability - measured by the average EBITDA/revenue ratio - was highest in Japan and Italy. In contrast, South Korea and the Netherlands are first if profitability is measured by average ROCE. On the basis of aggregate country data, the EBITDA/revenues and ROCE are not correlated as is also visible in Figure 13. There is however a positive correlation between EBITDA/revenues and ROCE if measured on an operator basis²⁰.

Figure 13: Profitability

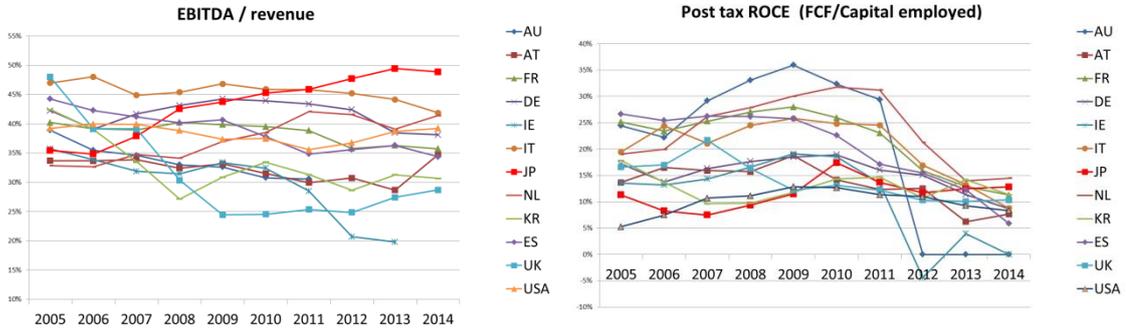


Source: New Street

Viewed over a longer time period, profitability levels and ranking of countries frequently change (Figure 14).

²⁰ The correlation coefficient between EBITDA/revenue and ROCE is 0.26 if measured on an aggregate country basis, but 0.67 if measured on an operator basis.

Figure 14: Profitability trends



Source: New Street

The linkages between investment and profitability measures are set out in Table 8. The Table shows correlation coefficients on the basis of country averages for the period 2005-14.

- A first observation is that there is no linkage between EBITDA/revenue and investment. The correlation coefficients are generally very low. This implies that, in general, countries which have a higher EBITDA margin are not spending a higher portion of revenues on investment or a higher investment amount per subscriber.
- Moreover, countries that on average have a higher ROCE do not invest more on a per-subscriber basis, i.e. there is no linkage between ROCE and CAPEX per subscriber. Moreover, there is, a strong negative correlation between ROCE and CAPEX/revenue, implying that operators with a higher ROCE actually spend a lower portion of their revenues on investment.

Table 8: Correlation coefficients between investment and profitability, country averages, 2005-14

		Investment	
		CAPEX/revenue	CAPEX per subscriber
Profitability	EBITDA/revenue	0.2488	0.3080
	ROCE	-0.7081	-0.3997

The results are also confirmed when looking at possible linkages in individual years. In the large majority of years, correlations between EBITDA/revenue and investment are

insignificant²¹. Moreover, the negative linkage between ROCE and CAPEX/revenue is also visible on a year to year basis.

The results, therefore, do confirm the view that higher profitability transforms into higher investments.

3.2.2.3 Possible factors driving investment: Competition

3.2.2.3.1 Number of MNOs and HHI

A second hypothesis widely voiced by the mobile industry is that consolidation - through a positive effect on profitability - increases investment. Since 2005, intra-market mergers between mobile operators have occurred in 7 countries: Australia, Austria, Germany, Ireland, Netherlands, U.S. and the UK. New entry has happened in three countries; these are Spain, France and the Netherlands. In April 2015, six of the countries assessed now have three-player markets²². The other six countries, including the UK, still have four-player markets (Table 9)²³.

Despite the mergers, there is no general trend towards a higher HHI in the period 2005-14. This is shown by Figure 15. The HHI has increased during this period only in four countries (Australia, Austria, UK and US). It has remained steady in one country (Korea) and even decreased in five countries (France, Germany, Italy, Japan, Netherlands, Spain). Note that, in Germany, the HHI has now increased following the merger between Telefónica and e-plus, which is not reflected in the 2014 data. Also note that, with four players and a HHI of 2700, the UK has a less concentrated mobile market than any other country (taking into account recent German merger).²⁴

²¹ I.e. correlation coefficients are below 0.5.

²² South Korea may move from a 3- to 4-player market in the future. South Korea's government has announced plans to facilitate the entry of a fourth player in the country's mobile market through reservation of spectrum in the forthcoming auction. See <http://www.totaltele.com/view.aspx?ID=490095&mail=1523&C=0>

²³ When counting the number of MNOs, we omit MNOs with regional licenses and MNOs with negligible market shares.

²⁴ We have used the HHI on the basis of subscriber market shares. Note that there is a high positive correlation with the HHI calculated on the basis of revenue market shares. The correlation coefficient is 0.94.

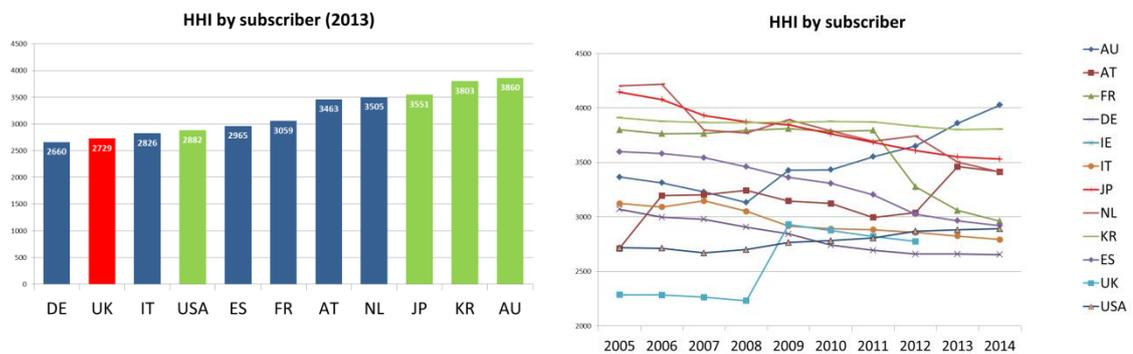
Table 9: Mergers and new entry, and number of MNOs,

Country	Intra-market mergers & new entry (1/2005-4/2015)	Impact on number of MNOs (1/2005-4/2015)	Number of MNOs (in 4/2015)
Netherlands	2005: Merger KPN/Telfort 2007: Merger T-Mobile/Orange NL 2013: New entry (as MNO): Tele2	5 to 4 4 to 3 3 to 4	4
Spain	2006: New entry of Xfera (now Yoigo)	3 to 4	4
France	2012: New entry of Iliad	3 to 4	4
UK	2010: Merger T-Mobile/Orange UK (EE)	5 to 4	4
US *	2005: Merger Sprint/Nextel (Sprint)	5 to 4	4
Italy	-	-	4
Australia	2009: Merger Hutchison AUS/Vodafone AUS (merged entity: Vodafone Hutchison AUS)	4 to 3	3
Austria	2006: Merger T-Mobile/tele.ring 2012: Merger H3G AT/Orange AT	5 to 4 4 to 3	3
Germany	2014: Merger Telefónica DE/e-plus	4 to 3	3
Ireland	2014: Merger H3G/Telefónica IE	4 to 3	3
Japan	-	-	3
South Korea	-	-	3

* Only national MNOs considered in US.

Source: WIK

Figure 15: HHI based on subscriber numbers



Source: New Street

3.2.2.3.2 Maverick firms

Since maverick firms are usually latecomers and new entrants, they have a high incentive to win market share against the incumbent MNOs through lower prices and service innovations. Thus maverick firms have a disruptive effect on the market and make coordination between incumbent MNOs less likely.

Maverick firms continue to be present in six countries as of April 2015 (Table 10): Netherlands, Spain, France, UK and the U.S. It should be noted that in these six countries, the mavericks have challenged incumbent operators in different degrees. T-Mobile in the US has not been a challenger operator in the same way that new entrant operators have been in European markets and had not the same incentives to aggressively grow market share in order to achieve scale.

In the other six countries, maverick firms disappeared as a result of mergers (Australia, Austria, Germany and Ireland) or never existed in the period under consideration. New entry, e.g. by Hutchison 3 (in UK, Austria and Ireland) and by Iliad (in France) was considered by some market participants as 'disruptive' due to pricing strategies.

Table 10: Presence of maverick firms, 2005-April 2015

Country	Maverick firms	Period *	Presence of a maverick firm in April 2015	Number of players in April 2015
Netherlands	Orange NL Tele2	Until 2006 Since 2013	√	4
Spain	Xfera (now Yoigo)	Since 2006	√	4
France	Iliad	Since 2012	√	4
UK	Hutchison 3	Throughout	√	4
US	T-Mobile	Throughout	√	4
Italy	Hutchison 3	Throughout	√	4
Australia	Hutchison AUS	Until 2008	-	3
Austria	tele.ring Hutchison 3 & Orange	Until 2005 Until 2011	-	3
Germany	e-plus	Until 2013	-	3
Ireland	Hutchison 3	Until 2013	-	3
Japan	-	-	-	3
South Korea	-	-	-	3

* If a maverick merged in year t with another firm, it was considered a 'maverick' until year t-1.
Source: WIK

3.2.2.3.3 MVNOs

A final competition indicator is the presence of MVNOs. MVNOs are present in all countries compared, either on the basis of SMP obligations, spectrum license conditions or - more commonly - commercial agreements. Depending on the type of access arrangement, MVNOs can in theory provide an additional competitive impetus. The presence of MVNOs in itself however is not sufficient. MVNOs in many countries operate on the basis of retail-minus wholesale agreements and provide minutes and data packages that largely replicate the retail tariff structures of the host MNOs. While such MVNOs have the potential of addressing market niches and enlarging markets, their impact on price and speed competition is likely to be small. In theory, MVNOs that purchase capacity on the basis of capacity-based wholesale prices are more likely to exert some price and service completion. However, it is not yet possible to fully gauge the outcomes on competition from this type of MVNO that has emerged as a result of recent merger commitments in Europe (see the case studies in *Section 5*).

3.2.2.3.4 Linkages between investment and competition

On the basis of data for the period 2005-14, there is no *a priori* indication that less competition is linked to more investment. Neither consolidation (lower number of MNOs) nor higher concentration (higher HHI) nor the lack of a maverick are linked to more investment. The correlation coefficients are shown in Table 11.

The absence of linkages between investment and number of MNOs, respectively HHI, is also confirmed if correlations are calculated for individual years in the period from 2005 to 2014:

- In individual years, the correlation coefficient between the number of MNOs and investment is generally below 0.5.
- Likewise, the correlation coefficient between the HHI and investment is below 0.5, except for a single year.

The presence of a maverick has a positive correlation of 0.5-0.7 with an investment measure in 4 out of 10 years. While one should be careful in drawing conclusions, this suggests that, if at all, the presence of a maverick (hence more competition) may increase investment.

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The presence of a maverick has a positive correlation between 0.5 and 0.7 with an investment measure in 4 out of 10 years. While one should be careful in drawing conclusions, this suggests that, if at all, the presence of a maverick (hence more competition) may increase investment.

Table 11: Correlation coefficients between investment and competition, aggregate country data, 2005-14

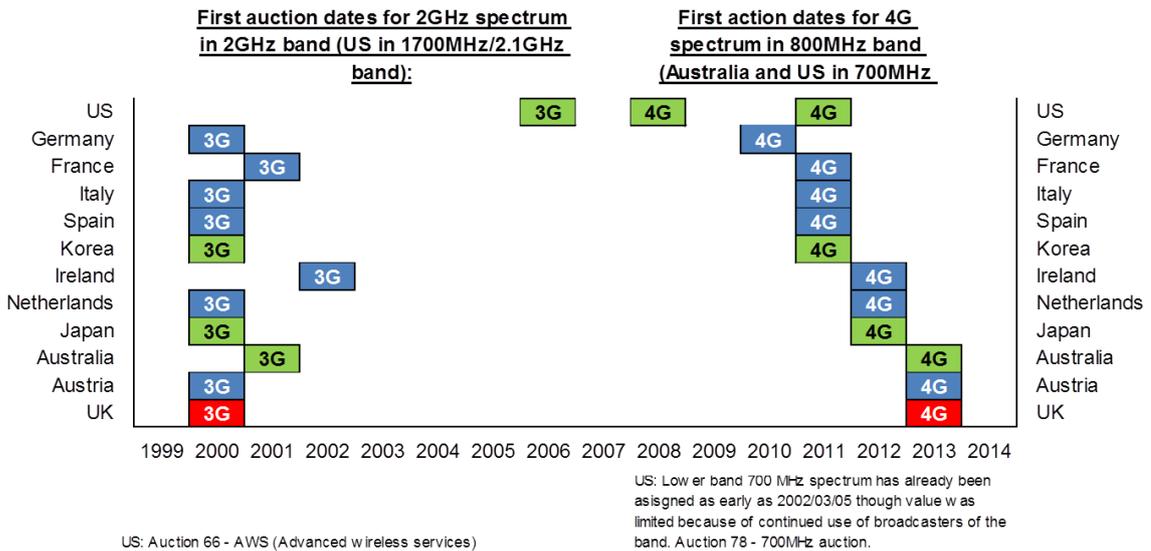
		Investment	
		CAPEX/revenue	CAPEX per subscriber
Competition	HHI (subscribers)	0.0681	0.1537
	Number of MNOs	-0.1539	-0.2091
	Presence of maverick	0.2728	0.2291

3.2.2.4 Possible factors driving investment: Spectrum auction dates

Spectrum auction dates trigger investment cycles. 2GHz auctions took place in a relatively short time period at the beginning of the 2000s (except in the US which offered spectrum for UMTS only in 2006), see Figure 16. Since most 2GHz auctions took place within two years, the 3G auction date is unlikely to explain inter-country differences in investment.

Auctions of 4G/700 or 800MHz spectrum were spread out over a longer time period, with the U.S. as frontrunner in 2008 and Germany leading the European auctions in 2010. Auction dates for 4G spectrum are spread over a longer time period and it is likely that countries with an earlier 4G auction date were also frontrunners in 4G investment. In turn, as the UK encountered a certain delay, this may have delayed investment compared to other countries.

Figure 16: Spectrum auction dates



Source: WIK

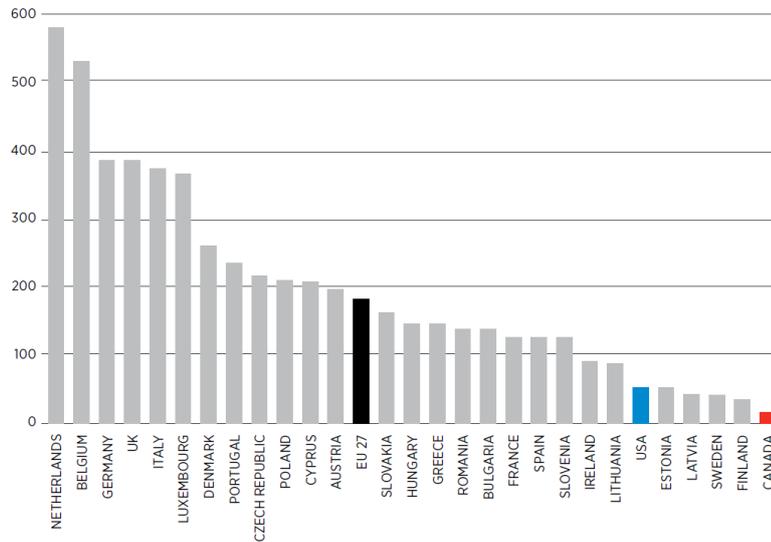
As our dataset begins with the year 2005, the investment triggered by the 3G spectrum auctions at the beginning of the 2000s cannot be traced back. The wave of 4G auctions that started at the beginning of the 2010s (except U.S. which started before) required new investment. This also seems to explain a general upward trend in investment in most countries.

3.2.2.5 Possible factors driving investment: Network deployment costs

Countries differ with regard to network deployment costs depending on country characteristics and extent of network sharing. Countries with higher network deployment costs are likely to spend more CAPEX on network coverage.

Wireless connections per sqkm of network area would be the best proxy for network deployment costs. Network deployment costs per subscriber are likely to decrease with increasing density of wireless connections. As data from the GSMA shows, the density is highest in the USA - see Figure 17 (Australia is not included).

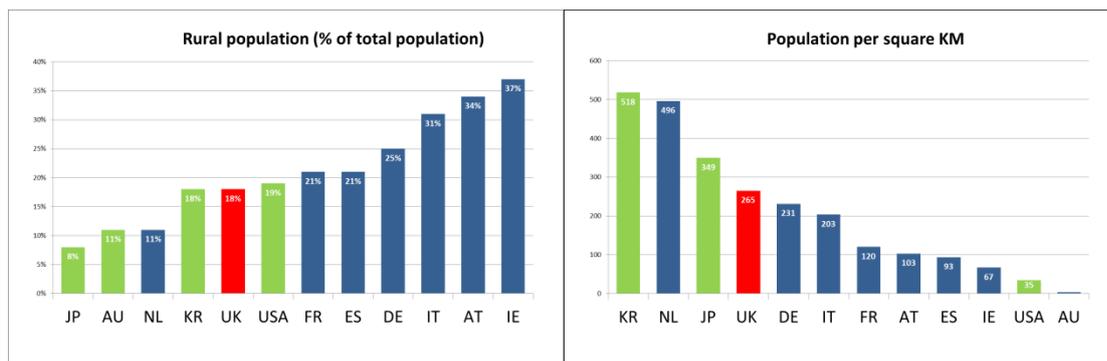
Figure 17: Wireless connections per square kilometer of wireless network



Source: Navigant based on GSMA

The population density is a poorer proxy than wireless connections per sqkm of network area, as in some countries there are large inhabited areas for which networks are not rolled out. The share of rural population is a better alternative. The share of rural population is highest in Australia and the U.S. – see Figure 18. This also suggests that network deployment costs in the U.S. are among the highest.

Figure 18: Share of rural population and population density



Source: WIK, based on THE WORLD BANK - DATA

Over the 6-year period 2008-13 we have found weak negative correlations between the share of rural population and investment measures for 4 years, which seems to be counterintuitive.²⁵ An explanation could be that MNOs use network sharing arrangements to achieve savings in network deployment costs. There are various

²⁵ Correlation coefficients between -0.5 and -0.7.

degrees of mobile network sharing, including site/mast sharing, RAN sharing, and national roaming.²⁶ The amount of savings in CAPEX increases with the amount of network sharing. National roaming, in fact, allows covering an area without investment as it substitutes roaming charges for network CAPEX.

Table 12 shows that, in Austria and France, site/mast sharing, RAN sharing and national roaming are all used (group 1).²⁷ In Germany and South Korea, both site/mast sharing and national roaming is applied (group 2).²⁸ Both site/mast sharing and RAN sharing exists in Australia, Ireland, Japan, Spain and the UK (group 3).²⁹ Italy, the Netherlands and the U.S. have the lowest degree of network sharing; here only site/mast sharing is used (group 4).

Table 12: Use of network sharing, April 2015

Country	Site/Mast sharing	RAN sharing	National roaming	Category
Austria	√	√	√	1
France	√	√	√	1
Germany	√		√	2
South Korea	√		√	2
Australia	√	√		3
Ireland	√	√		3
Japan	√	√		3
Spain	√	√		3
UK	√	√		3
Italy	√			4
Netherlands	√			4
US	√			4

Source: Frontier based on GSMA; WIK

²⁶ Note that we neglect here core network sharing which is only relevant in one country and spectrum sharing, which is not applied in any country.

²⁷ In Austria, T-Mobile provides national roaming to Hutchison 3. In France, Orange provides national roaming to Iliad (Free).

²⁸ In Germany, Telefonica O2 provides national roaming to E-plus, which after the merger continued to operate a separate network. In South Korea, LG Uplus provides national roaming to KFT.

²⁹ In the UK, Orange provided 2G national roaming to Hutchison 3, but this agreement has ended.

While network sharing is potentially cost saving, we could not establish a linkage between our measure of network sharing and investment. In the years 2013 and 2014, for which we had network sharing information, the correlation coefficient between the extent of network sharing and investment was generally below 0.5.

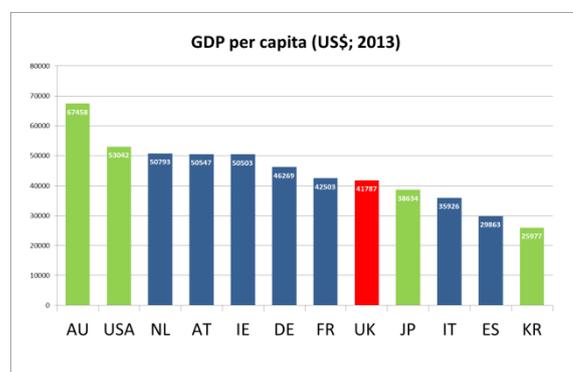
A possible reason is that the categorization in four types of infrastructure sharing is a very crude one. It is e.g. possible that site/mast sharing together with RAN sharing (if effectively applied as in the UK) may in reality deliver higher cost savings as in some other countries that use a combination of sit/mast sharing and national roaming.

3.2.2.6 Possible factors driving investment: Demand factors

Important demand factors that may impact on investment are GDP per capita, smartphone penetration and video usage.

Australia and the U.S. have the highest GDP per capita among the countries assessed as Figure 19 shows. It is interesting to note that GDP per capita does not have a direct linkage to investment in our 12 country sample. This is best illustrated by the fact that Korea has one of the highest CAPEX/revenue and CAPEX/subscriber ratios while GDP per capita is the lowest of all countries.

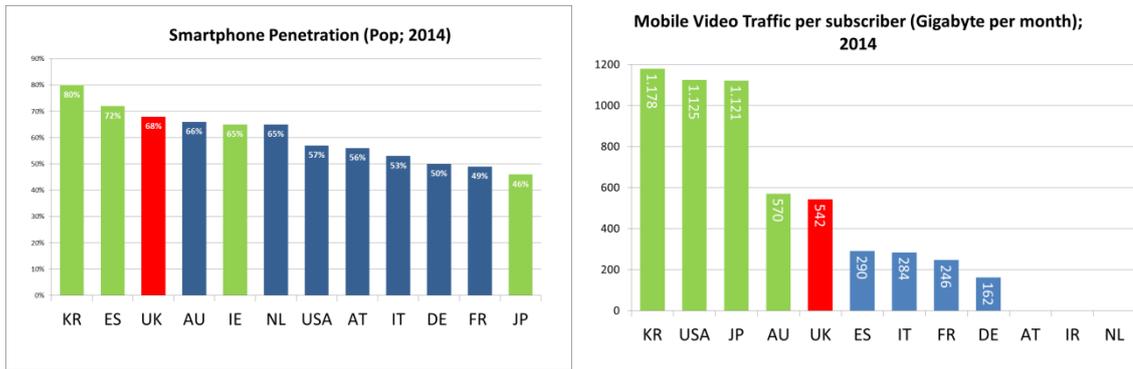
Figure 19: GDP per capita



Source: Worldbank

A relatively low GDP per capita, as in Korea's case, does not necessarily imply a low smartphone penetration (percentage of the population with a smartphone) or low mobile usage. In fact, as Figure 20 shows, Korea has the highest smartphone penetration and the highest mobile video usage in our country sample.

Figure 20: Smartphone penetration and mobile video usage



Source: Cisco VNI Forecast Widget; New Street

While different levels of GDP per capita do not explain differences in investment, linkages between investment and mobile video usage are clearly discernible from our statistical analysis. There is a positive correlation between mobile video usage and an investment measure in 2014.³⁰ In turn, there is a negative correlation between smartphone penetration and investment measures in some recent years, which is counterintuitive.

Conclusions

On qualitative evidence regarding the relationship between competition and investment:

The qualitative evidence does not confirm a linkage between consolidation (or higher concentration) in mobile markets and an increase in investment. Neither an increase in the number of MNOs nor an increase in the HHI is linked to higher CAPEX/revenue or higher CAPEX per subscriber.

There is also no compelling qualitative evidence that consolidation or a higher HHI impacts on investment through higher profitability. We found no direct linkage between number of operators and profitability or between HHI and profitability.

More generally, there are very few areas of strong statistical correlation, and these can change if examined on a year by year basis. The only strong linkage that exists is between investment levels over time. Current investment is strongly linked to last year's investment, which suggests the existence of long-term investment plans.

³⁰ Correlation coefficient between CAPEX/revenue and mobile video usage is 0.68.

3.2.3 Econometric evidence

Various reports claim to have provided evidence to support consolidation on the basis that it may boost (or at least does not harm) investment, and that it does not necessarily result in higher prices – a key measure which is examined by competition authorities when considering merger proposals. In this section, we briefly describe the approaches used by Frontier Economics (2015) and HSBC (2015) and the conclusions they reach. Moreover, we have carried out our own econometric analysis, in order to test whether these econometric approaches can be verified on the basis of our data. Subsequently, we summarise in brief for each study the relationships explored, the data base and the conclusions reached. A more comprehensive presentation of each study can be found in the Annex.

3.2.3.1 Frontier

Frontier Economics (2015) aims to determine the main factors that influence investments in the mobile industry. Investment is measured by capex per subscriber.³¹

Frontier uses quarterly data from EU MNOs in three and four player markets covering the time period 2000 – 2014 obtained from GSMA.

Frontier has estimated a number of different models of capex per subscriber encompassing the following explanatory variables:

- Competition measured by HHI,
- the timing of 3G and 4G auctions,
- the launch of 4G services,
- the percentage of prepaid connections,
- GDP per capita,
- Year dummies,
- the explained variable (capex per subscriber) lagged by one period.³²

Overall, the econometric results of the equation which Frontier identifies as the most relevant can be summarized as follows:

Statistically significant relationships

- past capex per subscriber influences current capex per subscriber (coefficient is positive and highly significant);

³¹ Frontier considers capex/subscriber to be a superior measure of investment to capex/revenue.

³² Frontier mentions the following reasons for this approach: (1) It is expected that capex adjusts slowly in response to changes in other factors because the costs of doing so are high. (2) Operators are likely to follow long-term investment plans, thus, a degree of path dependency in investment is expected.

- increases in the share of post-pay subscribers lead to an increase in capex per subscriber (coefficient regarding pre-paid connections is negative and highly significant);
- capex per subscriber is higher in auction years (coefficient is positive and highly significant),
- capex is higher for MNOs rolling out 3G and 4G networks, respectively (the respective coefficients are positive and highly significant).

Relationships that are not statistically significant

- the impact of the intensity of competition (HHI) on capex is negative ; however, the estimated coefficient (-0.14) is not statistically significant;
 - GDP per capita.

Frontier interprets the lack of a link between HHI and capex as meaning that there is no evidence that more intense competition increases investment.³³

3.2.3.2 HSBC

Like Frontier, the aim of the HSBC study is to assess the impact of the intensity of competition on network investment. However, the methodology and parameters used differ. The study uses company-level panel data and instrument variable estimation techniques. It is based on an unbalanced panel consisting of 66 operators with data extending over 11 years from 2003 to 2013. The firms are drawn from 22 national markets covering all regions of the world. In total, there are 606 observations.

In order to measure the intensity of competition at the firm level, the study uses the Lerner index of monopoly power, thus, defining the intensity of competition experienced by the firm i ($Comp_i$) by:³⁴

$$Comp_i = 1 - Ebitda_i / Revenue_i$$

The analysis is based on a two-stage structural approach. In the first stage, competition is modeled as a linear function of regulatory variables, which are deemed to be exogenous. These are:

- the cumulated number of frequency bands released in the market of firm i before the year 2005, thereby assuming the more the frequency bands assigned before this date, the greater the intensity of competition faced by the firm.
- the year of entry of firm i into the market allowed by the regulator. The assumption is that firms that enter later into the market face more competitors, and therefore experience higher intensity of competition.

³³ The intensity of competition (HHI) does not have a statistically significant impact in any of Frontier's regression models.

³⁴ This approach is based on the assumption of constant marginal cost of production.

HSBC has estimated a number of different models of investment including – apart from competitive intensity and competitive intensity squared - the following explanatory variables:

- Dummy variables for entry, merger, exit, and whether a mobile operator is simultaneously a fixed incumbent;
- the active population (in order to take into account a demand shift),
- the population density (in order to take into account cost shifts).

Overall, the key econometric result of the HSBC study is:

- The coefficient of competition is positive;
- The coefficient of competition squared is negative.

Both estimates are highly statistically significant. HSBC argued that this indicates the inverse-U relationship between competition intensity and investment.

According to HSBC, this finding confirms the theory that greater competitive intensity starting from low levels tends to increase investment, but that beyond a certain threshold, more competition actually reduces investment. The study estimates that investment is maximised when the level of competitive intensity corresponds to an EBITDA margin of 38%.

3.2.3.3 Our approach

Our database covers data from around 50 mobile operators from 12 countries and 9 points in time (2005 – 2013).

We have aimed to assess the factors influencing capex both in absolute terms and capex per subscriber. When assessing drivers of capex in absolute terms, the use of GDP (or revenues) as an explanatory variable ensures that scale effects are taken into account.

We assessed the relevance of the following explanatory variables:

- Competition, measured by HHI or the number of operators, respectively, in a given country;
- The explained variable (capex or capex per subscriber) lagged by one period,
- Profitability, measured by Ebitda (and/or Ebitda lagged by one period)
- GDP or GDP per capita, respectively,
- The timing of 4G auctions,
- Revenues or revenues per subscriber, respectively,
- The percentage of rural population (per country),
- The launch of 4G services.

We did not include the “percentage of prepaid connections” as such data is not consistently available in the public investor statements which form the source of NewStreet data³⁵. Apart from the “timing of 4G auctions” we have not included specific year dummies.

We have conducted our analysis on the basis of both aggregate country-wide data and per operator data. In the first case the annual values for Capex, Ebitda, Revenues of the operators within a country have been summed up, while in the second they are kept separate.

On the basis of aggregated (country specific) data our key results are:

- “Ebitda”, “GDP” and the “Investments of the previous period” (Capex.₁) have a statistically significant impact on current investments.
- “HHI”, however, does not have a statistically significant impact.

Including ‘revenues’ as a possible explanatory variable does not change these findings: Capex is likely to depend on “Revenues”; however, using “GDP” and “Revenues” together yields statistically insignificant estimates (the correlation coefficient of “GDP” and “Revenues” equals 0.93).

Regarding the estimates on the basis of disaggregated (operator specific) data our key results are:

- The “Investments of the previous period” (Capex.₁) play a key role in determining current investments.
- “HHI” as well as the “number of operators” do not have a statistically significant impact.
- There is no evidence that “Ebitda/revenue” has an impact.
- “GDP per capita” might have a (negative) impact on Capex/subscriber.

3.2.3.4 What do the econometric studies show?

It is informative to compare the methods and results of the analysis. Here, we contrast our aggregated (i.e. country level) and disaggregated (i.e. operator level) results, and then compare our results with those of Frontier and HSBC.

3.2.3.4.1 Our aggregated and disaggregated results

As regards our own analysis, the country-wide and per operator findings are consistent inasmuch as they show that:

³⁵ Moreover, new types of tariff structure including fixed payment, but without contract are blurring the boundaries between pre and post-paid.

- The “Investments of the previous period” (Capex_{t-1}) have a statistically significant impact on current investments.
- “HHI” does not have a statistically significant impact.

It is, however, interesting to note that the two approaches differ as regards the impact of Ebitda (Ebitda/revenue) and GDP (GDP per capita), respectively, on investments:

- Ebitda is likely to have an effect on an aggregated (“market”) level, however, not on an operator level.
- The impact of GDP on investment is likely to be positive on an aggregated (“market”) level; it is, however, likely to be negative on an operator level.

3.2.3.4.2 Frontier’s and our model results

There are some important differences between our study and the Frontier study when considering and interpreting the results:

- Database: Our dataset is annual rather than quarterly and covers a shorter time series starting in 2005; thus it does not include effects on investment relating to 3G auctions.
- Geographical scope: Our dataset covers fewer European operators (we take into account only 8 European countries and the respective operators); however, it is also broader as it reflects 4 non-European countries and associated operators.

Some of our results are consistent with Frontier’s findings:

- We do not find any robust link between concentration in mobile markets and investments. Frontier takes this result as evidence that mergers do not 'harm' investment. We would rather interpret our finding the other way round: Changes in the competition intensity such as mergers do not have a *direct* impact on operators’ investment in their respective markets, and cannot be said definitively to increase investments, as sometimes claimed. Thus, an appropriate competition policy assessment of mergers in mobile markets needs to take into account other factors -- in particular consumer outcomes.
- We do find a robust confirmation that past capex influences current capex in mobile markets. This is suggestive of capex trends which are part of longer-term plans.

3.2.3.4.3 HSBC study

The HSBC study applies the Generalized Method of Moments (GMM) econometric approach and is based on a large data base (over 600 observations). Unfortunately, the

database is not publicly available and therefore it is not possible to verify the robustness of the results.

We have however a few remarks on the methodology and outcomes.

It is surprising to see that the HSBC approach yields statistically meaningful results in which previous capex does not play any role in explaining investment in the mobile industry. This is in contrast to the analyses of both Frontier and WIK.

HSBC uses the Lerner index (based on EBITDA margins) as a proxy for the intensity of competition. HSBC then uses its finding of a link between EBITDA margins and capex to draw conclusions about the impact of consolidation on investment. Firstly, we note that in order to apply the Lerner paradigm HSBC must make the assumption of constant marginal costs. Our understanding of the mobile market is not in keeping with this assumption: Marginal costs are likely neither to be constant over time nor across operators of different size. Secondly and importantly, we would highlight that EBITDA margins are not a good proxy for competitive intensity. Rather concentration ratios (HHI index) as used by both ourselves and Frontier, and the number of operators, are more relevant in considering the effects of consolidation. In both analyses where HHI has been used as the measure, no statistically significant relationship has been found. We thus question whether HSBC can draw conclusions about the effects of consolidation based on its analysis.

One of the key variables is the number of frequency bands allocated by governments before a given point in time. It might be worth further examining whether merely adding up frequency bands is an appropriate approach given the different propagation properties of different bands. A different approach might yield different results.

3.2.3.4.4 Overall assessment

The results of the econometric studies must be interpreted with care.

- First, all the econometric studies described explore the relationship between investment and competition at the firm level. From an overall economic perspective, it is however the relationship between aggregate industry investment and market competition that is the relevant one. Even if it were true that individual operators invest more in a 3-player market than in a 4-player market, aggregated investment in a 4-player market may still be higher than in a 3-player market.
- Second, investment transforms into consumer outcomes in various ways depending on the overall amount of (industry) investment, the distribution of investment across players in a market and many other factors. It should be noted that it is ultimately the consumer outcomes that count and not investment *per se*.

Econometric analysis of this type (i.e. cross sectional data across mobile operators observed over time) provides more comprehensive insights than “simple” (one-dimensional) comparisons between two or more operators or countries on the basis of descriptive statistics.

However, our comparisons reveal that econometric analysis of this type is very rarely definitive. There are inherent (logical) limitations in as much as such studies rest on specific data regarding countries, operators, etc. as well as regarding time periods and observation units (e.g. quarters, years, etc.). In other words, there are no “laws of nature” to be detected by econometric analysis. Rather, the specific datasets and the operators/countries as well as the time periods observed do matter. Moreover, we note that interpretations of the same results vary. In addition, the econometric models described above are not able to identify “causality” between variables. Rather, in order to detect causality in a strict sense specific additional instruments need to be applied (like “Granger causality tests” and/or Difference-in-Differences approaches).

There is therefore inherently a degree of indeterminacy and it is flawed to take econometric analysis of the type described above as a “proof” which may guide competition policy. Thus, the outcome of a multi-country/operator analysis in all likelihood is not sufficient to make a comprehensive assessment of the given situation in a country at a specific time. Rather, all of these arguments call for an additional in-depth consideration of national circumstances – also concerning the effects of consolidation on consumer outcomes.

Conclusions

On econometric evidence regarding the relationship between competition and investment:

Like WIK, Frontier has conducted an econometric analysis in which they seek to examine whether investment is driven by competition (measured by HHI), regulation (such as the auction licence date) and other independent factors such as GDP per capita.

Neither Frontier nor WIK find any robust link between concentration in mobile markets (measured by HHI or number of operators) and investment. While Frontier interprets the lack of an association as evidence that competition does not drive investment, we would rather interpret this finding as indicating that there is no proof that consolidation may increase investment, as is sometimes claimed.

Both studies find a robust confirmation that past capex influences current capex in mobile markets. This is suggestive of capex trends which are part of longer-term

plans.

HSBC pursues a different approach for its analysis. Using the Lerner index (based on EBITDA margins) as a proxy for competition, HSBC claims to have proven the existence of an inverted U-shaped relationship in which, at low levels of competition, additional competitive impetus may drive investment, while beyond a given point, further competition may undermine investment. The study estimates that investment is maximised when the level of competitive intensity corresponds to an EBITDA margin of 38%.

The dataset of the HSBC study is not publicly available and therefore it is not possible to verify the robustness of the results. Moreover, certain assumptions of the HSBC analysis, in particular the use of EBITDA margins (rather than HHI) as proxy for competitive intensity and the inherent assumption of constant marginal costs are questionable. It is also surprising that, unlike WIK and Frontier, HSBC does not identify lagged capex as an explanatory factor.

Overall, we caution that the results of econometric analyses, while informative, cannot provide definitive 'proofs' that are sufficiently robust to guide merger analyses. The findings can depend on the time series and variables examined and interpretations of the results may differ. A more in-depth consideration of national circumstances – also concerning the effects of consolidation on consumer outcomes – is needed.

4 Do consumer outcomes in mobile markets improve with less competition?

Although mobile operators often make reference to the importance of investment (CAPEX), it is important to note that it is not CAPEX per se that delivers positive consumer outcomes, but rather network coverage and quality, offered at a competitive price, and delivered in a way which meets the demands of local populations. In this context we have therefore sought to examine what drives consumer outcomes, whether competition may play a role in achieving positive results, and what other nationally-specific factors may be relevant.

Section 3.1 summarises theoretical arguments on the relationship between competition and consumer outcomes. *Section 3.2* evaluates the hypothesis that competition may harm consumers, and discusses other factors that may explain differing consumer outcomes in different countries and regions internationally.

4.1 Theoretical arguments

The relationship between competition and consumer outcomes is as complex as the competition-investment relationship. Our main focus is to understand whether a reduced number of MNOs and an increase in market concentration influence availability, connection speed, prices, penetration and usage of mobile services. In this context, the opposing effects which we discussed in relation to investment are also relevant for consumer outcomes.

In the context of merger proceedings, it is often suggested that in a market with a few large players, operators may be better able to achieve cost efficiencies which enable them in theory to charge lower prices and/or deploy networks more widely, thereby passing benefits of scale to consumers. However, many of these benefits could also be achieved through means other than consolidation.³⁶

- Operators may benefit from lower unit costs as a result of economies of scale. At lower unit costs, it may become profitable to further roll out networks into areas that cannot be profitably served by operators with small market shares. Thus there may be a positive impact on consumer outcomes. However, some of the economies can also be achieved by network sharing.
- Larger operators may more easily aggregate spectrum assets into technically and economically efficient packages and combinations. More efficient spectrum aggregation and combination will allow earlier roll-out of innovative services and/or provision of services at lower costs. However, efficient spectrum

³⁶ See the Commission's decision practice in mobile mergers; see also Frontier (2015) for a description of efficiencies.

aggregation is also promoted by appropriate spectrum management policies and does not necessarily require concentrated markets.

- Larger operators may be better able to develop commercial partnerships to deploy innovative services. Commercial partnerships with the banking and car industry could however also be arranged in a cooperative approach of mobile operators.

A further observation is that it is debatable whether the efficiencies claimed to occur in consolidated markets will be fully exploited in the absence of competition. If consolidation leads to symmetrical market shares, the merged entity may have an incentive to coordinate its policies with the other players. The firms may choose not to realise productivity improvements, not to lower prices or not to improve services, or delay price decreases and service innovations if such strategies preserves profit margins. As a result, consolidated markets may result in higher prices and static welfare losses for consumers.

The impact of market power on investment in new technologies and innovation is also subject to opposing effects. Those favouring consolidation argue that in markets in which competition is less intense, there will be greater incentives for technological and service innovation, as the resulting financial benefits are less likely to be immediately competed away.³⁷ This is a similar argument to that posed for investment, and reflects the 'Schumpeterian effect'. On the other hand, as previously described, with an increase in market power, firms will have a weaker incentive to leapfrog their rivals by investing in new technologies, since market power will already generate profits before the investment is made.

A further complication is that consumer outcomes may not depend so much on the degree of concentration, but the nature and behavior of specific market players and their willingness to act as 'disruptors' of the status quo. In this context, competition authorities and national regulatory authorities have often observed specific effects on consumer outcomes from 'maverick' or 'challenger' operators, which are often associated with unbalanced market structures in which small players must innovate to gain market share.

³⁷ E.g. Frontier (2015), HSBC (2015a, 2015b).

Conclusions

On the theoretical relationship between consumer outcomes and competition:

The relationship between competition and consumer outcomes may be subject to opposing effects. Scale players may be able in theory to leverage scale economies to reduce prices and increase coverage. They may also have greater financial incentives to innovate if the resulting profits are not competed away. However, market power may mean that scale operators do not have incentives either to pass benefits to consumers or to innovate, if they can make higher profits without doing so.

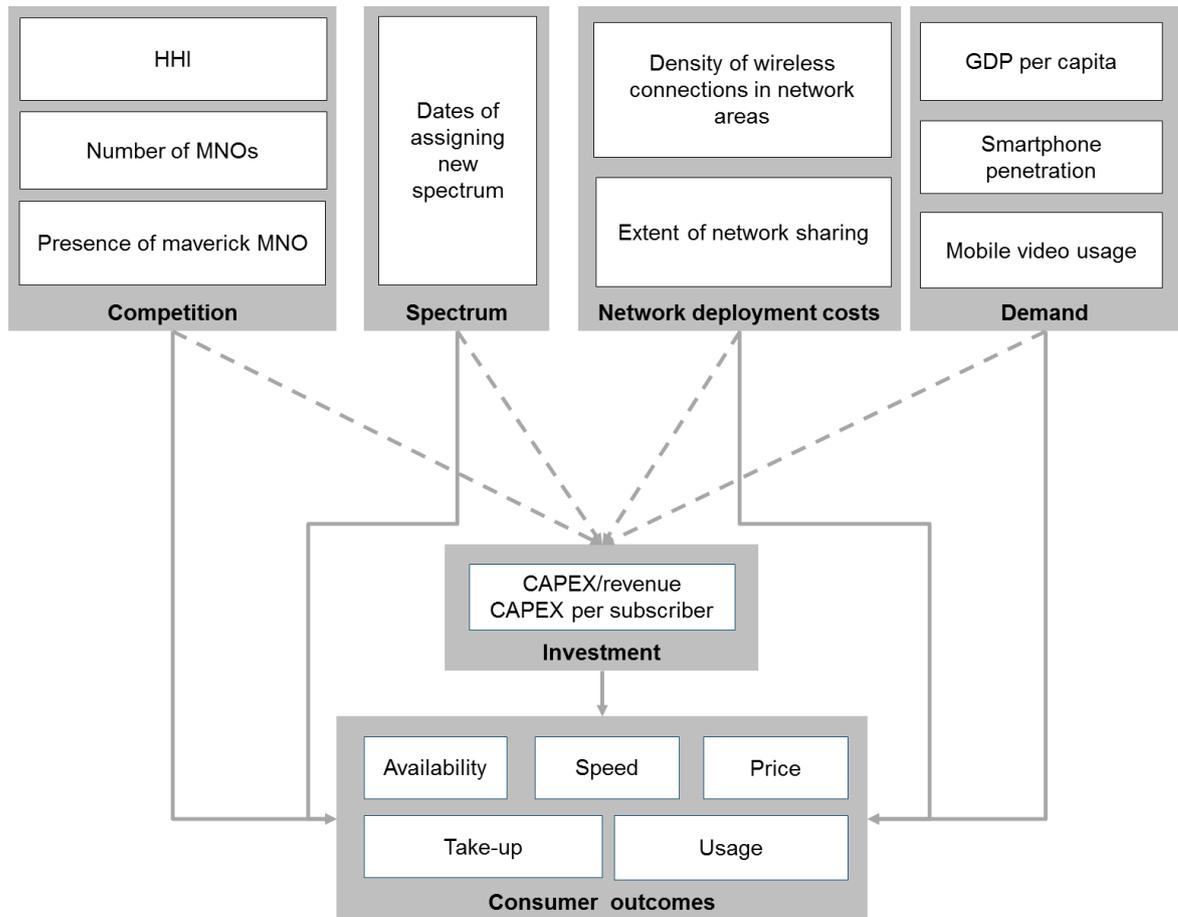
A further complication is that consumer outcomes may not just be affected by the number or concentration of the market, but the nature of players within it. In particular in unbalanced market structures, challenger operators may have an incentive to disrupt the status quo through low-cost or innovative offers in order to gain market share.

4.2 Empirical evidence

4.2.1 Metrics

Consumer outcomes and the factors potentially driving consumer outcomes are shown in Figure 21. For the metrics, refer to section 2 (metrics for consumer outcomes) and section 3 (metrics for competition, investment, spectrum, network deployment costs and demand factors).

Figure 21: Factors driving consumer outcomes



Economic theory suggests that competition may impact consumer outcomes in two ways.

- First, competition may impact investment, and through investment have an effect on consumer outcomes, notably availability and speed of mobile broadband services. The relationship between competition and investment has already been explored in Section 3. This is the effect on which studies put forward by the mobile industry focus on, e.g. Frontier (2015) and HSBC (2015a, 2015b).
- Second, there may also be direct effects from competition on consumer outcomes. E.g. the intensity of competition may have a direct impact on MNOs' policies with regard to prices and speeds offered. Lower prices and better speed should in theory support higher penetration and usage of mobile services.

4.2.2 Quantitative evidence

4.2.2.1 Linkages between consumer outcomes, investment, competition and other factors

Table 13 shows correlations between consumer outcomes and competition as well as investment and other factors for the year 2013. The Table indicates correlations of 0.7 and higher (strong correlation, marked in green and attributed a “++”) and between 0.5 and 0.7 (weak correlation, marked in yellow and attributed a “+”).

As with data on market structure and investment, it is notable that there are few significant direct correlations:

Competition

An interesting result is that there are no correlations that indicate that less competition, for example through fewer MNOs, higher concentration or lack of a maverick MNO result in improvements to any of the assessed consumer outcomes. Equally however, the data does not clearly indicate that there is a simple positive relationship between competition and prices.

Investment

Our data suggests that there is some relationship between investment and consumer outcomes. CAPEX per subscriber is linked to consumer outcomes in various respects:

- There is a weak positive linkage between CAPEX per subscriber and 4G coverage.
- There is a weak positive linkage between CAPEX per subscriber and price (both for prices of baskets that include mobile calls and prices of baskets that include mobile Internet). The direction of causality is however unclear – prices might be increased in order to support additional CAPEX (eg for 4G roll-out, to address higher costs of coverage), or higher prices might support higher revenues providing more financial scope for investment.
- Finally, a high correlation coefficient between CAPEX per subscriber and data usage suggests a strong positive linkage between investment and usage intensity of data services. This may be explained by the need for mobile operators to invest in additional capacity to support extra usage, or through investment in 4G supporting additional usage.

In turn, there are no linkages between CAPEX/revenue and consumer outcomes, except a weak correlation with mobile broadband penetration, which might also be related to costs associated with capacity or network roll-out.

Table 13: Correlation coefficients between consumer outcomes and competition as well as other factors, aggregate country data, 2013

		Consumer outcomes							
		4G coverage	Connection speed (Akamai)	Connection speed (Ookla)	Price for basket including calls	Price for baskets including Internet	Mobile broadband penetration	Voice usage	Data usage
Competition	HHI								
	Number of MNOs								
	Presence of maverick								
Investment	CAPEX/ revenue						+		
	CAPEX per subscriber	+			+	++			++
Costs	Share of rural population								
	Extent of network sharing								
Demand	GDP per capita								
	Smartphone penetration		+	++					
	Mobile video usage						++		++

'++' if correlation coefficient is above 0.7; '+' if correlation coefficient is between 0.5 and 0.7.

It is probable that efficient investment could benefit consumers in several ways: it may improve the speed of mobile services, enable innovation and, in a longer term perspective, lead to lower prices, and some of the linkages can be traced in the data. However, the data is far from clear-cut on whether investment can be raised with four-to-three consolidations and higher concentration. As pointed out in Section 3, the empirical evidence does not confirm such a link between less competition and more investment. By implication, there is also no confirmation of the hypothesis that less competition - through better investment incentives - will result in better consumer outcomes.

Costs

Our proxies for costs – share of rural population and extent of network sharing - do not suggest direct linkages with consumer outcomes.

Demand factors

The major linkages to consumer outcomes can be found on the demand side. Smartphone penetration and mobile video usage play an important role as the table above shows.

First, there is a positive linkage between smartphone penetration and connection speeds. The correlation is strongest if speed is measured by Ookla, but is also visible for speeds measured by Akamai.

Second, as is to be expected, there is also a strong positive correlation between mobile video usage and mobile broadband penetration, as well as between mobile video usage and data usage. Clearly, broadband penetration is increasingly driven by data usage, which itself is fueled by video usage.

Third, there is also a weak negative correlation between mobile video usage and voice usage. People who spend more time on watching videos seem to make less mobile calls, perhaps because they may rely on other methods for contact including messaging and voice applications.

4.2.2.2 What drives the overall performance of a country in terms of consumer outcomes?

From the previous discussion it is clear that no single parameter is likely to have a defining effect on consumer outcomes. However, Table 14 enables an overview of how several factors may work together (or against each other) to contribute to consumer outcomes. The Table shows country rankings for consumer outcomes as well as rankings for the potentially explaining factors (which are competition, investment, and cost and demand factors).

Colour coding has been used to visualise the following broad ranking categories for the various parameters:

- “Green” means that the country is ranked among the top-4.
- “Red” means that the country is ranked among the last-4.
- “Yellow” means that the country has a middle rank. The number of middle ranks is usually 4. However, where statistical information on a particular parameter was not available for all countries, the number of middle ranks is smaller (e.g. if information was only available for 11 countries, the number of middle ranks is 3).

Table 14: Country rankings for consumer outcomes, competition, investment and other factors, 2013

	Consumer outcomes	Investment CAPEX/revenue	Competition - HHI	Costs - share of rural population	Demand – GDP per capita	Demand – Smartphone penetration	Demand – mobile video usage
South Korea	1	4	10	4	12	1	1
Australia	2	na	11	2	1	4	4
UK	3	10	2	5	8	3	5
US	4	2	4	6	2	7	2
Japan	5	1	9	1	9	12	3
France	6	9	6	7	7	11	8
Austria	7	7	7	11	4	8	na
Netherlands	8	3	8	3	3	6	na
Ireland	9	na	na	12	5	5	na
Italy	10	5	3	10	10	9	7
Spain	11	8	5	8	11	2	6
Germany	12	6	1	9	6	10	9

To establish the country ranking for consumer outcomes, we use an unweighted average of the rankings for individual consumer outcomes as shown in Table 6 in Section 2.2.7.4. It is instructive to look at, and compare, the top-4 and last-4 countries in terms of consumer outcomes.

Top-4 countries in consumer outcomes

Table 14 shows in the first four rows the countries that perform best in terms of consumer outcomes; these are South Korea, Australia, the UK and the U.S.

The Table shows that, for these four countries, the relationship between consumer outcomes and investment is not straightforward. While South Korea and the U.S. rank among the top-4 in investment, this is not the case for the UK, which ranks relatively low in terms of the investment measures used.

The Table also illustrates for the top-4 performing countries that the relationship between consumer outcomes and competition (HHI) is not straightforward. Two of the countries doing best in consumer outcomes are among the most competitive countries (US and UK), while the other two are among the least competitive (South Korea and Australia). The evidence here does not confirm that less competition means better consumer outcomes or indeed the reverse. However, this does not mean that competition does not play any role. Rather the effects of competition may 'compete' with other factors affecting positive consumer mobile outcomes, which may outweigh the effects from competition.

For example, it is clearly visible that the good consumer outcomes of the top-4 countries are associated with cost and demand factors. The countries performing best in consumer outcomes rank lower in rural population shares (resulting in lower network deployment costs), and higher in smartphone penetration and mobile video usage (resulting in higher demand for broadband services). Notably these two demand factors are related to good consumer outcomes.

In turn, a high GDP per capita is not a necessary condition for top consumer outcomes as the country with the lowest GDP per capita is among the best performing countries (South Korea).

Last-4 countries in consumer outcomes

An opposite picture emerges for the countries that are last in terms of consumer outcomes. This group of countries comprises Ireland, Italy, Spain and Germany.

Table 14 again shows the lack of a clear relationship between consumer outcomes and investment. While Spain also ranks among the last-4 in investment, this is not the case for Italy and Germany, which have a middle rank in terms of investment.

The Table also confirms that there is no direct linkage between consumer outcomes and competition (HHI). Two of the countries doing worse in consumer outcomes are among the most competitive countries (Italy and Germany)³⁸, while another country is among the middle performers (Spain). Again, this evidence does not suggest that less competition leads to better consumer outcomes.

Finally, it is again visible that worse consumer outcomes are associated with cost and demand factors. The countries performing less in consumer outcomes rank higher in

³⁸ Germany was among the most competitive countries until the Telefonica/E-plus merger.

rural population shares (resulting in higher network deployment costs), and lower in smartphone penetration and mobile video usage (resulting in lower demand for broadband services).

Conclusions

On the relationship between consumer outcomes and competition:

The qualitative evidence does not confirm that consolidation and higher concentration in mobile markets is linked to an improvement in consumer outcomes. Neither an increase in the number of MNOs nor an increase in the HHI has a linkage to higher CAPEX/revenue or higher CAPEX per subscriber. However, neither does it show a clear link between increased competition and consumer outcomes. The reason may be that any effects from competition are outweighed by effects from other factors.

The major linkages to consumer outcomes can be found on the demand side. Higher connection speeds are linked to higher smartphone penetration. Both higher mobile penetration and higher data usage are linked to higher mobile video usage. Demand factors thus have a major role in explain better consumer outcomes.

Concretely, two of the countries doing best in consumer outcomes are among the most competitive countries (US and UK), while the other two are among the least competitive (South Korea and Australia). Thus the relationship between consumer outcomes and competition (HHI) is not clear-cut. It is however clearly visible that the good consumer outcomes of the top-4 countries are associated with demand factors. The countries performing best in consumer outcomes rank higher smartphone penetration and higher mobile video usage (resulting in higher demand for broadband services).

An analysis of this kind also highlights that it is simplistic to characterize US mobile markets as 'lacking competition'. Rather the US compares in the level of mobile competition with many European 4-player markets.

4.2.3 Econometric evidence

A number of studies have sought to investigate the relationship between market structure and prices (as well as other consumer outcomes) through econometric analysis. These are summarised below. An initial observation is that, in addition to different methodologies, the studies have used different 'proxies' for market structure and prices. As discussed, these may significantly affect how the data can be interpreted

and whether it is possible to draw conclusions from the analysis on any link between consolidated markets, prices and other consumer outcomes.

4.2.3.1 Studies relating to consumer outcomes: Prices

Frontier (2015)

A study carried out by Frontier³⁹ does not focus on “prices” directly, rather, it uses the average revenue per minute (ARPM) as a proxy for prices.

The data base consists of quarterly GSMA data between 2000 and 2014. The observation units taken into account are European MNOs in three- and four-player markets.

The Frontier study yields the following key findings:

- The level of competition (i.e. the HHI variable) is not significant in the vast majority of specifications. Thus, the Frontier estimate yields no direct link between the level of competition and prices as measured by ARPM.
- Past prices seem to be an important determinant of current prices (the lagged ARPM variable is highly significant).
- Apart from GDP per capita which is likely to have an impact on prices all other factors are statistically not significant.

Houngbonon (2015)

A study by Houngbonon (2015) analyses the effects of the change in the intensity of competition introduced by the entry of the fourth mobile operator in France and the merger between the third and the fourth mobile operators in Austria on prices.

Houngbonon specifies a “hedonic price function”, thereby assuming that each mobile plan has various attributes, to which a certain monetary value can be attached.

Houngbonon’s approach rests on attributes including the quantity of bundled voice minutes and MB of data capacity, and the download speed supported. Pricing also varies according to factors such as whether the plan is standalone (i.e. voice only or data only) or bundled (i.e. voice and data bundled together), whether a mobile device is provided alongside, whether it is intended for business customers or consumers, and whether it involves a contract or not.

Houngbonon has estimated a hedonic price model for Austria based on detailed tariff data for Austrian operators over 7 quarters.

³⁹ Frontier Economics (2015), op. cit.

Overall, this estimate rests on 614 observations. Hounqbonon reaches the following conclusions:

- Entry in the French market has raised the unit price of mobile data services by 4 dollars per Gigabyte.
- The merger in the Austrian market has lowered the unit price of mobile data by 6 dollars per Gigabyte.
- These results stem from a fall in the investment in new technologies following the entry in the French market; with a reverse effect in Austria.

HSBC (2015)

HSBC (2015) focus on the same issue as Hounqbonon (2015) thereby applying the same econometric approach. However, they use a slightly different database.

HSBC summarises its findings as follows: “In terms of voice pricing, we find that entry/exit has little material impact, whether in terms of the access price or unit price. In terms of data, in the case of bundled plans, we find that exit lowers unit prices and that entry raises them; while in the case of standalone plans, we do not find statistically significant effects.”⁴⁰

Csorba and Pápai (2013)

The key issue addressed by Csorba and Pápai (2013) is the impact of market entry and mergers on the price of mobile voice services. The study rests on a panel database of 27 European Member States between 2003 and 2010. The main results of Csorba and Pápai are:

- The effect of entry crucially depends on the number of active operators and the type of entrant.
- There is no robust evidence that entry has a price-decreasing effect on markets with originally 2 operators.
- However, the entry of a 4th operator does have a significant price-decreasing effect, but with different dynamics concerning the entrant's type.
- There are no price-increasing effects of mergers, independently of whether they reduce the number of operators to 4 or 3.

4.2.3.2 Studies relating to consumer outcomes: Take-up/penetration

Shinohara, Morikawa, and Tsuji (2015)

⁴⁰ HSBC (2015b), p. 26.

The key issue of the study by Shinohara, Morikawa, and Tsuji (2015) is the analysis of the drivers of mobile broadband adoption in selected countries. The database comprises six countries (UK, FR, DE, USA, JP, KR) and the period from 2000 to 2012.

Explanatory variables used comprise prices for voice and data, respectively, GDP per capita, HHI, the FTTH adoption ratio as well as dummy variables reflecting smartphone launches, and frequency auctions.

The authors conclude from their analysis (among others) that more competition is linked to increased penetration. Moreover, current mobile take-up depends on previous take-up, thus mirroring a “network effect“, the price of voice, and to some extent also on the launch of smartphones. Moreover, FTTH adoption is relevant for mobile penetration.

Kongaut and Bohlin (2014)

Kongaut and Bohlin (2014) address how the mobile Internet has developed in the last decade and which factors are currently determining mobile broadband adoption and usage in Sweden. The study provides a comprehensive analysis of socio-demographic and socio-economic factors impacting these two elements of diffusion. This study amongst others reveals that smartphone adoption depends on the frequency of Internet use. Moreover, income, age and education significantly affect smartphone adoption rates. As to smartphone usage, age and education seem to be important factors. Gender and income also affect smartphone usage.

4.2.4 Observations

The many studies conducted on the effect of mobile consolidation on consumer outcomes reveal interesting insights but each raise important questions which highlight that the results cannot necessarily be taken as definitive. For example:

- Czorba and Papai’s analysis does not reflect the important role that data plays in competition, especially in relation to the market strategies of mavericks such as ‘3’. This is an important omission, given that the authors highlight price reducing effects from 3’s entry into markets.
- The use by Frontier of the metric of ‘Average Revenue per Minute’ as a proxy for the mobile price may be misleading if the mix of call-types or volumes differs between countries. It also does not reflect the important data aspect.
- The hedonic price model used by Hounghonon (2015) and followed by HSBC (2015) rests on assumptions which are difficult to verify.

Moreover, it is worth noting that in attempting to isolate (or fail to isolate) relationships between consumer outcomes such as prices and competition, such analyses may miss other factors which affect prices or other consumer outcomes. Based on our qualitative analysis, we estimate that in practice nationally specific factors play an important role in determining outcomes alongside which competition may also have its role to play.

In this context, in-depth qualitative case studies in which specific developments can be mapped against outcomes in those markets, may be a more useful means to assess whether and how entry and consolidation may affect consumer outcomes.

Conclusions

On econometric evidence regarding the relationship between consumer outcomes and competition:

A number of recent studies have sought to investigate the relationship between market structure and prices (as well as other consumer outcomes) through econometric analysis:

- The Frontier study yields no direct link between the level of competition and prices.
- The study by Hounghonon and HSBC, respectively - applied to the French and Austrian mobile markets - conclude that entry/merger have had an impact on prices, in particular on the unit price of mobile data services.
- Csorba and Pápai conclude that the entry of a 4th operator does have a significant price-decreasing effect on voice calls in certain circumstances; however, there are no price-increasing effects of mergers.
- As to take-up/penetration Shinohara, Morikawa, and Tsuji show that more competition is linked to increased penetration.
- The study by Kongaut and Bohlin for Sweden shows that mobile broadband adoption and usage is heavily affected by socio-demographic and socio-economic factors.

Our observation on these various studies is that different metrics used as proxies for 'prices', different methodologies – and the focus of certain studies on voice (as opposed to data) mean that it is difficult to take any of the conclusions as 'definitive'. Moreover, the myriad of nationally specific factors may not always be reflected in econometric analyses, making it difficult to isolate precise results.

In this context, we would question whether the results of these analyses can be treated as definitive. In-depth qualitative case studies, in which specific developments can be mapped against outcomes in those markets, could help to provide indications on whether and how entry and consolidation may affect consumer outcomes.

5 What effect did entry and consolidation have on investment and consumer outcomes? – Case studies

In order to see from a more practical and tangible perspective, what impacts entry and consolidation may have had on mobile market structures, we have conducted four case studies – each of which seeks to explore specific aspects of mobile market developments.

- Austria offers an opportunity to examine – at least in the short term – the effects of a four-to-three merger. The Austrian case has also sparked a debate about price effects of consolidation, which we discuss further.
- Germany is a market which has been characterized by strong MVNO presence. In this case, we examine the role played by the MVNOs prior to the recently approved 4-3 merger, and what role they may play following the merger and associated remedies – which mandated the introduction of a capacity-based MVNO arrangement.
- Ireland allows us to explore the effect on consumer outcomes (and especially data pricing and usage) from the entry of a maverick, and to assess whether the market structure was economically viable in the Irish context. The players involved in the Irish consolidation mirror the planned 4-3 consolidation in the UK.
- The Netherlands provides an example in which consolidation was followed by new entry, with the reservation of spectrum for a new entrant in the 4G spectrum auction.

It should be noted in advance that each market has specific features, and therefore not all observations are necessarily relevant to the UK. However, we seek to understand whether these cases may shed light on the effects of entry and consolidation – including the role that mavericks and MVNOs may play in shaping market outcomes.

5.1 Austria

5.1.1 Consolidation in the Austrian mobile market

Until 2012 the Austrian mobile market consisted of four MNOs. In this year, the two smaller players in the market, Hutchison-3G (H3G) and Orange Austria, merged. In its review, the Commission voiced concerns that the elimination of one out of four mobile network operators would lead to less competition and higher prices, to the detriment of consumers. The Commission regarded the merging parties as close competitors, which was one of the factors that made a significant impediment to effective competition likely. The Commission predicted increases in quality-adjusted prices as a result of the merger in the order of 10–20% in the post-paid residential market segment.⁴¹ H3G was viewed

⁴¹ European Commission (2012), para. 362.

as an important driving force of competition in the market (“maverick”) and the Commission feared that their incentive to compete with the market leaders A1 Telekom Austria and T-Mobile Austria would be reduced as a result of the merger.

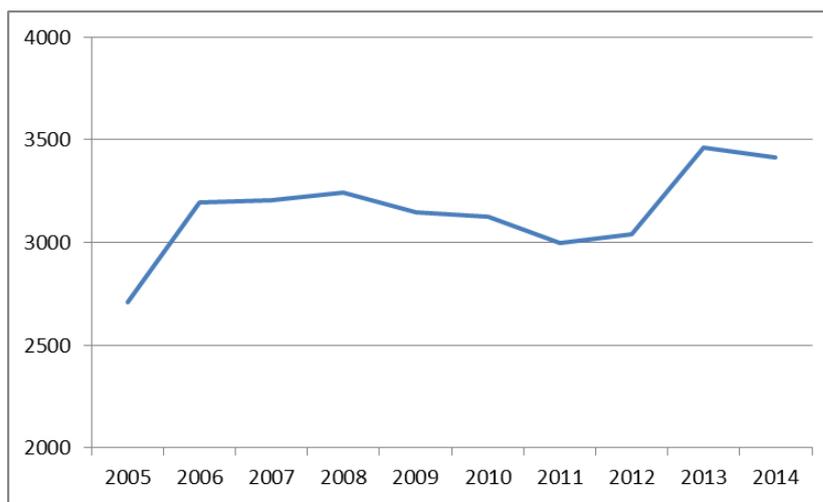
To overcome the concerns of the Commission H3G agreed to the following commitments:⁴²

- H3G committed to divest spectrum (2x10MHz in the 2.6GHz band) to a potential new entrant. For this potential new entrant, the Austrian regulator also set aside additional spectrum in the subsequent 2013 multiband auction.
- H3G also committed to provide, on agreed terms, wholesale access to its network for up to 30% of its capacity for up to 16 mobile MVNOs over the following decade in case there was no new entry by an MNO. H3G committed not to complete the acquisition of Orange Austria before it had entered into a wholesale access agreement with one MVNO.

5.1.2 Competition

The H3G/Orange merger reduced the number of players from 4 to 3 and led to an increase of the HHI of almost 500⁴³. This reversed the previous downward trend in the HHI as Figure 22 shows. Between 2006 and 2012, the HHI declined, reflecting that the two smaller MNOs were able to increase their market share at the expense of A1 Telekom Austria and T-Mobile Austria.

Figure 22: Herfindahl-Hirschman-Index (HHI) in Austrian mobile market, 2005-2014



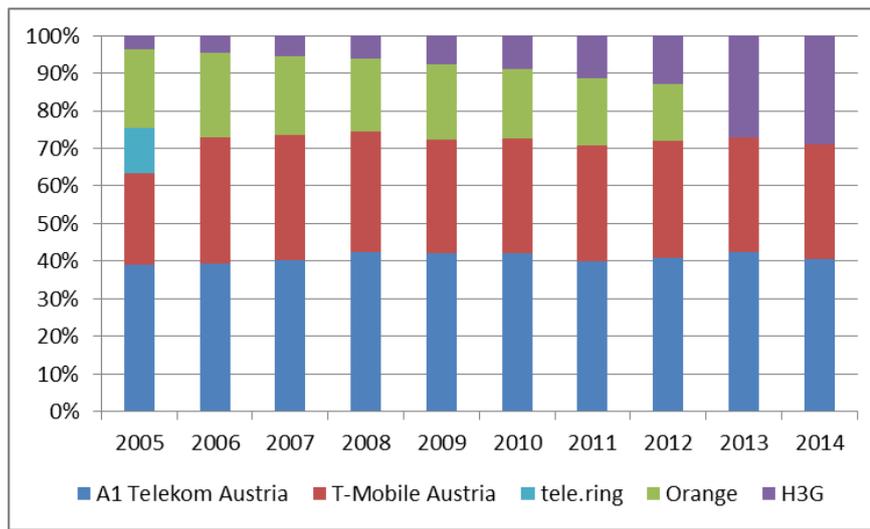
Source: WIK based on New Street

⁴² European Commission (2012), para. 518-553.

⁴³ The number of MNOs was 5 until T-Mobile Austria acquired tele.ring in 2006.

H3G is unlikely to continue to play a challenger role after its merger with Orange. Due to its size, the merged entity no longer has such incentives. The merger created a more symmetric market structure as Figure 23 illustrates. More symmetric market shares and the disappearance of a maverick have deteriorated competitive conditions.

Figure 23: Market shares based on subscribers in Austrian mobile market, 2005-2014



Source: WIK based on New Street

The merger commitments provided by H3G were insufficient to keep the previous level of competition.

- First, the commitment to divest spectrum in the 2.6GHz band to a potential new entrant proved to be of little value, as no such entrant materialised.⁴⁴
- Second, the commitment to provide wholesale access to MVNOs for up to 30% of its capacity for up to 16 mobile MVNOs worked poorly. Although an up-front commitment between H3G and an MVNO (UPC) was quickly reached in 2012, it took almost two years after the merger for UPC to launch a mobile offer. Only today further MVNOs are planning to enter the market using H3G's network, such as Tele2.

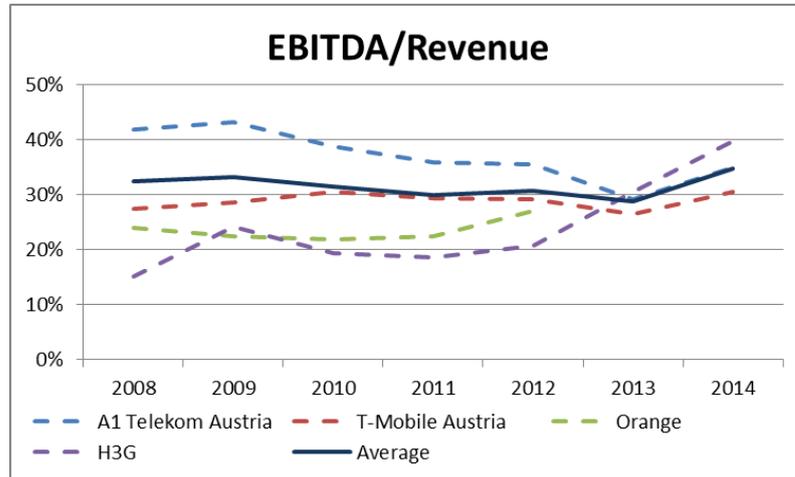
5.1.3 Profitability

In the years prior to the merger, the EBITDA margins were linked to market shares: The market leader A1 Telekom Austria had the highest EBITDA/revenue ratio followed by T-Mobile, Orange and H3G. However, the profitability differences between the four operators narrowed down until 2012. Following the merger, which increased H3G's

⁴⁴ For the auction results see RTR (2014), p. 51.

market share to the level of T-Mobile, H3G's EBITDA margin became the highest in the market. It is interesting to note that EBITDA margins of A1 and T-Mobile also improved, though to a lesser extent.

Figure 24: EBITDA/revenue margins of MNOs in the Austrian mobile market, 2008-2014

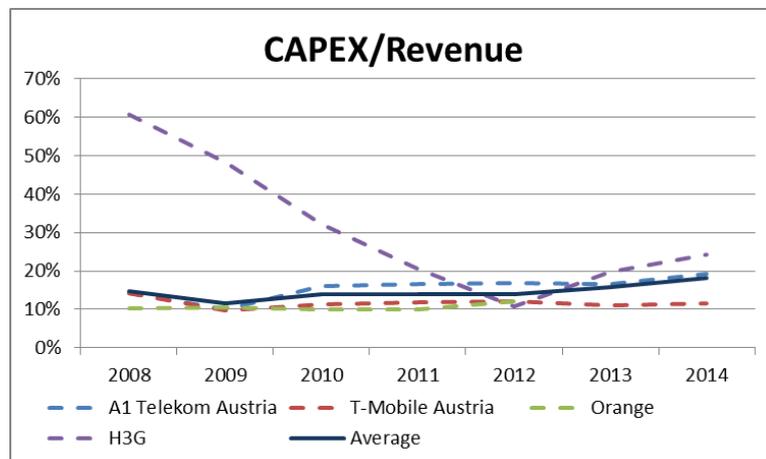


Source: WIK based on New Street

5.1.4 Investment

CAPEX/revenue ratios initially reflected market shares, with A1 having the highest CAPEX/revenue ratio followed by T-Mobile and Orange. The exception to this pattern was H3G which, as a new entrant, had to incur a substantially higher CAPEX/revenue ratio than the other operators, which however gradually decreased with network roll-out and built-up of a customer base (Figure 25).

Figure 25: CAPEX/revenue ratios of MNOs in the Austrian mobile market, 2008-2014



Source: WIK based on New Street

Following the merger, H3G's CAPEX/revenue ratio jumped up again, which may reflect the need to integrate the two networks and improve network coverage. It should be noted that the Austrian regulator also held its multiband spectrum auction in 2013, in which H3G acquired 900MHz spectrum. In contrast, CAPEX/revenue ratios of A1 and T-Mobile were much less affected both by the spectrum auction and the merger. The CAPEX/revenue patterns of A1 and T-Mobile point to long-term investment plans which do not appear to be affected by variations in EBITDA margins or consolidation of the market..

5.1.5 Prices

The Austrian regulator traces mobile price developments using four usage profiles: low user, medium user, high user and power user. The characteristics of the usage profiles (minutes/SMS/data) are adjusted annually. In addition, RTR calculates an average price index for all user groups.

For each user profile a price index is calculated as follows:⁴⁵

- For each user profile, the five lowest tariffs of each provider active in Austria⁴⁶ are identified. This is done by calculating the monthly fee that a new customer would pay if they signed up to a new contract.
- For each user profile, an unweighted average price is calculated for each provider on the basis of the five lowest tariffs.
- The price index of each user profile is then calculated as the average price of the prices of the providers, where the price of each provider is weighted with its market share⁴⁷.

Figure 26 shows the development of the prices since 2011:

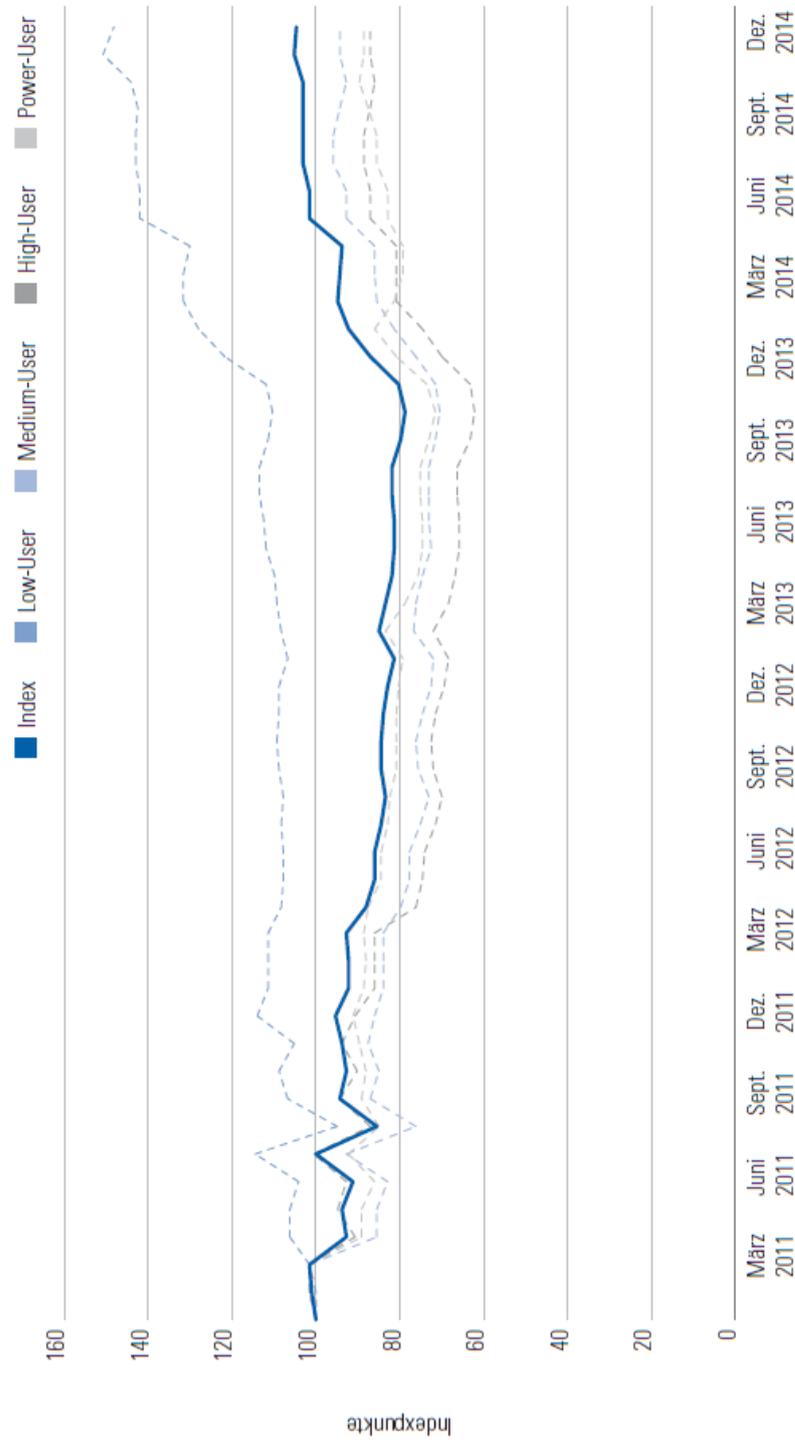
- Since January 2011, prices declined for medium users, high users and power users, while they increased for low users. From January 2011 until October 2013, the users that benefited most from price reductions were the high users (-38%), followed by medium users (-30%) and power users (-29%). In contrast, the prices for low users increased by 10%.
- A turning point was October 2013, when prices for all user groups started to increase. Between October 2013 and September 2014, the overall price index (an average of all user groups) increased by 31%.

⁴⁵ RTR (2015) and Serentschy (2014).

⁴⁶ Providers include MNOs (A1, T-Mobile, Drei) and MVNOs (tele.ring, Yesss!, Bob, Ge.org, Red Bull Mobile, S-Budget).

⁴⁷ RTR (2015) and Serentschy (2014).

Figure 26: Mobile price indices in Austria by user profiles, January 2011 - December 2014



Source: RTR Telecom Monitor (2015), p. 17.

Mobile operators have initially justified the price increases since October 2013 by the high spectrum prices paid in the 2013 multiband auction. This argument may explain the timing of the initial price increase as the mobile frequency auction was conducted in October 2013. The operators' justification was however met with skepticism from the Austrian regulator, which saw in the 2013 spectrum auction at most a partial explanation.

With a GSMA report commissioned to Frontier (2015) and a financial analyst report of HSBC (2015b) the debate has taken a different direction. Frontier and HSBC argue that the price index, since based on monthly bills incurred by new subscribers, does not capture the fact that consumers get more capacity and, as a result, benefit from decreasing unit prices. Unit prices are defined as total service revenues divided by total traffic. If voice and SMS volumes are converted into data equivalents and added to Internet data volumes, unit prices per MB can be calculated.⁴⁸ On the basis of its calculations, HSBC states that *"prices have not risen in Austria post consolidation, but fallen. Bills have risen in Austria (modestly), but bills are not prices. Bills are a product of price and capacity: the unit price multiplied by the quantity of units supplied. The reality is that unit prices have continued to fall, but operators are selling larger bundles of capacity, with the result that bills have risen."*⁴⁹

It is clear that unit prices calculated as average revenue per MB are generally declining independent of the number of operators in a market. This, however, does not invalidate RTR's price index:

- From a consumer perspective, monthly bills which consumers (defined by certain usage profiles) pay are relevant consumer outcomes. If consumers pay more for their usage profile, they are unlikely to be better off.
- Moreover, even if unit prices were used as the relevant consumer outcome parameter, the question is whether unit prices in the consolidated market have decreased more than they would have done in the absence of a merger.

Another argument, put forward by Frontier, is that it is too early for an assessment of post-merger effects and that developments should be traced over a longer period in order to capture longer-term dynamic effects on prices (presumably following positive impacts on investment), before conclusions can be drawn. This argument has some merits, as some of the effects are in fact longer term. It is also noticeable that RTR pursues its analysis of post-merger effects and in particular of effects on prices in order to arrive at a clear view of the impact of consolidation on consumer outcomes.

⁴⁸ HSBC (2015b) used technical conversion factors of 12.2 kbps for 3G voice and 150 bytes for SMS.

⁴⁹ HSBC (2015b), p. 2.

5.2 Germany

5.2.1 Consolidation in the German mobile market

Telefónica acquired E-plus in 2014. The Commission had concerns that the merger would result in a reduction of competition between MNOs and also weaken the position of MVNOs to the detriment of consumers. The merging parties have been close competitors in particular for low-value and pre-paid customers by offering a lesser network quality for less expensive tariffs than Deutsche Telekom and Vodafone. Since the merging parties were close competitors, this was one of the factors that made a significant impediment to effective competition likely.

To address the competition concerns of the Commission, Telefónica agreed to a package of commitments:⁵⁰

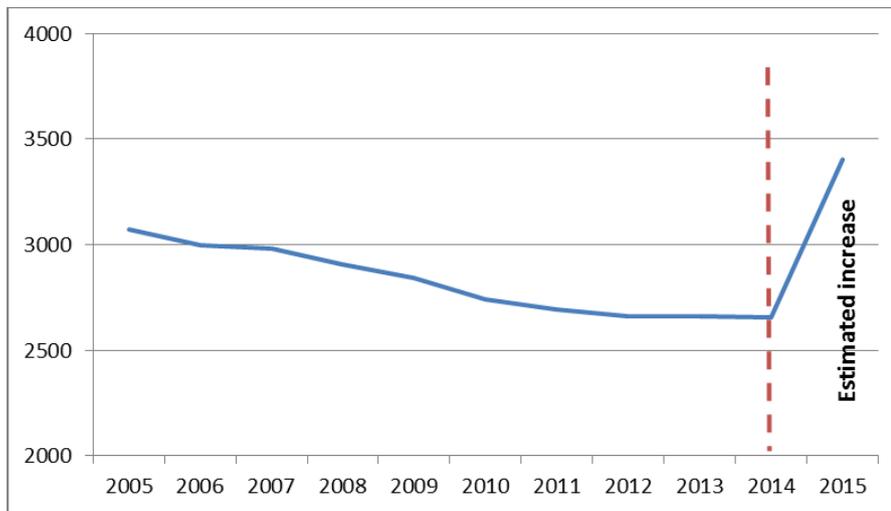
- First, Telefónica committed to enter into capacity-based wholesale agreements with up to three “Upfront Mobile Bitstream Access MVNOs”. These agreements foresee that the MVNO(s) can purchase against an upfront payment up to 30 % of the total capacity of the merged company’s network for up to 10 years after the completion of the merger.
- Second, Telefónica committed to extend existing wholesale agreements with Telefónica’s and E-Plus’ wholesale partners and to offer 4G services to the wholesale market in the future. In addition, Telefónica committed to allow its wholesale partners to switch their customers hosted on Telefónica’s and/or E-Plus’ networks from one business model to another without any penalty.
- Third, Telefónica committed to offer an agreement to be concluded with a new MNO entrant or subsequently with the upfront MVNO. This remedy is supposed to facilitate the entry of a new fourth MNO into the German market. For this purpose, Telefónica commits to make the following offers: (a) a spectrum offer consisting of the lease of spectrum in the 2.1GHz band and 2.6GHz band; (b) a national roaming offer; (c) a divestiture of sites offer; (d) a passive radio network sharing offer; and (e) a sale of shops offer.

5.2.2 Competition

Before the merger occurred, the German mobile market was characterized by a long-term trend of a declining HHI, as Figure 27 shows. The merger between E-Plus and Telefónica reversed this trend and led to an increase of the HHI by 748 points (from 2655 to 3403) on the basis of 2014 market shares.

⁵⁰ European Commission (2015), summary.

Figure 27: Herfindahl-Hirschman-Index (HHI) in German mobile market, 2005-2015

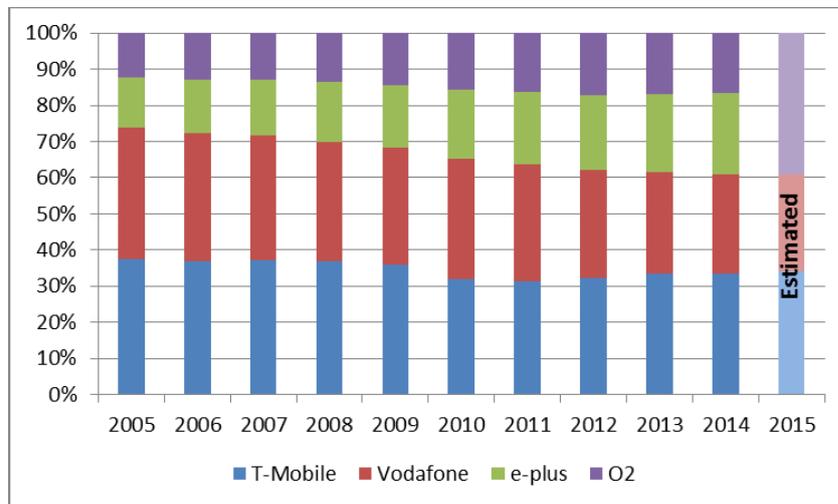


Source: NewStreet, New Street

The pre-merger competition was largely driven by the asymmetric market shares of the four operators, where notably E-Plus played the role of a maverick and where also Telefónica launched innovative and aggressive offers. Both Telefónica and E-Plus were important competitive forces in terms of pricing as well as in terms of the innovative nature of offers. Tariff innovations first launched by the smaller operators included flatrates, homezone tariffs and “no frills” offers. The German Monopolkommission (2011) related the competition intensity to the four-play market structure, the asymmetry in market shares and the incentives of the two smaller operators to win market shares by challenging t-Mobile and Vodafone with tariff innovations.

As a result of the merger, market shares of the three remaining players have become more symmetrical, with Telefónica becoming the market leader (Figure 28). The more symmetric market shares have clearly decrease the incentives to compete compared to the pre-merger market structure.

Figure 28: Market shares based on subscribers in German mobile market, 2005-2014



Source: WIK based on NewStreet

It remains to be seen whether the merger commitments provided by Telefónica will be capable of maintaining the previous level of competition. Doubts are raised by the following issues:

- First, it is already clear that the commitment to divest spectrum to a new entrant will remain irrelevant, as no such entrant materialized in the May/June 2015 multiband auction.
- Second, it remains to be seen how effective the commitment to provide wholesale access to MVNOs for up to 30% of Telefónica's capacity will work. As a result of the commitment, Telefónica sold up to 20% of its future capacities to Drillisch. Furthermore, Drillisch has the opportunity to acquire up to 10% of additional network capacity. The commitment also provides that upgrades of Telefónica's network and service qualities will be made available to Drillisch. In contrast to a standard MVNO agreement which is usage based, the agreement with Drillisch is capacity based and requires an upfront payment with no ongoing usage payments. Drillisch, in theory, thus has an incentive to compete for new customers to fill up the capacity acquired. It appears to be too early for a final judgement on the impact on competition. In any case, network competition is likely to decrease, because Drillisch - as an MVNO - will need to fully rely on Telefónica's network.
- Third, while Telefónica was required to improve the terms for existing MVNOs, their future raises questions. On the one hand, the MVNO market share is one of the largest in Europe. At the end of 2013, 25% of subscribers in Germany were MVNO customers.⁵¹ Today, there are still approximately 100 MVNOs,

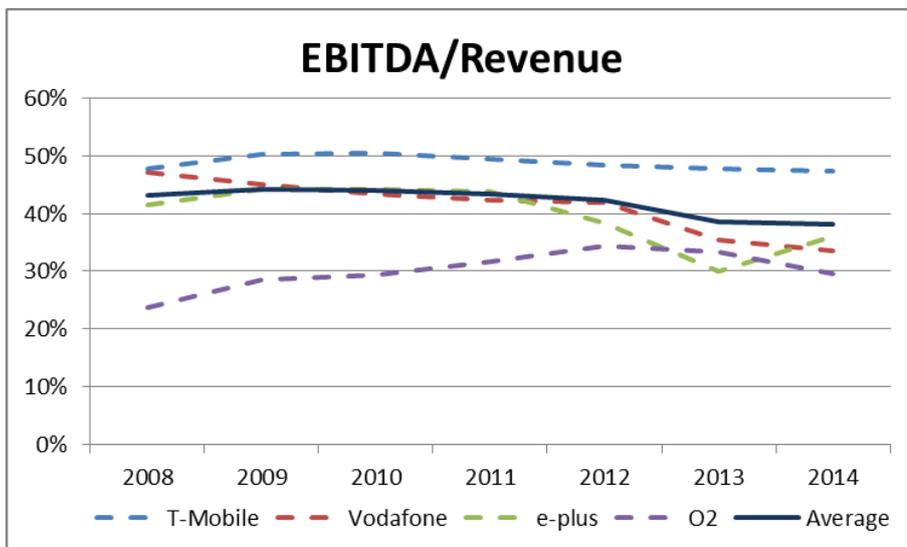
⁵¹ Analysys Mason (2014).

including MVNO brands of MNOs. These include a great variety of business models: classic Service Providers (which have agreements with multiple MNOs), MVNOs with online distribution (exclusive agreements), MVNOs of retail chains such as Tchibo (exclusive agreements), MVNOs of fixed telecoms and cable operators with multi-play strategies (exclusive agreements). On the other hand, MVNOs operate on the basis of commercially negotiated wholesale agreements, which leave limited room for price and service competition. Moreover, MVNOs with existing MVNO agreements are able to use Telefónica's 4G network not earlier than 12 months after the agreement with Drillisch and are at a competitive disadvantage during this period. It remains to be seen how existing MVNOs will be able to compete with mobile broadband services in the future.

5.2.3 Profitability

Given that the merger occurred only in 2014, its impact on EBITDA margins cannot yet be discerned. Up to 2014, T-Mobile had the highest EBITDA margin, largely ahead of the other three MNOs (Figure 29).

Figure 29: EBITDA/revenue margins of MNOs in German mobile market, 2008-2014



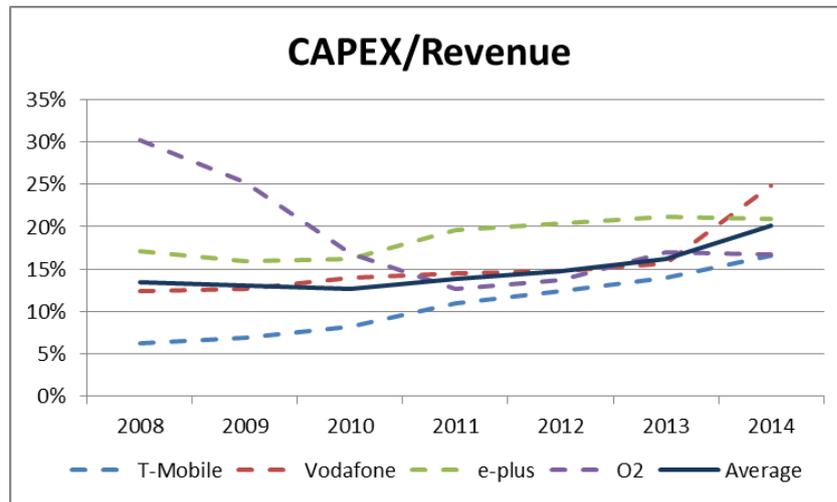
Source: WIK based on NewStreet

5.2.4 Investment

The CAPEX figures in Figure 30 seem to show the impact of the 2010 multiband spectrum auction. After 2010 (in Telefónica's case 2011), CAPEX/revenue ratios jumped up as all operators started to invest into the roll-out of 4G networks and make use of the acquired spectrum. In case of operators that acquired 800MHz spectrum (T-

Mobile, Vodafone, Telefónica), obligations to cover areas that previously had no broadband coverage at all may have also played an important role.

Figure 30: CAPEX/revenue ratios of MNOs in German mobile market, 2008-2014

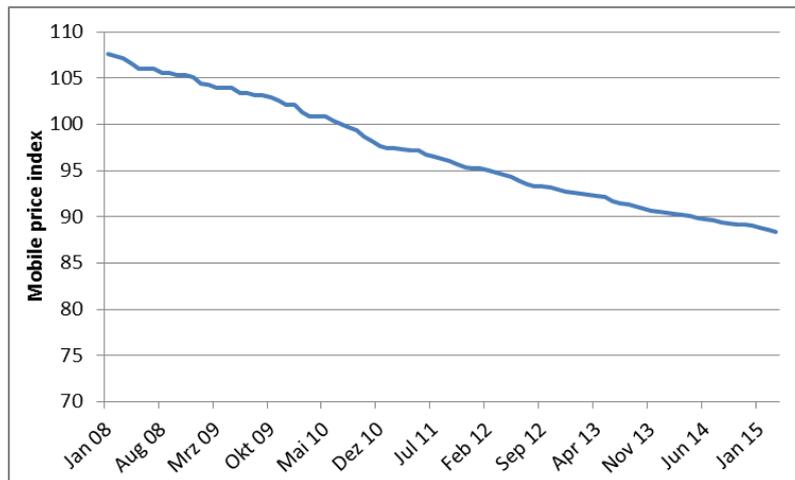


Source: WIK based on NewStreet

5.2.5 Prices

The mobile price index of the German Federal Statistics Office shows that prices have steadily declined over the past years. Between January 2008 and January 2015, the mobile price index decreased by 17.5%. The price index does not show yet an impact of consolidation on prices. It is noticeable that, after the 2010 spectrum auction, there was not increase in the price index. One reason that operators did not pass on added spectrum costs to consumers is likely to be the competitive environment with four market players. While the price index shows the benefits of a competitive four-play market structure prior to 2014, it is too early to draw conclusions on the impact of the merger on prices.

Figure 31: Mobile price index in German mobile market, 2008-2015



Source: Statistisches Bundesamt

5.3 Ireland

5.3.1 Entry and consolidation in the Irish mobile market

Ireland provides an interesting comparator case to the UK both because of its proximity and cultural similarities and because the actors in the planned UK consolidation are the same.

Ireland experienced the entry of an aggressive ‘maverick’ entrant Three (owned by Hutchison 3G UK) in 2005, which raised the number of MNOs from three to four. In 2014, the number of operators went back to three, when Three was merged with Telefónica Ireland.

As in other four-to-three consolidations, the Commission had concerns that the merger would result in a reduction of competition. Hutchison submitted a package of commitments, which were accepted by the Commission:⁵²

- Three committed to offer wholesale network access under a capacity-based MVNO model. Telefónica committed to conclude two such capacity agreements. Under the agreement each of the two MVNOs may increase their initial capacity allocation up to a maximum cap of 15 % of Three’s network capacity. The duration of the two capacity agreements is five years, with an option to extend the term of the agreement for another five years.
- Three committed to divest spectrum to either the two MVNOs (but not to both), in order to enable either one of these MVNOs to develop into an MNO.

⁵² European Commission (2014).

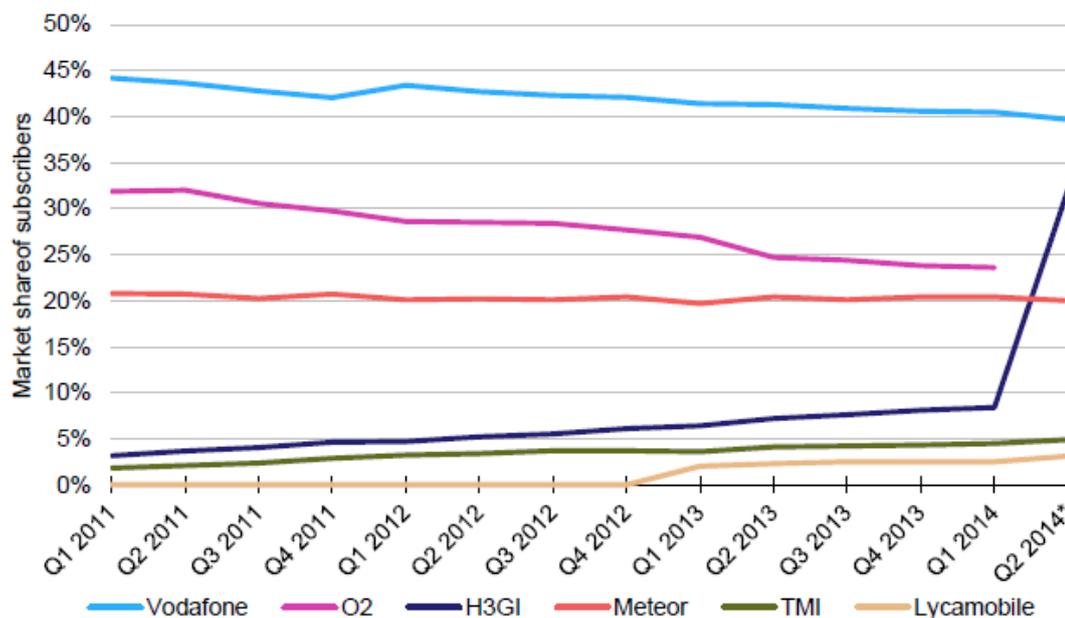
Telefónica committed to divest two blocks of 1800MHz spectrum and two blocks of 2100 MHz spectrum. In addition, Three committed to divest one block of 900MHz spectrum. The option for the MVNOs to acquire this spectrum is valid for 10 years from 1 January 2016.

- Three committed to amend and strengthen Eircom’s existing network sharing agreement with O2. Three would join the agreement and its terms would be revised, among others to increase the pace of site consolidation.

5.3.2 Competition

Data from the Irish regulator Comreg shows that Three’s entry as a significant market player is visible from 2007 onwards. From this point, Three began gaining market share, but remained below 10% of total subscriptions in a market characterized by unbalanced market shares during the period prior to consolidation (Figure 32 and Figure 33). Note that, in contrast to the Figures in the other case studies, MVNOs’ subscribers are not attributed to the network on which they are hosted, but shown in separate MVNO retail market shares. The MVNOs with a relevant subscriber share are Tesco and Lycamobile.

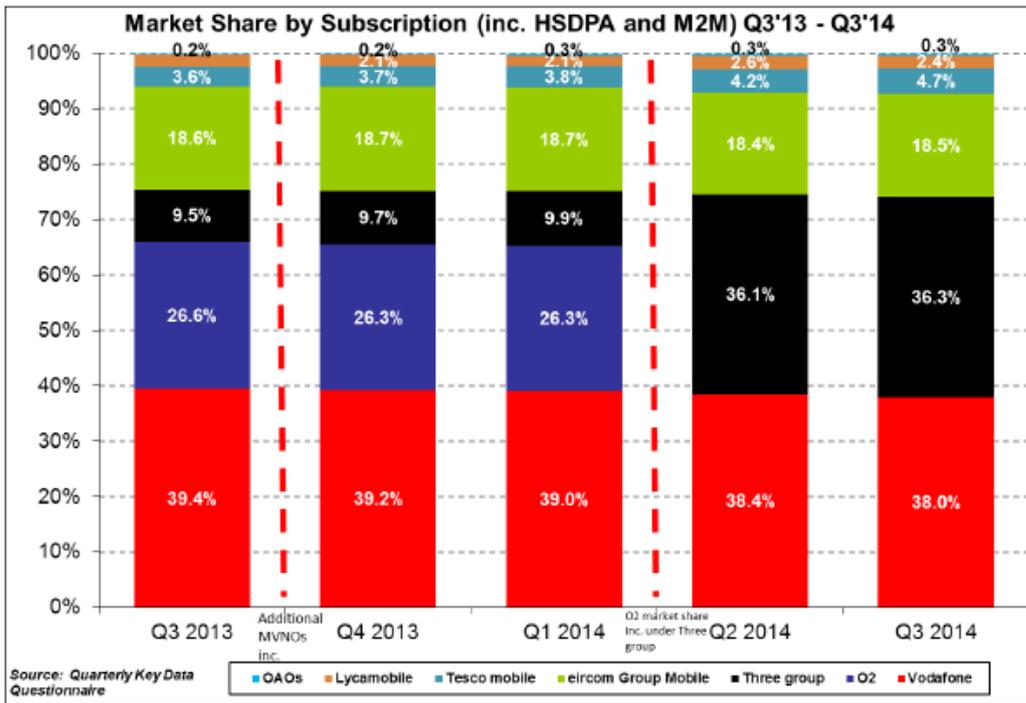
Figure 32: Market shares (subscribers) in Irish mobile market, 2005-2013



* The final data points for Q2 2014 are indicative and illustrate the impact of the merger of H3GI and O2.

Source: Analysis Mason (2015), p. 23.

Figure 33: Market Share by Subscription (incl. HSDPA and M2M), Q3'13 – Q3'14



Source: Comreg – quarterly key data questionnaire

An important aspect of Three’s business model was its focus on post-paid ‘all-you-can-eat’ data packages. Comreg reports also show that in 2014, Three had the higher share of mobile business (48%) and machine to machine (60%) subscriptions. Due to its focus on ‘high end’ and post-paid services, Three’s revenue share was higher than its share of subscribers.

The merger led to a market structure with two MNOs with a similar strong position, Vodafone and Three, both with a market share of roughly 40%, followed by the third more distant player, Eircom, with a market share close to 20%. The merger commitments provided by Three are unlikely to maintain the previous level of competition. The main MVNO which emerged under the merger agreement was Liberty Global, which operates Ireland’s cable network.⁵³ Liberty Global has the advantage of being able to leverage an existing fixed broadband customer-base, but is unlikely to resort to the type of aggressive pricing strategies in the mobile market as Three did in the past. Liberty also has not thus far usually sought to climb the investment ladder to act as a full MNO, with the exception of a recent decision to acquire the MNO Base in Belgium.⁵⁴

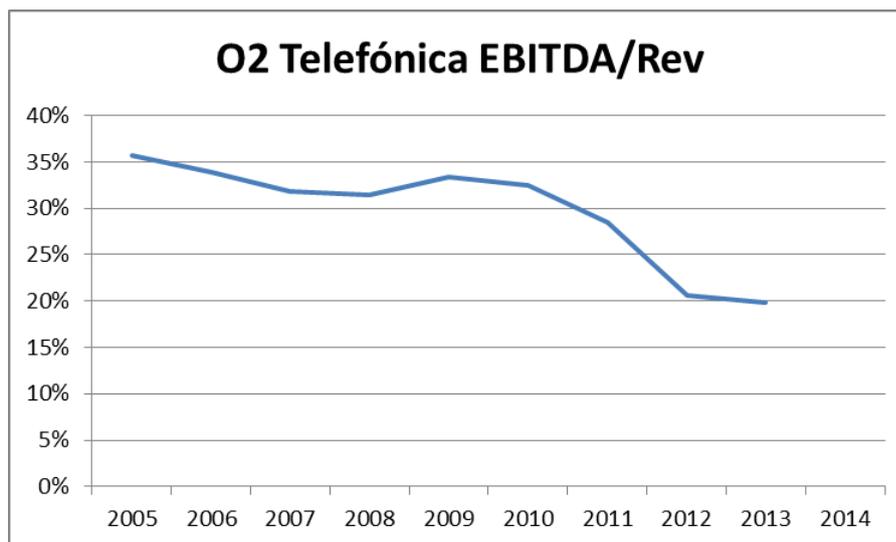
⁵³ The other MVNO that benefits from the merger commitment is Carphone Warehouse.

⁵⁴ <https://www.libertyglobal.com/pdf/press-release/Liberty-Global-BASE-Acquisition-FINAL.pdf>

5.3.3 Profitability

EBITDA is unfortunately not broken out in the financial statements of most operators active in the Irish mobile market. The information available does, however, give some signals of declining profitability from 2009 for Telefonica O2, the operator that was ultimately acquired by 3 (Figure 34).

Figure 34: Capex/revenues of Telefonica O2 Ireland



Source: New Street

It is also understood that Three became EBITDA positive only in H1/2013⁵⁵, having never previously reported a profit in the market.

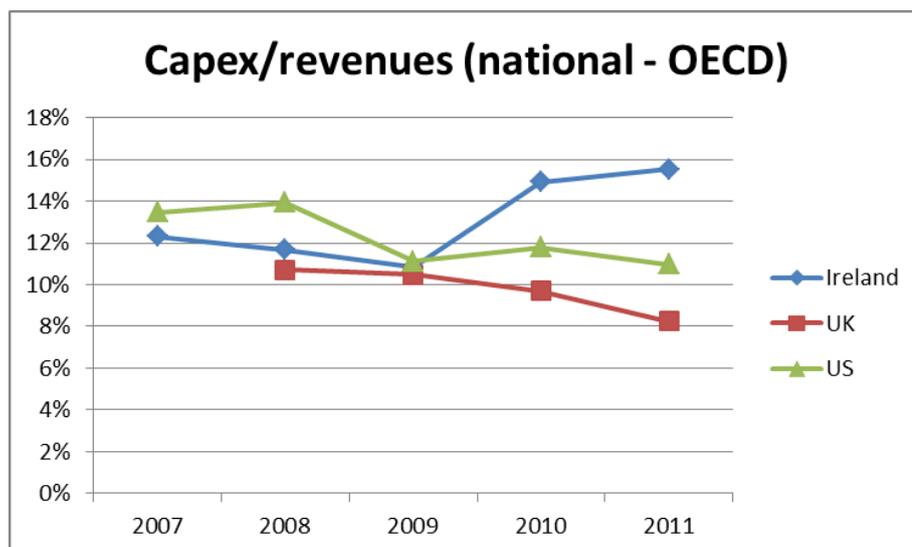
It is possible that the competitive intensity, increasing data usage and the CAPEX required to support it, influenced mobile profit margins in Ireland. However, there are other possible reasons including the economic downturn and Three's inability to gain significant scale through organic growth.

5.3.4 Investment

Disaggregated mobile CAPEX figures are not available for the Irish market. However, national data compiled by the OECD suggests that mobile investment (excluding spectrum fees) as a proportion of revenues in Ireland compare with other countries such as the UK and US and even increased from 2009 (Figure 35).

⁵⁵ <http://www.three.ie/press/releases/18-increase-in-active-customer-base-drives-three-ireland-to-ebitda-break-even-for-the-first-time/>

Figure 35: Capex/revenues (national – OECD)



Source: OECD

It is understood that, since the 2012 auction, all MNOs have pursued significant investment plans for the deployment of 4G networks resulting in almost 90% LTE coverage in Ireland⁵⁶.

5.3.5 Prices

Since its entry on the market, Three competed vigorously in order to grow its customer base. Three's competitive strategy was mainly focused on a three-prong strategy, namely⁵⁷

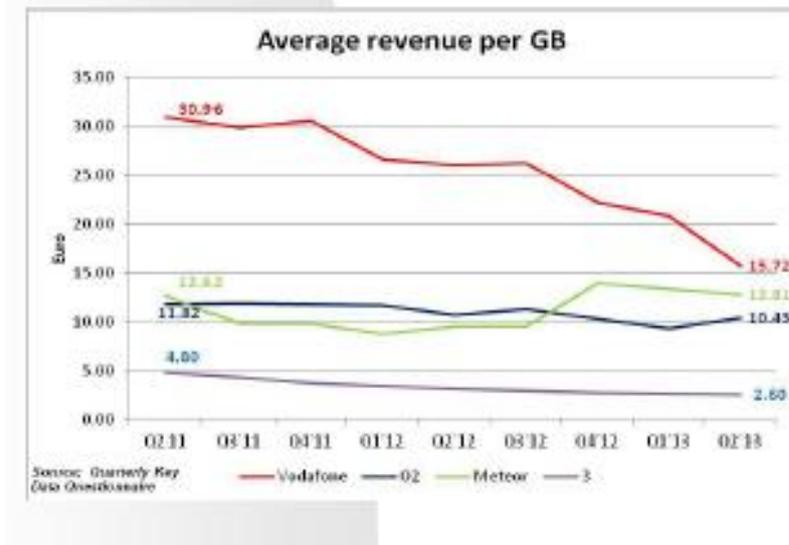
- unique data offers including All You Can Eat ('AYCE') data,
- attractive or unlimited minutes and text bundle allowances, and
- market-leading/free device pricing and competitive tariff plans.

Three's flat-rate pricing strategy for mobile broadband may also have triggered price reductions from competitors as is shown in Figure 36.

⁵⁶ European Commission (2015c).

⁵⁷ European Commission (2014).

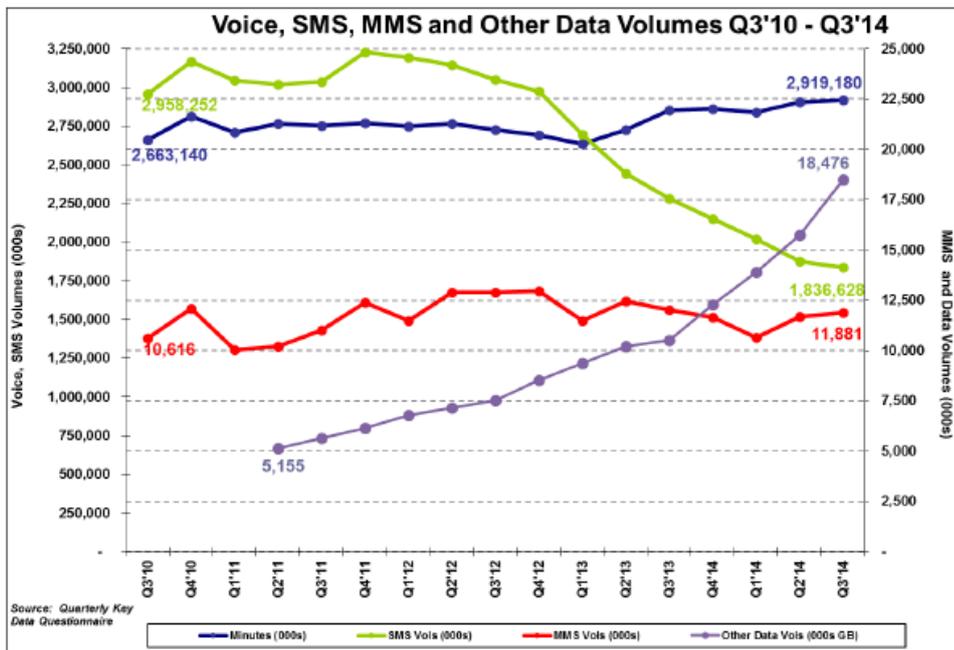
Figure 36: Average revenue per GB



Source: Comreg – quarterly key data questionnaire

Figure 37 shows that the market was characterized by high growth in data use, which accelerated after Q3/2013, accompanied by a decline in SMS. It is understood that data use was particularly high amongst Three’s customers.

Figure 37: Voice, SMS, MMS and Other Data Volumes Q3'10 – Q3'14



Source: Comreg – quarterly key data questionnaire

5.4 Netherlands

5.4.1 Entry and consolidation in the Dutch mobile market

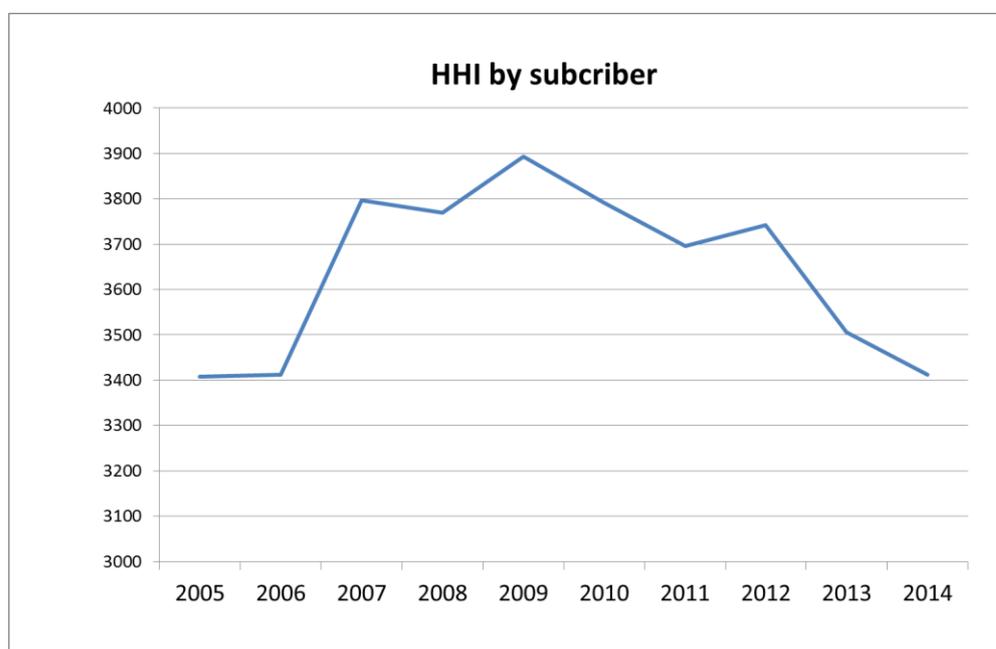
In late 2007, T-Mobile acquired Orange Netherlands, reducing the number of MNOs from four to three: KPN, Vodafone and T-Mobile. The Commission approved the merger without asking for commitments from the merged entity.

The market remained a three-player market until 2013, when Tele2 entered the market with 4G spectrum. Tele2 became the fourth MNO in the Netherlands after having acquired 2x20MHz of 2.600MHz spectrum (in the 2010 auction) and 2x10MHz of 800MHz spectrum (in the 2012 auction). Previously Tele2 was active as an MVNO. Tele2 benefits from a site-sharing agreement with T-Mobile.

5.4.2 Competition

The consolidation in the Dutch market in 2007 led to an increase in HHI. Subsequently the HHI decreased again as Figure 38 shows. The decrease in HHI was further supported by the emergence of Tele2 as a fourth MNO in 2013.

Figure 38: Herfindahl-Hirschman-Index (HHI) in Dutch mobile market, 2005 - 2014

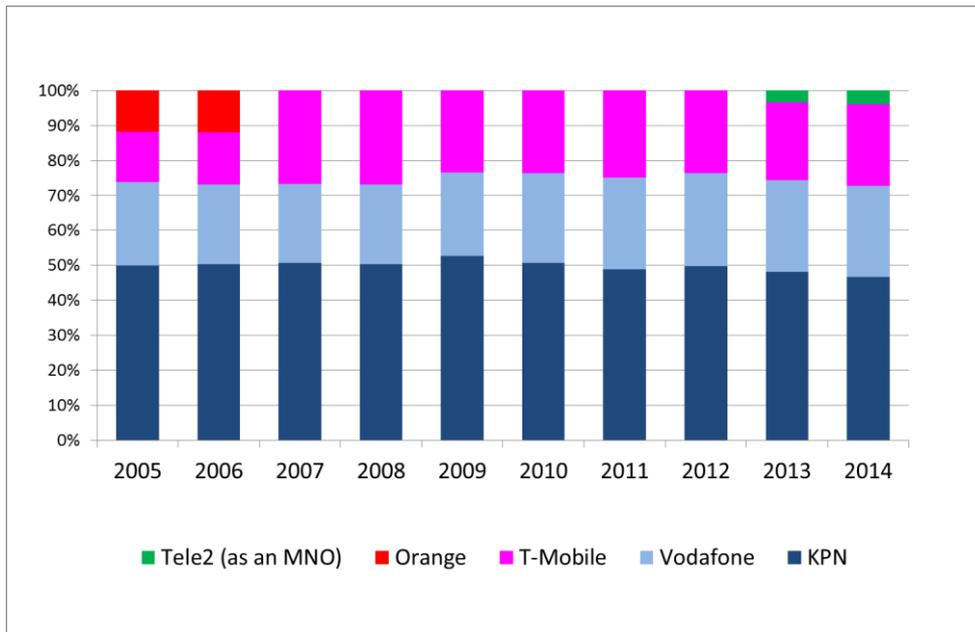


Source: WIK based on NewStreet; informa, Mobile communications Europe

Despite the T-Mobile/Orange merger in 2007 market shares in the Dutch market remained asymmetric with KPN leading its competitors Vodafone and T-Mobile. by a

significant margin. Tele2 still has a very low market share, which shows that new entrant MNOs need considerable time and investment to become viable competitors (Figure 39). It also suggests that four-to-three consolidations cannot be easily reversed by new entry.

Figure 39: Market shares based on subscribers in Dutch mobile market, 2005 - 2014



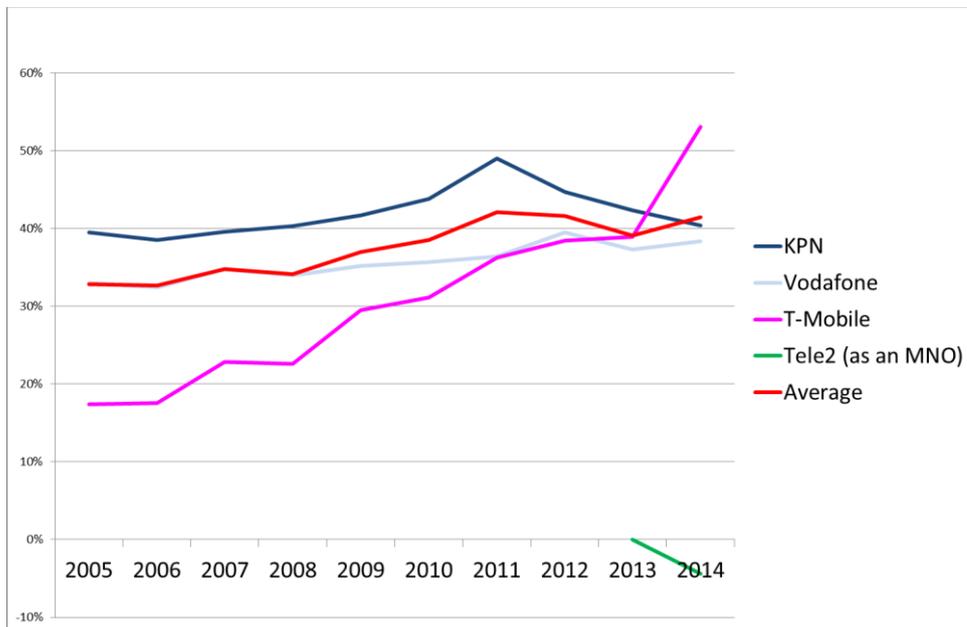
Source: WIK based on NewStreet; informa, Mobile communications Europe

5.4.3 Profitability

Market consolidation went together with an improvement of EBITDA margins as is shown in Figure 40. While T-Mobile’s EBITDA margin is still increasing, the margins of KPN and Vodafone peaked in 2011 and subsequently fell to a lower level.

Up to 2013, KPN had the highest EBITDA margin, followed its competitors. T-Mobile, which was initially the least profitable MNO, continuously improved its EBITDA margin to become the most profitable operator in 2014. Tele2, which became an MNO in 2013, has a negative EBITDA margin.

Figure 40: EBITDA/revenue margins of MNOs in the Dutch mobile market, 2005 - 2014

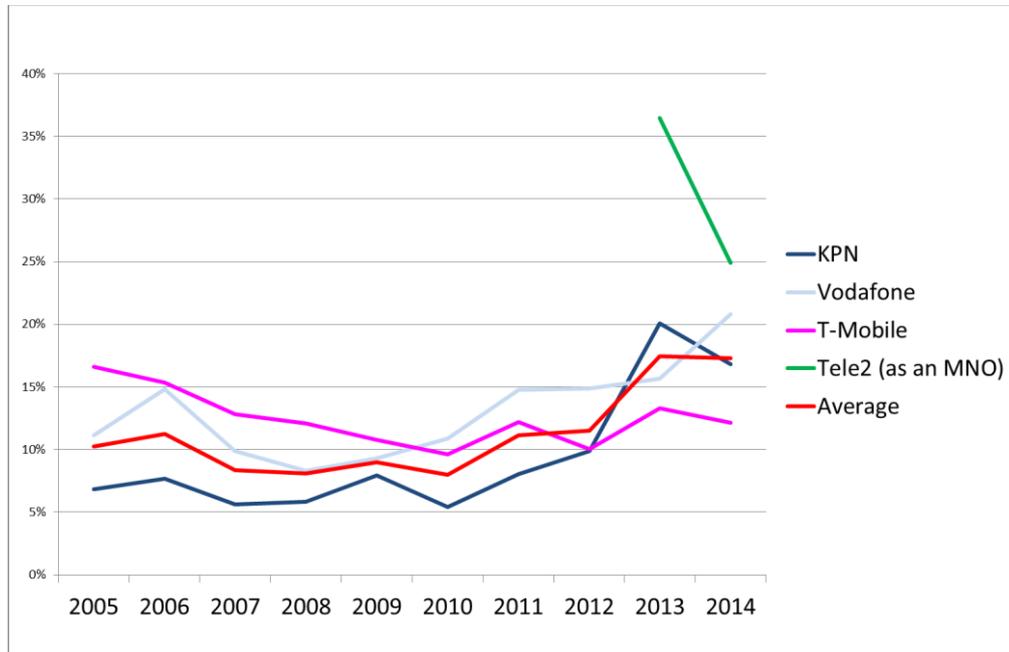


Source: WIK based on NewStreet

5.4.4 Investment

Figure 41 shows that the CAPEX/revenue ratio already fell for all MNOs before the T-Mobile/Orange merger, but the decline continued. Only after 2010 CAPEX/revenue rose again as all operators started to invest into the roll-out of 4G networks and make use of the spectrum in the 2010 and 2012 auctions. Tele2, because of the need to build a new network and because of its small market share, has the largest CAPEX/revenue ratio. Among the incumbent MNOs, Vodafone had the highest CAPEX/revenue ratio followed by KPN and T-Mobile.

Figure 41: CAPEX/revenue ratios of MNOs in the Dutch mobile market, 2005 - 2014

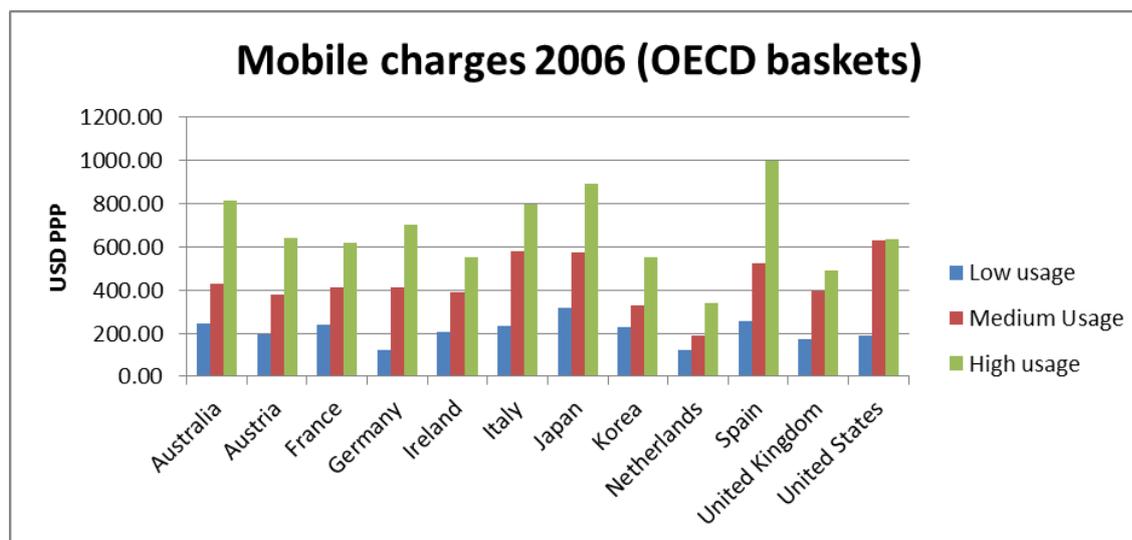


Source: WIK based on NewStreet.

5.4.5 Prices

The lack of a consistent time series for mobile prices in the Netherlands makes it challenging to gauge what if, any, impact consolidation had on mobile prices in the Dutch market. According to baskets defined by the OECD, prior to the merger in 2006, prices for low, medium and high user baskets in the Netherlands were cheaper than in all the other countries considered for this study. Prices remained amongst the lowest during the next OECD data gathering exercise for 2008.

Figure 42: Mobile charges 2006 (OECD baskets)



Source: WIK based on OECD Communications Outlook 2007

OECD basket methodologies changed for the publication of mobile pricing data from 2010 onwards. It is notable however that, according to the new methodology, the ranking of Dutch mobile charges for low, medium and high (call) baskets was between 4-6 out of the 12 considered countries as of August 2012, some years following consolidation and prior to the entry of Tele2 as a fourth mobile operator. There are various possible explanations, including the effect of the new basket methodology, as well as changing circumstances in the other markets considered. It cannot be excluded however that a reduction in competition may have contributed to higher charges. Time series for mobile data baskets are not available over a sufficient period for us to gauge any potential effect on data.

Conclusions

On the impact of consolidation on investment and consumer outcomes in the case studies:

All of the countries covered in case studies are characterised by four-to-three consolidation: Netherlands in 2007, Austria in 2010, Germany and Ireland in 2014.

In the more recent three mergers, the Commission tried to avoid the deterioration of competition by making the merger subject to MVNO access and spectrum divestiture commitments. Given the recent occurrence of the mergers it is too early to draw definitive conclusions. However, there are doubts whether the MVNO access arrangements can compensate for the removal of competitors with a maverick role. It is also doubtful whether the MVNOs that benefit from access

commitments will ultimately develop into MNOs and acquire or lease the spectrum provided for in the commitments.

In the Dutch case, the earlier merger was not subject to similar commitments. Tele2 which operated as an MVNO on commercially negotiated terms became a fourth operator in 2013 using spectrum acquired in the 2010 and 2012 auctions. There are some indications that the Netherlands, which prior to consolidation had especially low mobile charges (for calls baskets), had higher charges relative to the other 11 countries considered some years after consolidation and prior to the entry of Tele2.

The case studies suggest that 4-to-3 consolidations are not easily reversed by spectrum divestiture commitments (on merged entities) or reservation of spectrum (in new spectrum auctions). The spectrum divestiture commitments, intended to keep market entry open, have not resulted in the emergence of new MNOs. While reservation of spectrum in the Dutch 2012 auction has facilitated the entry of Tele2 as a fourth MNO, its market share is still very small and it will take time for Tele2 to establish itself as a viable fourth competitor.

6 References

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7 Annexes

7.1 Alternative rankings

Table 15 shows how countries would be ranked if connections speed was measured by Ookla rather than Akamei. The overall country ranking is based on all broadband and voice outcomes with equal weights attributed to each outcome.

Table 15: Overall ranking with equal weighting of consumer outcomes (broadband and voice), with connection speed measured by Ookla

	Broadband outcomes							Voice outcomes			Number of observations	Average rank value	Overall rank
	3G Coverage	4G Coverage	Average connection speed (Ookla)	Average Price of mobile baskets with internet	Mobile BB penetration	LTE penetration	Data usage	Average Price of mobile baskets with calls	Mobile penetration	Voice usage			
Australia	3	7	3	3	1	2	5	4	4	na	9	3,56	1
South Korea	3	1	6	7	3	1	1	6	9	6	10	4,30	2
UK	8	8	9	2	5	9	6	2	5	3	10	5,70	3
US	7	2	7	9	4	4	3	8	12	1	10	5,70	3
France	2	6	1	4	11	8	10	3	11	2	10	5,80	5
Austria	9	12	4	1	9	10	7	1	1	4	10	5,80	5
Netherlands	3	3	2	6	10	5	12	7	6	7	10	6,10	7
Japan	1	3	11	12	2	3	2	12	8	10	10	6,40	8
Ireland	11	11	12	5	6	7	4	5	10	na	9	7,89	9
Italy	10	10	10	8	8	na	9	10	2	5	9	8,00	10
Spain	3	9	8	11	7	na	8	11	7	8	9	8,00	10
Germany	12	5	5	10	12	6	11	9	3	9	10	8,20	12

The overall ranking in Table 16 only takes broadband outcomes into account with equal weights attached to each outcome. Connection speed is measured by Akamai.

Table 16: Overall ranking with equal weighting of consumer outcomes (broadband only), with connection speed measured by Akamai

	Broadband outcomes							Number of observations	Average rank value	Overall rank
	3G Coverage	4G Coverage	Average connection speed (AKAME)	Average Price of mobile baskets with internet	Mobile BB penetration	LTE penetration	Data usage			
South Korea	3	1	5	7	3	1	1	7	3,00	1
Japan	1	3	3	12	2	3	2	7	3,71	2
Australia	3	7	12	3	1	2	5	7	4,71	3
US	7	2	5	9	4	4	3	7	4,86	4
UK	8	8	1	2	5	9	6	7	5,57	5
France	2	6	2	4	11	8	10	7	6,14	6
Netherlands	3	3	5	6	10	5	12	7	6,29	7
Ireland	11	11	4	5	6	7	4	7	6,86	8
Austria	9	12	8	1	9	10	7	7	8,00	9
Spain	3	9	10	11	7	na	8	6	8,00	9
Germany	12	5	9	10	12	6	11	7	9,29	11
Italy	10	10	11	8	8	na	9	6	9,33	12

If connection speed is measured by Ookla, the overall country ranking for broadband outcomes is as shown in Table 17.

Table 17: Overall ranking with equal weighting of consumer outcomes (broadband only), with connection speed measured by Ookla

	Broadband outcomes							Number of observations	Average rank value	Overall rank
	3G Coverage	4G Coverage	Average connection speed (Ookla)	Average Price of mobile baskets with internet	Mobile BB penetration	LTE penetration	Data usage			
South Korea	3	1	6	7	3	1	1	7	3,14	1
Australia	3	7	3	3	1	2	5	7	3,43	2
Japan	1	3	11	12	2	3	2	7	4,86	3
US	7	2	7	9	4	4	3	7	5,14	4
Netherlands	3	3	2	6	10	5	12	7	5,86	5
France	2	6	1	4	11	8	10	7	6,00	6
UK	8	8	9	2	5	9	6	7	6,71	7
Austria	9	12	4	1	9	10	7	7	7,43	8
Spain	3	9	8	11	7	na	8	6	7,67	9
Ireland	11	11	12	5	6	7	4	7	8,00	10
Germany	12	5	5	10	12	6	11	7	8,71	11
Italy	10	10	10	8	8	na	9	6	9,17	12

7.2 Econometric evidence on linkage between consolidation and investment

This Annex presents in more detail the econometric evidence regarding investments and competition that was summarized in Section 3.3.

7.2.1.1 Frontier's approach and results

Frontier Economics (2015) aims at determining the key factors that influence investments in the mobile industry. Investment is measured by capex per subscriber.⁵⁸

⁵⁸ Frontier outlines that they consider capex/subscriber to be a superior measure of investment to capex/revenue.

Frontier uses GSMA data, based on quarterly data from EU MNOs in three and four player markets covering the time period 2000 – 2014. Frontier has estimated a number of different models of capex per subscriber encompassing the following explanatory variables:

- Competition measured by HHI,
- the timing of 3G and 4G auctions,
- the launch of 4G services,
- the percentage of prepaid connections,
- GDP per capita,
- Year dummies,
- the explained variable (capex per subscriber) lagged by one period.⁵⁹

Most of the equations estimated are specified as log-log models, i.e. they are linear with all non-dummy variables in logarithmic form. Frontier uses a fixed effect approach appropriate for panel data.

The following table contains the main results that Frontier has achieved.

⁵⁹ Frontier mentions the following reasons for this approach: (1) It is expected that capex adjusts slowly in response to changes in other factors because the costs of doing so are high. (2) Operators are likely to follow long-term investment plans, thus, a degree of path dependency in investment is expected.

Table 18: Econometric results achieved by Frontier concerning the key factors determining investment in mobile markets

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	log(capex per subscriber)	log(capex per subscriber)	log(capex per subscriber)	capex per subscriber	log(capex per subscriber)	log(capex per subscriber)
HHI	-0.14 (0.31)	-0.44 (0.32)	-	0.01 (0.00)	0.14 (0.11)	-
4 player dummy	-	-0.12** (0.06)	-0.07 (0.06)	-	-	-0.06* (0.03)
Auction dummy	0.09** (0.04)	0.09** (0.04)	0.09** (0.04)	3.70*** (1.22)	0.08* (0.05)	0.08* (0.05)
3G network dummy	0.22*** (0.08)	0.24*** (0.09)	0.24*** (0.09)	2.46 (1.88)	0.15** (0.07)	0.15** (0.08)
4G network dummy	0.34*** (0.09)	0.33*** (0.10)	0.33*** (0.10)	5.79*** (2.19)	0.16** (0.07)	0.16** (0.07)
% prepaid connections	-0.38*** (0.11)	-0.40*** (0.12)	-0.40*** (0.12)	-12.87* (7.52)	-0.03 (0.02)	-0.03 (0.02)
GDP per capita (in PPP terms)	0.06 (0.46)	0.03 (0.48)	0.17 (0.44)	0.00*** (0.00)	0.35*** (0.05)	0.36*** (0.05)
Lagged capex per subscriber	0.18*** (0.05)	0.18*** (0.05)	0.18*** (0.05)	0.22* (0.11)	0.47*** (0.03)	0.47*** (0.03)
Number of observations	2,293	2,293	2,293	2,293	2,293	2,293
R ²	0.22	0.23	0.23	0.15	0.40	0.40
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
MNO FE	Yes	Yes	Yes	Yes	No	No
Methodology	FE	FE	FE	FE	OLS	OLS

Source: Frontier Economics (2014); op. cit., p. 26. *** p<0.01, ** p<0.05, * p<0.1.

Frontier outlines that relationship (1) is their preferred specification, which they sensitivity test through relationships (2) to (6). Thus, the functional form of relationship 1 equals:

$$\begin{aligned}\log(\text{capex per subscriber}) &= -0.14(\log HHI) + 0.09(\text{Auction dummy}) + 0.22(3G \text{ dummy}) \\ &+ 0.34(4G \text{ network dummy}) - 0.38(\log \% \text{ prepaid connections}) \\ &+ 0.06(\log GDP \text{ per capita in PPP terms}) \\ &+ 0.18(\log \text{ lagged capex per subscriber})\end{aligned}$$

According to Frontier the aforementioned econometric results suggest that the following conclusions hold:

- There is no evidence that more intense competition increases investment; this is indicated by the fact that the intensity of competition (HHI) does not have a statistically significant or positive impact in any of the regression models.
- This conclusion is robust to the relationship that Frontier assumes about capex and its explanatory factors, as illustrated by the sensitivity tests carried out around the preferred specification.⁶⁰
- Several other factors appear to be important for determining capex:
 - past capex influences current capex (coefficient is highly significant);
 - increases in the share of post-pay subscribers may increase capex per subscriber (coefficient regarding pre-paid connections is negative and highly significant), as post-pay subscribers tend to utilise 3G and 4G services more than pre-pay users;
 - increases in GDP per capita may result in increases in capex per subscriber, as increasing wealth increases users' budgets for mobile services; this result, however, is *not* supported by Frontier's preferred specification as the coefficient of GDP per capita is not statistically significant.
 - capex is higher in auction years (coefficient is highly significant),
 - capex is higher for MNOs rolling out 3G and 4G networks, respectively (the respective coefficients are highly significant).

⁶⁰ Including lagged capex per subscriber also allows to estimate the long-run impact of competition on investment; this is outlined in more detail in annex 2 of the Frontier study. Performing statistical tests on this impact suggests that competition does not materially influence investment in the long-run.

7.2.1.2 HSBC

HSBC (2015) in many respects rests on a previous study by Hounghonon and Jeanjean (2014).⁶¹ In *Section 3.1*, - dealing with theoretical arguments - we have already presented the inverted-U shaped relationship between market power and investment that was postulated in Hounghonon and Jeanjean (2014).

The focus of both studies is an empirical assessment of the causal impact of the intensity of competition on network investment. Both studies use company-level panel data and instrument variable estimation techniques.

The HSBC study is based on an unbalanced panel consisting of 66 operators with data extending over 11 years from 2003 to 2013. The firms are drawn from 22 national markets covering all regions of the world. In total, there are 606 observations.⁶²

In order to measure the intensity of competition at the firm level, the studies use the Lerner index of monopoly power. Assuming constant marginal cost of production, the studies conclude that the ratio between a firm's operating profit (Ebitda) and its total revenue is a valid measure of the Lerner index of monopoly power. Thus, the intensity of competition experienced by the firm i ($Comp_i$) is defined to be:

$$Comp_i = 1 - Ebitda_i / Revenue_i$$

The studies are based on a two-stage structural approach. In the first stage, competition is modeled as a linear function of regulatory variables deemed to be decisive in this context, namely:

- the cumulated number of frequency bands released in the market of firm i before a given date (HSBC uses the year 2005) thereby assuming the more the frequency bands assigned before this date, the greater the intensity of competition faced by the firm.
- the year of entry of firm i into the market allowed by the regulator. The assumption is that firms that enter later into the market face more competitors, and therefore experience higher intensity of competition.

Against the backdrop of the inverted-U shape relationship the key endogenous variables of the HSBC approach are $Comp_i$ and $Comp_i$ squared. The “number of frequency bands released before 2005” and the “year of entry of firm i into the market” serve as “instruments” for the two endogenous variables.

Overall, HSBC's estimation approach is based on the following specification:

⁶¹ Subsequently, we do not go into the details as to the differences between both studies.

⁶² The data base of Hounghonon and Jeanjean (2014) is larger: This study is based on an unbalanced panel of 240 firms from 119 countries observed from 2000 to 2014. As a result the main estimation sample contains 4695 observations.

$$Y_{it} = \alpha + \beta_1 \theta_{it} + \beta_2 \theta_{it}^2 + \gamma X_{it} + \delta D_t + C_{it} + \varepsilon_{it}$$

where

- Y_{it} is investment for the firm i in the year t ,
- θ_{it} is the measure of competitive intensity for the firm i in the year t ,
- β_1 is the coefficient of competition and β_2 is the coefficient of competition squared,
- X_{it} is a set of control variables, including time as well as dummy variables for entry, merger, exit, and whether a mobile operator is simultaneously a fixed link incumbent.
- D_t is the demand shifter (the active population),
- C_{it} is the cost shifter (the population density), and
- ε_{it} is a stochastic disturbance term.

In order to estimate the instrument variable approach HSBC uses the Generalized Method of Moment (GMM) estimation.

Overall, the key econometric results of the model deemed to be the most appropriate by HSBC can be summarized as follows:

- The coefficient of competition is positive, the coefficient of competition squared is negative; both estimates are highly statistically significant;
- “Active population” has a positive effect on investment which is highly statistically significant.

This most preferred model by HSBC controls in addition for region and year effects and it is derived from a model in which the dummy variables for entry, merger, exit, and whether a mobile operator is simultaneously a fixed link incumbent are statistically not significant.

The two aforementioned results for competition and competition squared underlines the inverse-U relationship between competition intensity and investment. Overall, HSBC concludes that greater competitive intensity starting from low levels tends to increase investment, but beyond a certain threshold, more competition actually reduces investment. The study estimates that investment is maximised when the level of competitive intensity corresponds to an EBITDA margin of 38%.

7.2.1.3 Our approach

Our data base comprises mobile operators from 12 countries and 9 points in time (2005 – 2013).

We have estimated a great number of different models of either capex or capex per subscriber (explained variable). To this end, we have made use of the following explanatory variables:

- Competition, measured by HHI or the number of operators, respectively, in a given country,
- the explained variable (capex or capex per subscriber) lagged by one period,
- Profitability, measured by Ebitda (and/or Ebitda lagged by one period)
- GDP or GDP per capita, respectively,
- the timing of 4G auctions,
- Revenues or revenues per subscriber, respectively,
- The percentage of rural population (per country),
- the launch of 4G services.

We did not include the “percentage of prepaid connections” as such data is not consistently available in the public investor statements which form the source of NewStreet data⁶³. Moreover, apart from the “timing of 4G auctions” we have not included specific year dummies.

Most of the equations estimated (see next section) are specified either in nominal form (i.e. we have taken no logarithms) or log-log models, i.e. they are linear with all non-dummy variables in logarithmic form. Like Frontier we use a fixed effect approach appropriate for panel data.

Overall, we have estimated two different sets of models:

- For each operator-specific variable of the operators within a country the annual values have been summed up and only country specific data has been used for the estimates.⁶⁴ This reduces the available number of observations per model run significantly; however, the resulting number of observations remains sufficient for a fixed effect approach.⁶⁵
- We have used the disaggregated operator specific data whenever possible (i.e. for Capex, Ebitda, Revenue).

⁶³ Moreover, new types of tariff structure including fixed payment, but without contract are blurring the boundaries between pre and post-paid.

⁶⁴ To give an example: Ebitda for operator 1, 2, 3 and 4 at time t ($t = 2005 - 2013$) in country A has been summed up; likewise, the Ebitda's for operator 1, 2, 3, and 4 in country A at time $t+1$ have been added up, etc.

⁶⁵ Instead of taking into account on average 4 operators per country, 12 countries and 9 points in time (thus, equaling $4 \cdot 12 \cdot 9 = 432$ observations) one disposes in the aggregated approach only of 12 countries and 9 points in time (thus, equaling $12 \cdot 9 = 108$ observations). Due to missing values the latter number usually is once again reduced resulting at about between 95 and 100 observations.

7.2.1.3.1 Estimates on the basis of aggregated (country specific) data

The next table provides estimation results for the following functional specification of the investment equation:

- $Capex = f(Ebitda, Ebitda_{-1}, HHI, GDP, Capex_{-1})$

whereby f is a linear function of the mentioned variables.

In the table, each row denotes a specific model run in which the respective variables denoted in the columns have been used.⁶⁶

Table 19: Estimates based on the approach: $Capex = f(Ebitda, Ebitda_{-1}, HHI, GDP, Capex_{-1})$

Explanatory variables											
Ebitda		Ebitda ₋₁		Ebitda ₋₂		HHI		GDP		Capex ₋₁	
Expected sign: +		Expected sign: +		Expected sign: +		Expected sign: -		Expected sign: +		Expected sign: +	
sign	stat sig*	sign	stat sig*	sign	stat sig*	sign	stat sig*	sign	stat sig*	sign	stat sig*
+	+					+	-	+	-		
+	++					+	-	+	+	+	++
		+	+	+	-	+	-	+	-		
		+	+	+	-	+	-	+	++	+	++
+	+	-	-			+	-	+	-		
+	+	-	-			+	-	+	++	+	++

* statistical significance: ++ denotes 99% level; + denotes 90% level

The key result of this table can be summarized as follows:

- “Ebitda”, “GDP” and the “Investments of the previous period” (Capex₋₁) have a statistically significant impact on current investments.
- “HHI”, however, does not have a statistically significant impact.

Overall, we have carried out many more model runs than those described in the table. However, the results are not materially affected.

The aforementioned approach does not take account of scale, but it is highly likely that scale should be taken into account. We therefore have used “revenues” as a proxy to control for the respective scale. The next table provides estimation results for the following functional specification of the investment equation:

⁶⁶ If a field is empty in the table the specific variable denoted in the column has been omitted in the model run specified in the row.

- $Capex = f(Ebitda, HHI, Capex_{-1}, Revenues, Revenues_{-1})$

whereby f is a linear function of the mentioned variables.

Table 20: Estimates based on the approach: $Capex = f(Ebitda, HHI, Capex_{-1}, Revenues, Revenues_{-1})$

Explanatory variables											
Ebitda		HHI		GDP		Capex ₋₁		Revenues		Revenues ₋₁	
Expected sign: +		Expected sign: -		Expected sign: +		Expected sign: +		Expected sign: +		Expected sign: +	
sign	stat sig*	sign	stat sig	sign	stat sig	sign	stat sig	sign	stat sig	sign	stat sig
								+	++		
						+	++	+	++		
+	++	+	-					+	+		
+	-	+	-			+	++	+	+		
+	++	+	-							+	++
+	+	+	-			+	++			+	++

* statistical significance: ++ denotes 99% level; + denotes 90% level

The key result of this table can be summarized as follows:

- Apart from “Ebitda” and the “Investments of the previous period”, capex is also likely to depend on “Revenues”.
- “HHI”, however, does not have a statistically significant impact.
- Using “GDP” and “Revenues” together yields statistically insignificant estimates.

As to the latter finding it deserves to be stated that the correlation coefficient of “GDP” and “Revenues” equals 0.93.

Also in this case we have carried out many more model runs than those described in the table. However, the essential results didn’t change.

7.2.1.3.2 Estimates on the basis of disaggregated (operator specific) data

We have carried out a whole range of estimates both for “capex” and “capex per subscriber” as explained variable.

First, we focus on “Capex” as explained variable. The next table provides estimation results for the following functional specification of the investment equation:

- $Capex = f(Capex_{-1}, Ebitda, HHI, GDP, Auction\ date, Revenues, Percentage\ of\ rural\ population)$ whereby f is a linear function of the mentioned variables.

Moreover, we have carried out estimates where “HHI” has been replaced by the “Number of operators” in each country (over time).

Table 21: Estimate based on the approach: $Capex = f(Capex_{-1}, Ebitda, HHI, GDP, Auction\ date, Percentage\ of\ rural\ population, Number\ of\ operators)$

Explanatory variables				R squared	
Capex ₋₁	Coeff		+0.609	p-value*	0.00***
Ebitda	Coeff		+0.014	p-value	0.88
HHI	Coeff		0.072	p-value*	0.74
GDP	Coeff		1.51e-09	p-value*	0.19
Auction date	Coeff		43.17	p-value*	0.67
Rural pop	Coeff		-7483.4	p-value*	0.281
Number of operators	Coeff		-12.19	p-value*	0.81
				No. of observations	222
				R squared	0.74

*** statistical significance at 1% level.

The key result of this table can be summarized as follows: The “Investments of the previous period” (Capex₋₁) play a key role in determining current investments. All other explanatory variables – in particular HHI and the number of operators - are not significant.

We have carried out other model runs than those described in the table. However, the essential results didn't change.

Second, we focus on “Capex per subscriber” as explained variable. The next table provides estimation results for the following functional specification of the investment equation:

- $\text{Capex/sub} = f(\text{Capex/sub}_{-1}, \text{Ebitda/revenue}, \text{HHI}, \text{GDP per capita}, \text{Auction date}, \text{Percentage of rural population})$

whereby f is a linear function of the mentioned variables.

Moreover, we have carried out estimates where “HHI” has been replaced by the “Number of operators” in each country (over time).

Table 22: Estimate based on the approach: Capex/sub = f (Capex/sub₋₁, Ebitda/revenue, HHI, GDP per capita, Auction date, Percentage of rural population)

Capex/sub ₋₁	Ebitda/revenue		HHI		GDP per cap.		Auction date		Number of operators		Rural pop		No. of observ.; R2 squared
	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	
0.57	-5.64+	0.78	0.01+	0.14	0.00	0.77	0.08	0.96	3.57	0.28	-115.6	0.58	221; 0.72

*** statistical significance at 1% level.

The key result of this table can be summarized as follows:

- The “Investments of the previous period” (Capex.₁) play a key role in determining current investments.
- There is no evidence that “Ebitda/revenue” has an impact.
- There is no evidence that “HHI” and the “number of operators” has an impact.
- Moreover, all other variables are statistically not significant.

Next we have carried out estimates where we have taken logarithms on both sides of the equation to be estimated. Moreover, we have omitted either the variable “number of operators” or HHI as these two variables are highly correlated. In addition we have omitted the variable “percentage of rural population” as our data base only has values available for 2009 and thereafter.⁶⁷ Thus, we have estimated the following equation:

- $\ln \text{Capex/sub} = f(\ln \text{Capex/sub}_{-1}, \ln \text{Ebitda/revenue}, \ln \text{HHI}, \ln \text{GDP per capita}, \text{Auction date}, \ln \text{Percentage of rural population})$

⁶⁷ Hence omitting this variable increases the number of observations.

Table 23: Estimate based on the approach: $\ln \text{Capex/sub} = f(\ln \text{Capex/sub}_{-1}, \ln \text{Ebitda/revenue}, \ln \text{HHI}, \ln \text{GDP per capita}, \text{Auction date}, \ln \text{percentage of rural population}; \ln \text{number of operators})$

In Capex/sub ₋₁	In Ebitda/revenue		In HHI		In GDP per cap.		Auction date		In number of operators		In rural pop		No. of observ.; R ² squared
	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value	
0.60	0.00***	-0.04	0.46	0.06*	-0.78	0.04**	0.03	0.41					293; 0.62
0.52	0.00***	-0.4			-0.43	0.35	-0.5	0.42	0.28	0.16			301; 0.66
0.62	0.00***		0.4	0.14	-0.78	0.03**	0.04	0.29					296; 0.64

*** statistical significance at 1% level; ** at 5 % level; * at 10 % level.

The key result of this table can be summarized as follows:

- The “Investments of the previous period” (Capex.₁) play a key role in determining current investments.
- “HHI” as well as the “number of operators” do not have a statistically significant impact.
- There is no evidence that “Ebitda/revenue” has an impact.
- “GDP per capita” might have a (negative) impact on Capex/subscriber.

Replacing “capex/subscriber” by “capex/revenue” changes of course the estimated coefficients, however, it still remains the case that the variable “Investments of the previous period” is statistically significant as well as “GDP per capita” (negative sign).

7.3 Econometric evidence on linkage between consolidation and consumer outcomes

This annex presents in more detail the econometric evidence to which we refer in section 4.2.3.

7.3.1 Studies relating to prices

7.3.1.1 Frontier (2015)

The Frontier study⁶⁸ among others aims at estimating econometrically the key factors determining prices in the mobile sector. The study, however, does not estimate “prices” directly, rather, it focuses on a proxy for prices, namely the average revenue per minute (ARPM).

The data base consists of quarterly GSMA data between 2000 and 2014. The observation units taken into account are European MNOs in three and four player markets. Overall, Frontier specifies the following equation to be estimated:

- $\text{Log (ARPM)} = f(\text{HHI, 4 player Dummy, 3G network Dummy, 4G network Dummy, \% of pre-paid connections, GDP per cap, subscribers, ARPM}_{-1})$

The following Table presents the main econometric results of the Frontier study.

⁶⁸ Frontier Economics (2015), op. cit.

Table 24: Econometric results achieved by Frontier as to the relationship between competition and prices

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	log(ARPM)	log(ARPM)	log(ARPM)	log(ARPM)	log(ARPM)	log(ARPM)
HHI	0.03 (0.06)	0.03 (0.06)	-	0.00 (0.00)	0.02 (0.02)	-
4 player dummy	-	0.00 (0.01)	0.00 (0.01)	-	-	-0.01* (0.00)
3G network dummy	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
4G network dummy	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.00 (0.00)	0.00 (0.01)	0.00 (0.01)
% prepaid connections	0.00 (0.02)	0.00 (0.02)	0.00 (0.02)	-0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
GDP per capita (ln PPP terms)	-0.11** (0.05)	-0.11** (0.05)	-0.11** (0.05)	0.00 (0.00)	0.04*** (0.01)	0.04*** (0.01)
Subscribers	0.01 (0.03)	0.01 (0.03)	0.01 (0.03)	-0.00** (0.00)	0.00 (0.00)	0.00 (0.00)
Lagged ARPM	0.89*** (0.02)	0.89*** (0.02)	0.89*** (0.02)	0.83*** (0.02)	0.97*** (0.01)	0.97*** (0.01)
Number of observations	2,340	2,340	2,340	2,340	2,340	2,340
R²	0.95	0.95	0.95	0.93	0.98	0.98
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
MNO FE	Yes	Yes	Yes	Yes	No	No
Methodology	FE	FE	FE	FE	OLS	OLS

Source: Frontier Economics (2014); op. cit., p. 26. *** p<0.01, ** p<0.05, * p<0.1.

The Table shows the following key findings:

- The level of competition (i.e. the HHI variable) is not significant in the vast majority of specifications. Thus, the Frontier estimate yields no direct link between the level of competition and prices.⁶⁹
- Past prices seem to be an important determinant of current prices (the lagged ARPM variable is highly significant).
- GDP per capita also is likely to have an impact on prices.
- All other factors appear to be not important for determining prices.

7.3.1.2 Hougbonon (2015)

The key issue addressed in this study⁷⁰ are the effects of the change in the intensity of competition introduced by the entry of the fourth mobile operator in France and the merger between the third and the fourth mobile operators in Austria on prices.

To this end, Hougbonon specifies a “hedonic price model” which is estimated following a double-difference matching identification strategy. Part of this study therefore is an econometric estimate of a “hedonic price function”. In short, a “hedonic price model” assumes that any product can be viewed as a bundle of attributes such that firms and consumers trade to determine the price attached to each attribute. Applied in the specific case of mobile communications this approach therefore assumes that each mobile plan has various attributes, to each of which a certain monetary value can be attached.

Hougbonon’s approach rests on attributes including the quantity of bundled voice minutes and MB of data capacity, and the download speed supported. Pricing also varies according to factors such as whether the plan is standalone (i.e. voice only or data only) or bundled (i.e. voice and data bundled together), whether a mobile device is provided alongside, whether it is intended for business customers or consumers, and whether it involves a contract or not.

To be more specific, the hedonic price model writes:

$$T_i = \lambda_v + \lambda_d D_i + \delta B_i + \alpha_s S V_i + \alpha_b B V_i + \beta_s S D_i + \beta_b B D_i + \gamma X_i + F e_i + \varepsilon_i$$

The terms in the equation are defined as follows:

- T_i is the monthly price of the mobile plan i , in constant 2013 US dollars PPP.

⁶⁹ Frontier claims that this conclusion is robust to the assumptions that it has made about the relationship between price and its explanatory factors, as illustrated by the sensitivity tests carried out around their preferred specification.

⁷⁰ Hougbonon, G.V. (2015).

- D_i is the download speed of plan i in Gigabits per second. $D_i = 0$ for mobile voice plans so that the coefficients λ_v and λ_d measure the access price to mobile voice and data respectively.
- B_i is a dummy variable for bundle plans. Its coefficient δ measures the bundle discount on the access price. Its sign should be negative.
- SV_i and BV_i are respectively the number of hours of voice calls included in standalone and bundled plans. Their coefficients α_s and α_b measure respectively the unit price of standalone voice and its bundling discount or premium.
- Similarly, SD_i and BD_i are respectively the number of Gigabytes of data included in standalone and bundled plans. Their corresponding coefficients β_s and β_b measure respectively the unit price of standalone data and its bundling discount or premium.
- X_i includes the characteristics of the plans such as the duration of the contract in months, the market segment addressed (business or residential) and a dummy for SIM-only plans.
- The hedonic price model also includes country, operator and quarter fixed effects represented by the variable Fe_i

The aforementioned equation is estimated by OLS correcting for arbitrary heteroscedasticity. The study is based on a detailed tariff dataset provided by Teligen over 7 quarters and 40 countries. Overall, the study rests on 614 observations.

The following table comprises the estimation results where the preceding equation is estimated for Austria.

Table 25: Hedonic Price Model estimation for Austria according to Hougbonon (2015)

Plan's Tariff component	Regression variables	Monthly price
Access to mobile voice	Constant	5.33*** (1.23)
	Download speed (Mbps)	0.22*** (0.01)
Access to mobile data	Fixed + Mobile broadband	-16.73*** (1.80)
	Mobile voice and data bundle (Bundlem2p)	-8.03* (4.77)
Discounts on bundles	Hours of mobile voice calls	1.06*** (0.07)
	Bundlem2p*Hours of voice calls	-0.38 (0.28)
Price per hour for mobile in standalone	Gigabytes of Mobile broadband	0.14*** (0.03)
	Bundlem2p*Gigabytes of mobile broadband	2.41*** (0.30)
Price per hour for mobile bundle	Business	2.49** (1.17)
	Mobile SIM-Only plan (voice or bundled with data)	-4.60*** (0.62)
Basic characteristics	Contract duration (months)	0.12*** (0.03)
	Operator (Orange Austria as reference)	✓
Fixed effects	Quarter (Q1-2013 as reference)	✓
Observations		614
R-squared		0.803

Hedonic regression of the monthly subscription price on the characteristics of the mobile plans in Austria. Significant at 1%(***) , 5%(**) and 10%(*). Robust standard errors in parentheses.

Source: Hougbonon (2015).

The Table shows in the far right column the different monetary valuations given to the specific components of mobile pricing plans.

Hougbonon has carried out in addition a statistical analysis in order to identify the “comparable” markets to the two mobile markets in question in this study, Austria and France. This analysis yields that the best counterfactual (“closest”) market regarding Austria is Italy whereas Korea is the closest market to France.

Based on these results and the double-difference estimation strategy using the counterfactual market as the control group Hougbonon reaches the following conclusions:

- The entry in the French market has raised the unit price of mobile data services by 4 dollars per Gigabyte.
- The merger in the Austrian market has lowered the unit price of mobile data by 6 dollars per Gigabyte.
- These results stem from a fall in the investment in new technologies following the entry in the French market; unlike in Austria.

7.3.1.3 HSBC (2015b)

The key issue and the approach are the same as in Hounghonon (2015), i.e. a hedonic analysis of pricing. HSBC apparently focuses, however, on a slightly different data base compared to Hounghonon as their analysis for Austria rests on 599 observations.

The following table comprises the estimation results of HSBC for Austria.

Table 26: Hedonic Price Model estimation for Austria according to HSBC

Plan component	Regression variables	Monthly price
Access to mobile voice	Constant	2.45 (1.64)
Access to mobile data	Download speed (Mbps)	0.23*** (0.01)
Discount on Bundles	Mobile voice and data bundle	-9.03* (4.73)
Price per hour for mobile in standalone	Packmob*Hours of voice calls	-0.35 (0.28)
Price per GB of mobile in standalone	Gigabits of mobile broadband	0.12*** (0.03)
Price per GB of mobile in bundle	Packmob*Gigabits of mobile broadband	2.64*** (0.43)
Basic characteristics	Business	2.53*** (0.72)
	Mobile SIM Only	-4.15*** (0.66)
	Contact duration	0.12*** (0.04)
Fixed effects	Operator (Orange Austria as reference)	Yes
	Quarter (Q1-2013 as reference)	Yes
Observations		599
R-Squared		0.803

Source: HSBC (2015), p. 21.

In keeping with Hounghonon (2015) HSBC also has applied a double-difference estimation to assess the impact of the “externality” (entry in the French market, merger in the Austrian market) using Italy and Korea as the counterfactual markets for Austria and France, respectively.

HSBC summarises the conclusions from their findings as follows: “In terms of voice pricing, we find that entry/exit has little material impact, whether in terms of the access price or unit price. In terms of data, in the case of bundled plans, we find that exit lowers unit prices and that entry raises them; while in the case of standalone plans, we do not find statistically significant effects.”⁷¹

7.3.1.4 Csorba and Pápai (2013)

The key issue of this paper is the impact of market entries and mergers on the price of mobile voice services. The study rests on a panel database of 27 European Member States between 2003 and 2010. The study uses a difference-in-differences econometric methodology in order to exploit the variance in different structural changes between countries to separate the respective effects.

⁷¹ HSBC (2015), p. 26.

The main results of Csorba and Pápai are:

- The effect of entry crucially depends on the number of active operators and the type of entrant, and not controlling for these differences might lead to misleading conclusions.
- No robust evidence that entry has a price-decreasing effect on markets with originally 2 operators.
- However, the entry of a 4th operator does have a significant price-decreasing effect, but with different dynamics concerning the entrant's type.
- When we separate entry effects for the subsequent years, we show that the significant price-decreasing effects for local operators entering occur only in the first year after entry, while the significant price-decreasing effects for multinational entries are present in the long-run.
- No price-increasing effects of mergers, independently whether they reduced the number of operators to 4 or 3.

7.3.2 Studies relating to take-up/penetration

7.3.2.1 Shinohara, Morikawa, and Tsuji (2015)

Key issue of this study is the analysis of the factors of mobile broadband adoption in selected countries. The data base comprises six countries (UK, FR, DE; USA; JP, KR) and the period from 2000 to 2012.

The authors specify the following function to be estimated:

$$Subscriber_{it} = \alpha_1 Subscriber_{it-1} + \alpha_2 Price(Voice)_{it} + \alpha_3 Price(Data) / Speed_{it} + \alpha_4 Income_{it} + \alpha_5 HHI_{it} + \alpha_6 FTTH_{it} + \sum_j \alpha_7^j Factor_{it}^j + \alpha_8 Z_{it}$$

where the explanatory variables are defined as follows:

- $Subscriber_{it}$: denotes the mobile broadband adoption ratio in country i at t (quarter in 2000 to 2012);
- $Subscriber_{it-1}$ one period lag for examining network effect;
- $Price(Voice)_{it}$: monthly charge of voice services calculated by $(Voice\ ARPU)/MOU$;
- $Price(Data)/Speed_{it}$: Monthly Price of data normalized by speed for country i ;
- $Income$: GDP per capita;

- HHI_{it} : the Herfindahl-Hirschman Index of mobile broadband market;
- $FTTH_{it}$: FTTH adoption ratio;
- $Factor_{it}$: Dummy variables of Android, iPhone, FMC, Frequency Auction.

The following Table visualizes the main results of the econometric panel estimate.

Table 27: Econometric results of Shinohara, Morikawa, and Tsuji regarding the key drivers of mobile broadband adoption

Mobile Broadband Adoption Ratio (one lag, Log)	0.769 *** (0.00789)
Price (Voice, Log)	-0.0736 *** (0.0244)
Price/Speed (Data, Log)	-0.0000145 (0.00474)
Income (GDP/Capita, Log)	0.0505 (0.0927)
HHI (Log)	-0.305 *** (0.0265)
FTTx (Adoption Ratio, Log)	0.0273 *** (0.00682)
Android (Dummy)	0.032 *** (0.0113)
iPhone (Dummy)	0.00485 (0.0115)
FMC (Dummy)	-0.0518 *** (0.0195)
Frequency Auction (Dummy)	-0.0193 (0.0160)
Constant	2.739 *** (0.911)
Observations	190
R-squared (within)	0.9973
R-squared (between)	0.9890
R-squared (overall)	0.9923
Wald test (model)	1.90E+06
Prob. > χ^2	0.00000
Test of overidentifying restrictions (Sargan-Hansen statistic)	0.027
Prob. > χ^2	0.8686
Note: Standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

The Table yields the following key findings. Mobile take-up depends on

- previous take-up (mobile broadband adoption ration lagged by one period), thus mirroring a “network effect“,
- Competition intensity (HHI) („more competition is linked to increased penetration“),
- price of voice,

- FTTH adoption; this effect is to mirror both supply side (linking base stations) and demand side developments, and
- the launch of smartphones (the “Android dummy” is statistically significant).

7.3.2.2 Kongaut and Bohlin (2014)

The issue addressed in this paper is how mobile internet adoption has developed in the last decade and what factors are currently determining mobile broadband adoption in the current stage where smartphones are highly developed and transmission speed is much improved.

To this end, a case study of Sweden is carried out. The dataset consist of two sets of binary outcomes (adoption and usage). More concretely, the data used in this paper is mainly based on the annual questionnaire conducted by the Swedish Post and Telecom Authority (PTS) in 2013.⁷² There are 1,732 observations in this dataset; however, 1,616 observations are used for estimation. The econometric approach rests on a bivariate probit estimate with sample selection:

- The dependent variables are categorised into two parts, adoption in the first part and usage in the second.
- The first part (selection stage) is a binary outcome which determines the probability of a respondent whether or not to adopt smartphone ($Y1 = 1$ if a respondent adopts smartphone; otherwise $Y1 = 0$).
- The second part (outcome stage) is a binary outcome which determine the probability of a respondent whether or not to use a smartphone for a particular purpose (for example, music application, video, application or social network application; $Y2 = 1$ if a respondent use a smartphone for a particular purpose; otherwise $Y2 = 0$).

The variables used in order to capture the different dimensions of the usage of smartphones are:

- Use for watching TV/video/clip,
- Use for listening to music (streaming/radio),
- Use for buying tickets and online shopping (e.g. train/bus/movie),

⁷² Since 2002, PTS have annually asked respondents to answer the survey consisting of several questions related to telecommunications services, fixed telephone, mobile phone, broadband and television, including their socio-economic information. Although mobile broadband services have been introduced since 2006 in Sweden, an immense growth of mobile broadband adoption started to have significant impact since 2010 due to the rise of smartphone use. In 2013, PTS added a new question regarding to an adoption of smartphone and its usage. To capture smartphone adoption, data in this paper is taken from the PTS national survey on 2013.

- Use for browsing website,
- Use for sending email,
- Use as internet telephone (Skype), and the
- Use for social media (facebook/twitter/linkedin).

Moreover, socio-economic variables are used including gender, age, income, education, the living area, and resident type. In addition, some internet behaviours such as usage frequency, transmission speed preference and having fixed broadband are used as explanatory variables in this study as well.

The following Table provides an overview of the empirical results of this study.

Table 28: Regression results of smartphone adoption and usage in Sweden

Variable	Adoption (selection stage)	Usage (outcome stage)						
		Browsing	Video	Music	Social	Shop (ticket)	Internet phone	E-mail
Freq.Use	0.7288*** (0.1002)	-	-	-	-	-	-	-
Fixed	0.1117 (0.0814)	-	-	-	-	-	-	-
Speed	-	-0.0892 (0.1319)	-0.0001 (0.0807)	0.0500 (0.0746)	0.0364 (0.0791)	-0.0031 (0.0680)	-0.0211 (0.0664)	0.2071** (0.0834)
Gender	0.0379 (0.0741)	-0.0259 (0.1227)	0.0666 (0.0792)	-0.0017 (0.0752)	-0.2579*** (0.0773)	0.1402** (0.0715)	-0.0056 (0.0695)	-0.0358 (0.0829)
L.income	-0.2470** (0.1067)	-0.3006 (0.1989)	-0.0754 (0.1384)	0.0727 (0.1326)	0.2115 (0.1372)	0.2666** (0.1139)	0.3761*** (0.1095)	0.0188 (0.1358)
H.income	0.2611*** (0.0912)	0.1707 (0.1410)	0.0271 (0.0881)	0.0597 (0.0841)	-0.1142 (0.0847)	-0.0527 (0.0800)	-0.1192 (0.0795)	0.1411 (0.0949)
Over60	-0.8422*** (0.0845)	-0.4110** (0.1774)	-0.3459*** (0.1263)	-0.1748 (0.1372)	-0.3651*** (0.1401)	0.0757 (0.1366)	0.2472* (0.1387)	-0.1860 (0.1419)
Under30	0.4242*** (0.1104)	0.9137*** (0.2667)	0.5210*** (0.1101)	0.4416*** (0.0995)	0.6636*** (0.1094)	0.2575*** (0.0896)	0.1652* (0.0884)	0.1495 (0.1088)
University	0.1523** (0.0776)	0.0282 (0.1225)	0.0808 (0.0820)	0.2292*** (0.0788)	0.1413* (0.0802)	0.1957*** (0.0752)	0.0368 (0.0723)	0.2156** (0.0861)
Sthlm	0.2964*** (0.1009)	0.0346 (0.1535)	0.0658 (0.0974)	0.0441 (0.0927)	0.0715 (0.0938)	0.0105 (0.0860)	0.0850 (0.0861)	0.2708** (0.1090)
Apartment	0.0497 (0.0826)	-	-	-	-	-	-	-
Constant	-0.0884 (0.1215)	1.7178*** (0.1552)	0.7404*** (0.0994)	0.3771*** (0.0968)	0.6463*** (0.0988)	-0.2267** (0.1025)	-0.2180** (0.1017)	0.6815*** (0.1077)
ρ	-	-0.4457 (0.2284)	-0.7708 (0.0963)	-0.6968 (0.1098)	-0.7220 (0.1021)	-0.8246 (0.0824)	-0.8912 (0.0745)	-0.6347 (0.1426)
Wald test ($\rho = 0$)	-	2.83*	18.55***	16.29***	18.29***	20.70***	15.57***	9.84**
χ^2	361.32***	19.55**	34.10***	30.17***	76.02***	28.97***	32.05***	22.13**
No. of Obs.	1616	1616	1616	1616	1616	1616	1616	1616

The first row of estimated coefficients comprises the coefficients of independent variables for smartphone adoption. From the second to the seventh row the coefficients are related to the different smartphone usages.

These results allow the following interpretation regarding smartphone adoption: Respondents who tend to often use internet (using everyday or almost everyday) are likely to adopt smartphone compared to those who use less. Moreover, several socio-economic factors significantly affect the probability of the respondents to adopt a smartphone:

- Income, age and education significantly have an impact.
- The results show that respondents with young age, high income and have education at the university level are more likely to adopt smartphone than those who are elder, having low income and have education below university level.
- Furthermore, respondents who live in the capital city, Stockholm, have more probability to adopt smartphone than those who live outside as well.
- However, in Sweden, gender as well as the type of residence (e.g. apartment or house) does not have significant effect on smartphone adoption.
- Interestingly, insignificant result of coefficient for fixed broadband may imply that smartphone is neither substituted nor compliment to fixed broadband.

As to smartphone usage the results can be interpreted as follows:

- Age seems to be an important factor to determine the purpose of smartphone usage. The results show that young respondents tend to use more for browsing, video application, music application, social network, and online shopping. Conversely, the elder respondents are less likely to use smartphone for browsing, video application and social network.
- In addition, education also has an effect on smartphone usage: Respondents with education at university level have more probability to use smartphone for e-mail, music application, online shopping and social network.
- Results regarding the impact of gender and income on smartphone usage:
 - While respondents who have low income are less likely to adopt smartphone, those who have, nevertheless, are more likely to use smartphone for online shopping and internet telephone (e.g. skype) than high income respondents who have smartphone.
 - For gender, female have more probability to use smartphone for social network than male; however, male respondents are surprisingly more likely to buy products online than female.
- Results regarding email and internet telephone applications:
 - Respondents who have education at university level, live in Stockholm and believe that transmission speed is important tend to use email services on smartphone than those who do not.
 - For internet telephone, such as Skype, service, not only younger respondents have more probability to use internet telephone, but elder

respondents are more likely to use internet telephone as well, compared to those in the middle age (30-50).