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A PRICE CONCENTRATION STUDY ON EUROPEAN MOBILE TELECOM MARKETS

LIMITATIONS AND INSIGHTS

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Abstract

A price concentration study on European mobile telecom markets: Limitations and insights[+]

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Price concentration studies investigate the relationship between market concentration and price levels. They are increasingly used in the mobile telecom industry. This paper provides a detailed account of the limitations of such studies. In addition, it proposes a specific approach in order to account for quality differences across countries, which are likely important when explaining price differences. When applying our approach to European mobile telecom markets from 2003 to 2012, we find that there is no positive relationship between concentration and prices and some indications that the relationship may be negative.

Keywords: Price concentration study, mobile, wireless, merger control, efficiencies

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+ The paper draws on work conducted on behalf of Telefónica in the context of the merger proceedings Hutchison 3G UK/Telefónica Ireland in Ireland (case COMP/M.6992) and Telefónica Deutschland /E-Plus in Germany (case COMP/M.7018). We would like to thank Scott Thompson and Federico Mini from Bates White and Michal Grajek, ESMT, for valuable comments and support on related work. Our colleagues Juri Demuth, Melissa Newham, Christopher Milde and Annekathrin Schoofs provided helpful input and research support at various stages of the research.

1 Introduction

Price concentration studies investigate the relationship between market concentration and price levels. They are increasingly used in the mobile telecom industry. Analysts refer to them in order to form a view on the expected industry development, they have played a role in recent merger proceedings[2] and while not always at the heart of academic studies many methods and techniques are relevant in academic work on mobile telecom topics.[3]

This paper attempts to provide a more detailed account of the limitations of such studies than what is usually presented in publicly available research. In addition, it proposes a specific approach in order to account for quality differences across countries, which are likely important when explaining price differences. When applying our approach to European mobile telecom markets from 2003 to 2012, we find that there is no positive relationship between concentration and prices and some indications that the relationship may be negative. From a policy perspective this result suggests that higher concentration, e.g. as a result of a merger, either has very limited negative effects on competition or it is compensated by sizeable efficiencies which are passed on to consumers. While this result is quite robust given the data at hand, it is still subject to many of the limitations that we reveal. Moreover, due to the ongoing transition from a "voice centric" to a "data centric" mobile telecom industry, future work will have to tackle new challenges, given limited reliable information on data usage.

2 Literature

In the context of ongoing merger proceedings press articles often refer to experiences in selected countries in order to draw conclusions for the ongoing proceedings. For example, when Hutchison 3G UK/Telefónica Ireland in Ireland and Telefónica Deutschland/E-Plus in Germany were investigated by the European Commission there was significant press coverage referring to alleged price increases that occurred after a recent merger in Austria had been cleared (Hutchison/Orange). Drawing lessons from the post-merger developments in just one country is like conducting a price concentration study with just one observation. It is obvious that statistical analysis is potentially more meaningful. Such an analysis can use many observations (e.g. comparing prices in countries with three operators with those in countries with four operators) and thereby attempt to account for obvious differences across countries and over time.

Several such statistical analyses exist for the mobile telecom industry. In order to discuss how meaningful their results are, it is helpful to group them according to the measure of price that is used in these studies. In the mobile telecom industry choosing the appropriate measure of price is not trivial. Operators typically offer several tariff categories and several hundred tariff variants at the same time and tariff portfolios are constantly adapted. In addition, specific promotions that change the conditions of a tariff may be added temporarily, on a regional basis or for specific distribution channels. For instance, the supply of data packages would require accounting for additional variables, such as speed and data volume. Thus, it is impossible to track all tariffs. Moreover, the actual price paid usually

[2] Examples include Hutchison 3G UK/Telefónica Ireland in Ireland (case COMP/M.6992) and Telefónica Deutschland /E-Plus in Germany (case COMP/M.7018).
[3] See Section 2 for a detailed review of the relevant work.

depends on the usage of the customer and customers with different usage patterns obviously also get different services from their respective providers.

Three approaches to deal with this challenge can be distinguished:

- **Studying a sample of tariffs:** One response is to study a sample of tariffs (e.g. the lowest tariffs of the largest Mobile Network Operators, MNOs). Such approaches are taken by Rewheel (2013) and also the Austrian regulator rtr (when tracking prices over time, see rtr (2014)). Such studies face the following problems: They may pick tariffs that are relatively meaningless in the country. They will have to assume one or more consumption baskets (voice minutes, data volume etc) in order to compare tariffs. This may drive results. Apart from these difficulties such comparisons require very careful tracking of tariffs and their changes. Even if one assumes studying a sample of tariffs is potentially meaningful, a comparison across countries (or over time) would still require taking into account key differences across countries (or over time) like differences in demand, costs, network quality etc. We are not aware of any study which does this carefully.

- **Studying ARPU:** Due to the difficulties discussed above many studies compare Average Revenue Per User (ARPU) levels. However, all such studies which ignore differences in usage levels present differences in revenue and not in prices. This is a serious issue as high ARPUs may be due to high usage induced by low prices or high prices. We therefore consider such analysis that does not account for differences in usage as unreliable. Most analyst reports that come out with statements on the relationship between prices and concentration follow this approach. However, also some academic studies do not control for usage or just by referring to the number of subscribers (see for example McCloughan and Lyons 2006).

- **Studying ARPU taking usage into account:** Most scientific studies that attempt to measure prices in the mobile telecom market take usage into account. This is true for example for Lyons (2006), Sung and Kwon (2011), Hazlett and Muñoz (2008), and Hausman and Ros (2013). Scientific studies also attempt to take into account important differences across countries, proxied by various measures of demand (e.g. GDP) and costs (e.g. population density).

In this paper we follow the latter approach by studying a price measure which takes (voice) ARPU and usage into account. In order to account for differences across countries and over time, previous studies made use of various indicators. For market concentration, most studies use the Herfindahl-Hirschman-Index (Sung and Kwon 2011, Hausman and Sidak 2007, Hazlett and Muñoz 2008, HSBC Global Research 2014) or the number of network operators (Hausman and Ros 2013) or a variety of concentration measures (Lyons 2006, McCloughan and Lyons 2006). Another popular control variable is GDP per capita, which is used by almost all academic studies (exceptions are Sung and Kwon 2011 and Hausman and Sidak 2007). Sometimes some measure of population density or population distribution is included to capture differences in costs (Sung and Kwon 2011, Hazlett and Muñoz 2008 and McCloughan and Lyons 2006). To our knowledge, no study accounts for quality differences across countries.

The main contributions of the approach presented below are the detailed discussions on the limitations of the data that underlies these studies as well as the inclusion of a measure for quality differences.

3 Data limitations and approach

For the realisation of a price concentration study, the choice of appropriate measures for the two main variables, price and concentration, is of particular importance. Furthermore, suitable variables in order to control for differences in costs, quality, and demand need to be identified.

In this section, we explain the choice of our preferred specification and the data limitations that need to be taken into account when choosing the preferred specification and when interpreting the results. We identify the effective price per minute (EPPM), based on voice ARPU and voice minutes of use, as the best available price measure. As explanatory variables, we use the number of MNOs as concentration measure (all MNOs with subscriber based market share above 1%), a linear time trend to account for cost changes over time, the mean capital expenditure per subscriber as an indicator for country quality levels and GDP per capita as demand indicator.

Moreover, alternative price and concentration measures, as well as complementing control variables, which will be part of our robustness checks, are discussed in this section.

3.1 Price

Although mobile telecom operators market their services to end customers and publicly announce their prices, it is extremely difficult to obtain precise measures of price. This is due to the variety of tariffs, the differing relevance of tariffs, differences in user profiles and the bundling of services in one tariff.

As discussed in the literature review there are several approaches to respond to this challenge. One option is to define usage profiles and then identify the cheapest tariff for each user profile (usually only for the largest two network operators in a country) each year (or on shorter intervals) and construct a hypothetical monthly price. This is the approach taken by the OECD in the OECD Communications Outlook and some private companies. The problem with this approach is that very often one may pick largely irrelevant tariffs, apply a user profile that is not suited for a country and, if such tariffs are tracked over time, changes in user behaviour may make services difficult to compare or may (if profiles are adapted) lead to changes in profile definition such that one does not compare like with like. In addition, it appears difficult to compare prices across countries as one would have to weigh prices by some metric (e.g. subscriber numbers with a similar profile) that is not publicly available.

An alternative approach is to track aggregated revenue figures. However, as relatively low revenue may well result from high prices combined with low usage, we consider it essential to control for usage.

As shown in the literature review most academic studies follow this approach and relate aggregated revenue figures to aggregated usage data. For the revenue side, one standard measure used in the industry is the Average Revenue Per User (ARPU). This indicator tracks revenue related to voice, SMS and data services and relates them to subscriber figures. This approach has its downsides too:

- **Usage:** As services offered and average user profiles change over time and differ across countries, one would have to relate revenue data to usage information to make it comparable. However, only imperfect measures of usage exist and those usually only relate to voice services. A well reported indicator is minutes of use, which is defined as voice minutes for outgoing and incoming calls as

well as calls on the net of the reporting operator (on-net calls).[4] While these are well documented, the identification of voice ARPU requires allocating revenue to voice and other services (SMS and data) which usually relies on figures reported by operators. Voice ARPU over minutes of use is called Effective Price per Minute (EPPM).

- **Total ARPU and data/SMS usage:** Unfortunately, there is – to our knowledge – no systematic information on data usage across countries and over time. Data providers only offer information on mobile broadband connections and mobile data connections. If related to subscribers, this allows constructing a broadband penetration indicator. With the support of Telefónica and KPN we sent out questionnaires to mobile network operators in eight countries to gather information amongst others on mobile broadband penetration and on the date when mobile broadband penetration reached 10% and 30% respectively. We chose mobile broadband connections as a more meaningful, albeit still far from perfect indicator for the ability to use data services in each country/year pair. We also tested the inclusion of SMS usage (number of SMS per subscriber) and month in the ARPU regressions, however this variable did not show the expected sign.

- **MVNO revenues:** We observe differences in ARPU reported by data providers. These could be due to a difference in the treatment of Mobile Virtual Network Operator (MVNO) revenues. If the wholesale revenue of MNOs is included in the ARPU (which it usually is) and the MVNOs' reported retail revenues are included as well (in order to capture their value added), the wholesale revenue is counted twice (and ARPU is overstated). If data providers ignore MVNO revenues entirely, they understate the total market revenue as the value added by MVNOs is not stated. In order to take such differences into account we attempted to make use of information on MVNO revenues. We conducted some own research on current MVNO shares in order to check the reliability of MVNO subscriber shares as reported by data providers. For this purpose we contacted regulators and asked Telefónica and E-Plus to provide MVNO market shares. While for large countries, the figures are consistent, they clearly differ for smaller countries. As a result of this comparison and other inconsistencies, we decided not to use data on MVNO market shares as our own research could not confirm the reliability of this data.

- **Small MNOs:** Some analysts use the average ARPU of the two largest operators. This is motivated by the fact that there is no consistent data on all operators for all countries. We compared the average national ARPU and the average ARPU of the two largest operators and found sizeable differences (in particular in earlier years). We decided to use national average ARPU and voice ARPU figures.

- **Unused SIM cards and roaming:** The calculation of average ARPU may be influenced by the identification and treatment of unused SIM cards. The exact method to correct subscriber numbers by eliminating unused SIM cards differs from MNO to MNO. ARPU figures also include roaming charges. Thus, in countries in which people are more likely to take a holiday abroad, roaming charges may have a relevant effect on ARPU.

Whether to choose an ARPU-based approach or a price basket based approach matters. A comparison of EPPM and price basket data[5] shows that many countries change rank to a significant extent. Some

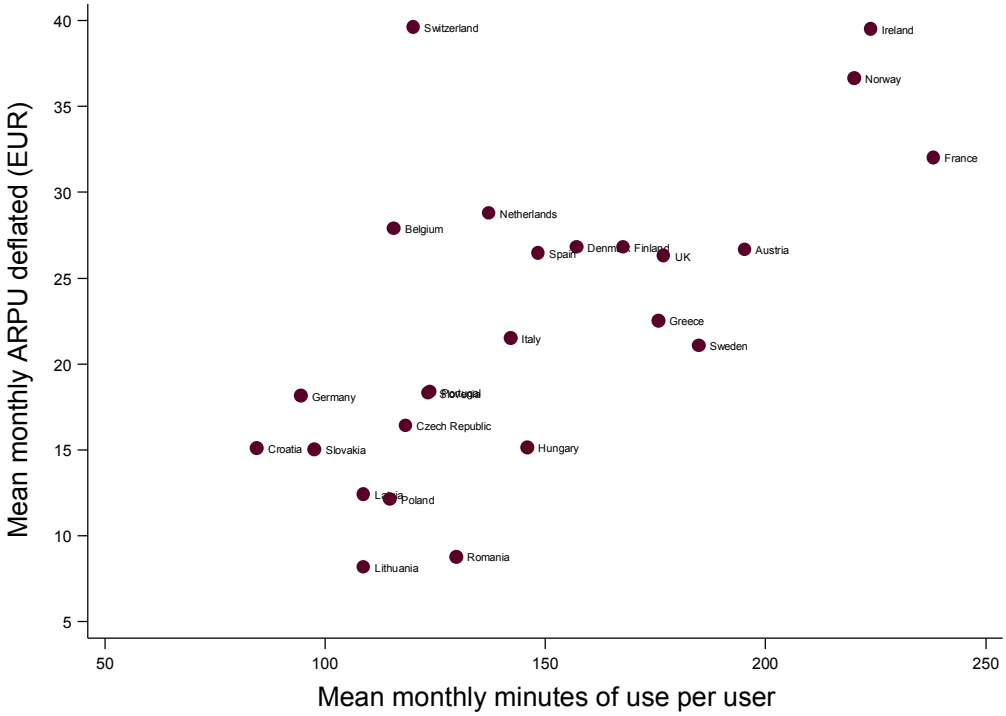
[4] Minutes of use is the sum of minutes from outgoing calls, incoming calls, and on-net calls, whereby on-net calls are counted only once as outgoing calls.

[5] Here and in the following we use EPPM data calculated based on voice ARPU and minutes of use as reported in 451 Research's EMEA Mobile Carrier Monitor June 2013. The price basket data is taken from OECD Mobile Voice Benchmarks. They are collected by Teligen, a division of Strategy Analytics Ltd. UK, based on the OECD methodology of 2002. The dataset contains one observation per country and year for all OECD member states in the period 2002-2012. Each observation consists of the lowest priced tariffs that buy one of three specified consumption baskets. The lowest priced tariffs are selected among all published

countries change order by more than five places on average (over the usage categories), e.g. the Netherlands are identified as high price by EPPM and significantly lower price in the basket (rank 3 vs. 14/14/10 for the different usage profile price baskets). The same applies to Denmark which is ranked 6 vs. 19/19/19. Norway also improves by moving to the basket, albeit to a lesser extent (rank 7 vs. 12/12/14). Finland improves from 10 to 18/18/18. Ireland worsens from 8 to 4/7/4, France from 15 to 5/6/2 and the UK from 14 to 11/9/9. The rank of the Czech Republic also worsens from 13 to 8/8/11 and Italy from 11 to 7/5/7. Again, such differences may systematically influence outcomes. For example, large countries usually appear to price higher based on the price basket data than on EPPM.

In order to see why, when working with a revenue indicator, it is essential to take usage into account - either by choosing EPPM as a (voice) price indicator or by controlling for usage by including minutes of use - consider the following figure which shows that ARPU is largely driven by usage. The figure shows the mean total ARPU for 25 European countries averaged over the years 2003 to 2012 and the corresponding minutes of use.[6]

Figure 1: Deflated ARPU over minutes of use per user (both averaged over the period 2003 to 2012)



A similar picture emerges when comparing the mean voice country ARPU and the mean total minutes of use. An analysis that does not take into account differences in usage misses the point. Looking at the large countries (where we have reliable ARPU) we can compare ARPU and EPPM rankings (where the latter is voice ARPU per minute of use). The ranking is not consistent. In particular, France, which has the highest ARPU in most years, has one of the lowest EPPMs in most years. Except for Poland (where the difference in history and GDP leads to low ARPU and low EPPM), all countries but Spain change position. Thus, taking usage into account appears important.

tariffs on the operator websites of the top two providers in each country, based on market share. For the yearly data, which is available to us, the tariffs are selected in November of each year.

[6] Unless otherwise stated, the underlying data stems from 451 Research's Mobile Carrier Monitor dataset. Minutes of use were not available in the 451 Research's EMEA Mobile Carrier Monitor dataset for Romania in 2003 and 2004 and for Slovakia in 2003. Furthermore, minutes of use seem much too low for the first year of reporting for the two countries. This might be due the fact that minutes of use are not reported for all quarters of these years. Therefore we also excluded the minutes of use for Romania in 2005 and for Slovakia in 2004 from the following analysis.

Based on the analyses presented above we decided to use EPPM data derived from voice ARPU and minutes of use information in the main specification.

Although country rankings depend on the price indicators chosen, our results are robust regarding the choice of the price indicator.

3.2 Concentration

Concentration in the mobile telecom industry may be measured by a number of variables. As presented in the literature review in Section 2, it is common to investigate the number of MNOs or the concentration index HHI[7]. Moreover, we attempted to include the market share of non-MNOs. However, as explained in Section 3.1 the data on MVNO subscriber shares appears unreliable and other data, e.g. MVNO revenue shares, are to our knowledge not available.

As the effect of concentration on prices depends on the net effect of a potential negative effect of a reduction of the number of competitors on competition and a potential positive effect of the efficiencies derived from combining the operations, the number of MNOs appears a straightforward choice for the purpose at hand.

Data providers report the number of domestic MNOs for each country as well as subscriber based market shares of these MNOs. We used these subscriber based market shares at the operator level and counted only MNOs with subscriber based market share above 1%. Furthermore, we cross-checked the number of MNOs with other sources and corrected the number of MNOs manually for some years in Austria, Denmark, Poland and Slovenia. The subscriber based market shares of MNOs also allow the construction of the HHI.[8]

As the competition effect will increase with the degree of concentration, the net effect of a reduction by one operator may depend on the number of operators that are left in the market and the number that was in the market before the merger. However, as the efficiencies that can be reaped from a merger may also depend on the number of operators, the overall effect is not clear but a non-linear relationship may exist. We take into account the number of MNOs and focus on observations with three or four MNOs (conducting robustness checks including all observations).

This approach appears sensible as many of the efficiencies that can be reaped as a result of a merger follow from the fact that parallel networks can be combined to one network. However, in order to measure the effect on competition more sophisticated measures of concentration are available. The Commission uses the revenue based HHI and often calculated both, on a basis of MNOs only and including MVNO revenue. Unfortunately, data on reliable MVNO revenue shares are not available. As a consequence, we focus on the HHI excluding MVNO market shares.

Our analysis shows that using the number of MNOs or the HHI yield similar results. We base the main specification on the number of MNOs restricting the analysis to observations with either three or four MNOs.

[7] The HHI is an index of market concentration. It is calculated as the sum of squared market shares in percentage terms. Ideally one should calculate the HHI based on revenue market shares. However, due to data limitations most analyses take subscriber market shares as an (imperfect) proxy for revenue market shares.

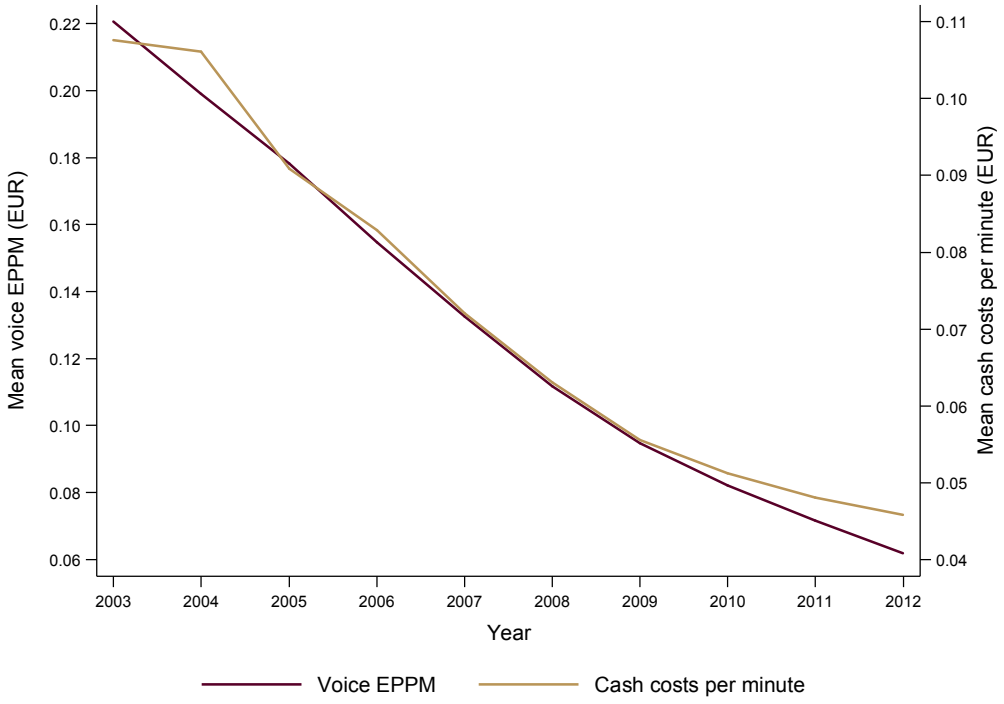
[8] Initial information on the number of MNOs and market shares are based on data provided by Quantum. We construct the HHI as the sum of squared market shares. Note that for the construction of the HHI, we include all MNOs, also those with market shares below 1%. Furthermore, while we are able to correct the number of MNOs manually, we are not able to correct the HHI measure. We revert to subscriber based market shares instead of revenue market shares due to data limitations.

We conduct robustness checks including all observations and using subscriber based HHI instead of the number of MNOs.

3.3 Costs / time trend

As mobile telecom subscriber numbers increased and the costs of equipment with a given capacity and reach decreased, overall costs per subscriber and minute of use decreased significantly over time. We used the variable cash costs per minute, which measures the Operating Expenditure (Opex) without customer acquisition costs divided by minutes of use.[9] Figure 2 shows how closely voice EPPM over time and cash costs per minute of use are related.

Figure 2: Voice EPPM and cash costs per minute over time (averaged over 24 European countries)



Note: All plots presenting averages over countries include only countries for which both EPPM and concentration measures are available. The EPPM data does not contain information on Bulgaria, Estonia and Luxembourg while the concentration data does not contain Croatia. Except for Switzerland, the countries included in these graphs also constitute the sample on which the regression analyses are run.

As concentration decreases over time, not accounting for the cost reduction would suggest a positive relationship between concentration and prices purely due to an omitted variable.

We therefore considered using cash costs averaged across all countries in order to take the downward trend in costs into account. However, there are the following issues with using cash costs:

[9] Based on 451 Research's EMEA Mobile Carrier Monitor June 2013.

- **Cash costs include costs for services that are not part of the EPPM**. As data services increased significantly during the last years, we would expect the slope of the cash cost curve to increase as well. Indeed, as Figure 2 shows, we observe that cash costs fall by less in later years (this may still be true when excluding costs for data services, but we do not know from these data).

- **Cash costs show a few less plausible shifts in the earlier years**, which are more likely due to reporting and data tracking issues than that they reflect true shifts. Therefore, the risk remains that the cash cost indicator may not show the explanatory power it deserves.

At the same time as shown in Figure 2 the downward trend appears very linear. We therefore decided to use a linear trend to account for changes in costs over time. In order to check the robustness of this approach, we also use cash costs per subscriber and year fixed effects (where the latter takes out non-linear changes over time that apply to all countries).

As both average costs and average concentration measures show a relatively linear path over the years observed, one could raise the concern that a linear trend would take out the linear improvements in EPPM that are due to the decrease in concentration. However, given that the slope of a linear approximation of the cash cost curve and the slope of the linear trend are almost identical (but for the later period where data services come into play) we consider a large effect unlikely.

Moreover, to the extent that cash costs are driven by the number of MNOs in the market we may underestimate the positive effect of concentration by applying a linear trend (or using the cash cost index).

More generally, as the positive effect of concentration will be passed on through cost savings, including a cost variable that also reflects such cost savings is not ideal. In order to account for cross-country cost differences we therefore tested a number of variables that influence costs independent of the level of concentration. Those include population density[10], percentage of population living in densely populated areas[11], and percentage of landmass used by accumulated 50% of population.[12] We would expect costs per subscriber to be lower when the population density is higher or a higher share of population is living in densely populated areas. Similarly, a smaller landmass used by accumulated 50% of population is expected to lead to lower costs to install and to operate the network. However, the validity of this assertion depends inter alia on mobile coverage, especially in less densely populated areas, or the specifics of a country's topography.

To support the decision on our main specification we also regressed cash costs per minute on GDP per capita, number of MNOs and the different demographic variables described above. While the coefficient for GDP per capita is positive and statistically significant, the effect of the number of MNOs is statistically insignificant. From the demographic variables, population density and landmass used by accumulated 50% of population were statistically significant. However, the sign of their parameters were different than expected: Higher population density and smaller landmass used by accumulated 50% of population are related to higher cash costs per minute. We therefore decided not to include an

[10] We use population density from Eurostat (tps00003). The series is available for the period 2000 to 2011 (only to 2010 for UK). We use the figures from the year 2011 (from 2010 for UK) for the year 2012.
[11] We use the measure "percentage of population living in densely populated areas" from the statistics on urbanisation degrees from Eurostat (hbs_car_t315). The percentage is given for the year 2005 only.
[12] The percentage of landmass used by accumulated 50% of population is taken from the OECD broadband portal statistic 3c "Broadband penetration per 100 inhabitants and percentage of total landmass used by 50% of the population". The measure is given for the year 2009.

additional cost indicator in the main specification but rather conduct robustness checks including landmass covered by 50% of the population.[13]

Based on the analysis above we make use of a linear trend in order to account for the decline in costs over time.

We conduct robustness checks by

- applying year fixed effects which take out all average price differences between years (independent of the functional form) and by
- using cash costs averaged across all countries instead of a linear trend and by
- additionally including landmass covered by 50% of the population to account for cost differences across countries.

3.4 Quality

Mobile services differ in quality with regards to several dimensions. Common indicators in terms of voice quality include the call success rate, the time to place the call, average speech quality, coverage etc. With respect to data services the following measures have been used: Average session duration, basic data rate and the top data rate in terms of data upload and download. Several magazines measure and publish national network quality scores (e.g. in Germany Connect, Bild, Chip), which are also heavily used in marketing. Higher quality is extremely valued by customers since it allows making proper use of smartphones.

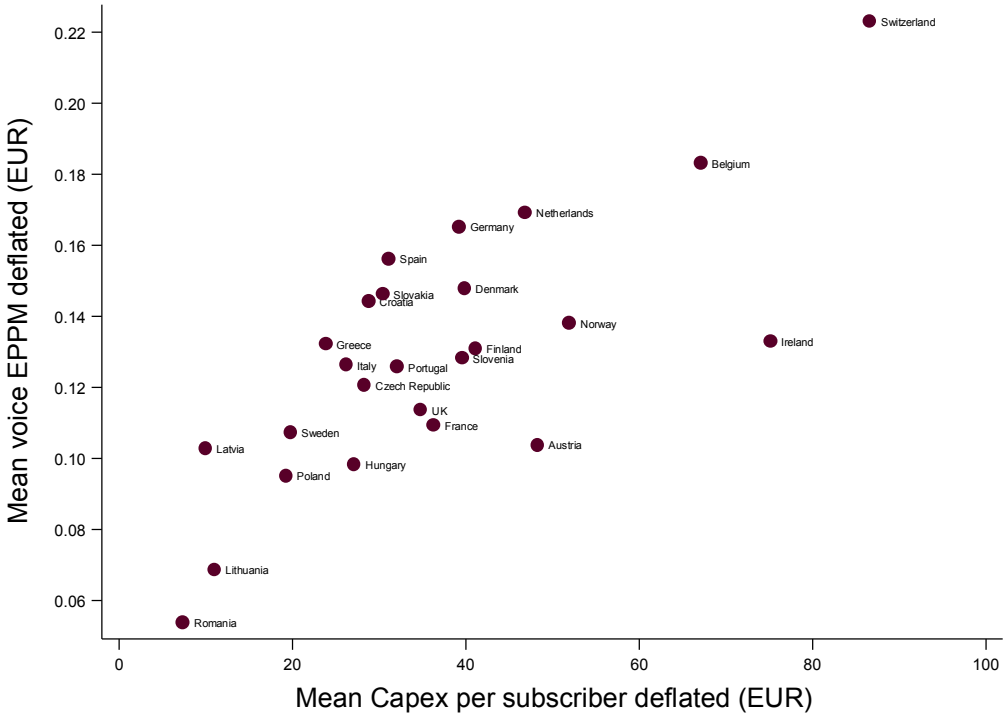
To our knowledge a coherent comparison of quality levels across countries does not exists. This is the conclusion of our own country research. Moreover, even within a country, quality scores cannot easily be compared over longer periods, as the measurement criteria evolve over time. We therefore used data on capital expenditure (Capex) as an indicator for quality differences across countries. In particular, as Capex is often lumpy and may fluctuate, we calculate the mean Capex per subscriber over the entire period covered (2003 to 2012).[14]

Mobile telecom equipment is largely procured on the world market and its costs will therefore not depend on the general economic development. However, other parts of Capex (e.g. capitalised labour costs or locally manufactured equipment) will depend on the general economic development. Capex differences across countries may also reflect differences in costs of covering the country with mobile services due to the topology or the distribution of the population across the country. Thus, Capex is not purely an indicator of quality but also partly an indicator of differences in costs (at given quality levels).

Figure 3 plots the mean Capex per subscriber averaged over the period 2003 to 2012 as an indicator for quality levels against the mean EPPM. It shows that EPPM and Capex are highly correlated.

[13] Note that once we include the landmass variable in the regression, the number of observations decreases as the landmass variable is not available for Latvia, Lithuania, Romania, Slovakia and Slovenia.
[14] Capex data is based on 451 Research's EMEA Mobile Carrier Monitor June 2013.

Figure 3: Voice EPPM over Capex per subscriber (averaged over the period 2003 to 2012)



In fact the mean Capex per subscriber explains 55% of the mean differences of EPPM across countries.

While the choice of the quality level may also depend on the EPPM (higher EPPM may cause higher quality levels, which would lead to some endogeneity of the Capex variable), not accounting for differences in quality appears misplaced as it would lead to a comparison of products which differ significantly.

Capex may also be affected by concentration as after a merger the Capex required to achieve a given quality level is reduced. This is a beneficial effect of concentration that we would like to identify but cannot, when including Capex as an indicator.

Accounting for quality differences appears essential as the omitted variable bias could otherwise determine the results. We use a specification which includes mean Capex per subscriber as an indicator for country quality levels (also capturing some differences in costs). We also use another specification where we take country differences that are stable over time out by introducing country fixed effects. Such an analysis will mainly exploit differences over time in the analysis.

Our results are robust as both specifications show that higher concentration does not go along with higher prices. However, while the first approach, which still includes a lot of cross-country variation in EPPM, does not identify any statistically significant relationship between concentration and prices, the second approach, which takes out all differences across countries that are stable over time, shows that higher concentration goes along with lower prices.

We also observe that the inclusion of a quality indicator is important for the overall robustness of our results. When excluding Capex in a regression without country fixed effects, we do find specifications where higher concentration is associated with higher prices.

3.5 Demand

As a measure of demand, we incorporate GDP per capita. GDP per capita will also capture some other factors. As it is correlated with labour costs and rents, it will also capture some cost differences. Moreover, a lower GDP per capita may also induce lower quality levels. Thus, a lower GDP per capita may induce reduced prices due to lower demand but also due to lower costs and lower quality levels.

Figure 4 plots the mean GDP per capita[15] averaged over the period 2003 to 2012 as an indicator for demand levels against the mean EPPM. It shows that EPPM and GDP per capita are highly correlated.

In fact the mean GDP per capita explains similar levels of the mean differences of EPPM across countries as the Capex. GDP and Capex are highly correlated.

Figure 4: Voice EPPM over GDP per capita (both averaged over time period 2003 to 2012)

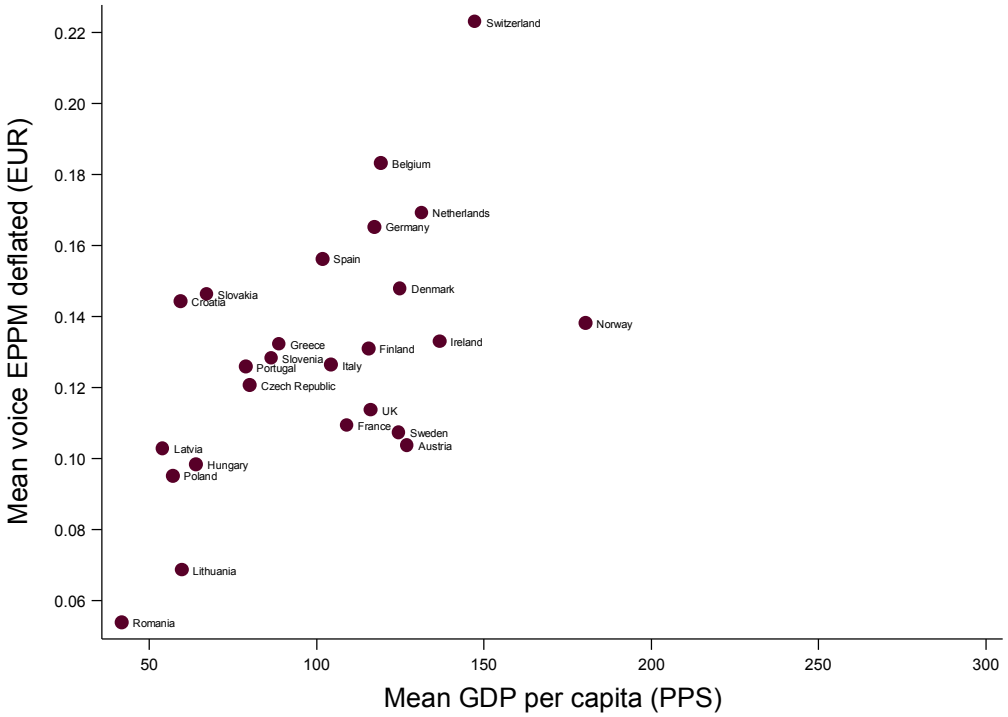
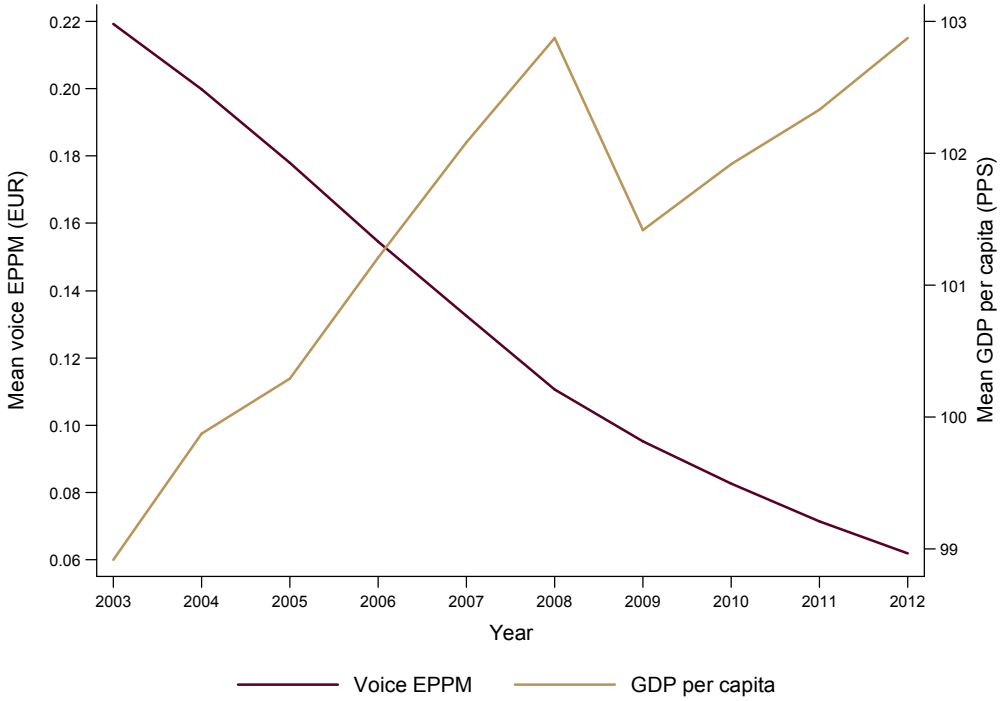


Figure 5 shows the development of mean GDP per capita across all countries over time against EPPM. At the aggregated level GDP per capita appears to have little explanatory power for changes in EPPM over time. Thus, GDP per capita seems to be a suitable variable to explain differences in levels of voice EPPM across countries, while it is less useful to explain the development of voice EPPM within a country.

[15] We use the volume indices of real expenditure per capita in Purchasing Power Parity Standard (PPS, EU28=100) from Eurostat (series prc_ppp_ind).

Figure 5: Mean voice EPPM and mean GDP per capita (over time averaged over countries)



Residual demand for mobile telephony services will also depend on the availability of substitutes. Fixed net voice and data (broadband) services are a substitute. For voice services we assume that similar fixed voice telephony coverage is offered across countries for the period considered. More interesting are differences when total ARPU is analysed where in the later years mobile broadband revenues are included. Depending on the coverage and quality of the fixed broadband offer, mobile services may face more or less intense competition from these substitutes.

We analyse the influence of fixed broadband offers by taking into account fixed broadband penetration rates.[16]

In the main specification we include GDP per capita as an indicator for demand.

We conduct the following robustness checks by excluding GDP per capita and by taking into account fixed broadband penetration when analysing regressions on total ARPU.

We find that our results in our main specification based on EPPM are robust to excluding GDP per capita. The same holds when using ARPU. However, in the ARPU specification higher fixed broadband penetration goes along with lower prices. This may suggest that the negative effect on costs per user due to lower usage may dominate the effect of lower demand.

[16] The data is available for all European countries, except Norway, from Eurostat (series isoc_tc_broad) for the period 2002M7-2011M01 and Eurostat (isoc_tc_fbsupe) for the period 2008M06-2012M12. The two series measure the number of broadband access lines and fixed broadband subscriptions, respectively. As the numbers are almost the same for overlapping years, we believe it is justified to combine the two data sets. We use the first series for the years 2003-2010 and the second series for the years 2011 and 2012. Due to differences in the data, for the years 2003-2010, the end of the year figure is used, while for 2011 and 2012 the beginning of the year figure of the succeeding year is used.

4 Results

In this section we report the results of a regression analysis to examine the relationship between concentration and price.

As described in Section 3.1 in our preferred specification, we use EPPM as an indicator for price, the number of MNOs as an indicator for concentration and GDP per capita as well as Capex per subscriber as control variables for demand and quality, respectively. The declining trend in costs is captured by a linear trend variable. The analysis is based on data for the period 2003 to 2012 for the following countries: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the UK.[17]

In the main specification we focus on a comparison of observations with either three or four MNOs to ensure comparability with the pre- and post-merger market structure in Germany. We conducted robustness checks which include observations with two and five MNOs.

In the regressions we use a log-level functional form, i.e. we use the logarithm of EPPM as the dependent variable and regress it on the raw values (levels) of the explanatory variables. The regression coefficients can then be interpreted as the percentage change in the dependent variable if the explanatory variable marginally changes (by one unit). For example, a regression coefficient of 0.01 on the number of MNO variable would mean that the EPPM increases by 1% if the number of MNOs increases by one.[18]

First, in Section 4.1, we focus on cross-country comparisons, i.e. we aim to explain variation in prices related to differences between countries that are unrelated to concentration by using appropriate control variables (GDP per capita and mean Capex per subscriber). We find no statistically significant relationship between price and concentration. At the same time, a large part of the variation in price (about 80%) is explained by our control variables.

Second, in Section 4.2, we include country fixed effects into the regression (i.e. we take out differences across countries that are stable over time), thereby focusing on a comparison over time. With country fixed effects, a statistically significant negative relationship between price and concentration is found.

Both results are shown to be robust when applying a number of robustness checks.

[17] These are all countries for which ARPU and voice ARPU information is available but Switzerland. Note that while ARPU information is also available for Croatia, this country is not included in the dataset providing concentration measures. Given that we use the number of MNOs, Croatia is excluded from the regression analysis. We excluded Switzerland from the main regression due to two reasons: (1) we had to approximate the inflation index for Switzerland as no harmonized EU data is available for the entire period. (2) In addition, Switzerland appeared an outlier with extremely high prices and extremely high concentration ratios throughout due to a market share of the incumbent between 60% and 70% (mean HHI in the period 2003-2012 of 4,060 compared to sample mean of 3,515). We conducted a robustness check which includes Switzerland and yielded the same qualitative results. Regarding point (1): In order to correct prices for inflation, we used the Harmonized Consumer Price Index (HCPI) of Eurostat (prc_hicp_aind) with the base year 2005. As Switzerland applied the HCPI methodology only after 2005, we use the consumer price index of the years 2000-05 from the Swiss federal statistics office to complement the Eurostat data. To make the two indices comparable, we debased the Swiss index on the year 2005.

[18] We checked the robustness of our results running level-level and log-log regressions of our preferred specification. The results are robust to the change in functional form.

4.1 Focus on cross-country comparisons

In this section we present results where we use available control variables to account for cross-country differences that are not due to differences in concentration. As significant variation in EPPM remains even after controlling for these factors, this approach puts a focus on the cross-country comparison (but also includes variation over time).

Table 1 shows the results of various regressions of log deflated country EPPM voice on the number of MNOs as defined above (i.e. excluding observations with 2 or 5 MNOs).

Table 1: Regressions of log deflated country EPPM voice on number of MNOs

Variable	(1)	(2)	(3)	(4)	(5)
Number of MNOs (market share > 1%)	-0.153*	0.022	0.041	-0.055	0.005
Linear time trend		-0.161***	-0.162***	-0.160***	-0.162***
Mean Capex (EUR/subscriber)			0.013***		0.009***
GDP per capita (PPP)				0.006***	0.003***
Constant	-1.732***	321.089***	323.176***	318.508***	321.557***
Observations	199	199	199	199	199
Adjusted R-squared	0.014	0.655	0.795	0.770	0.802

Notes: *** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level.

Specification (1) shows that the level of concentration has almost no explanatory power for the observed differences in EPPM. Only around 1% of the differences can be explained by concentration if no further differences are accounted for (see Adjusted R-squared). The coefficient is negative and statistically significant at the 10% level.

Specification (2) shows that at this stage (without further control variables) the negative sign is due to the downward trend in prices combined with the upward trend in HHI. When including a trend variable, the explanatory power of the model increases to about 65% and the effect of the number of MNOs on EPPM becomes statistically insignificant.

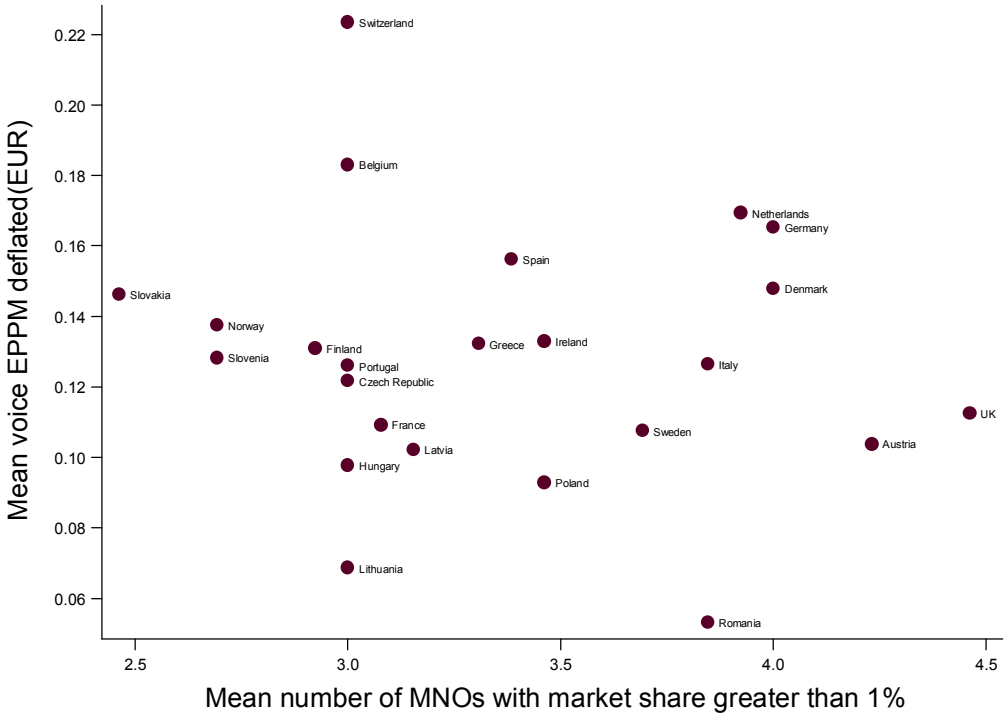
Specification (3) regresses the EPPM on the number of MNOs, a linear trend and the mean Capex per subscriber (averaged over all countries considered). The coefficient of mean Capex per subscriber is statistically significant (at the 1% level) and the regression now explains 79% of the EPPM differences. There is no statistically significant effect of the number of MNOs on EPPM. Specification (4) uses GDP per capita instead of mean Capex per subscriber and shows the same result (no significant coefficient of the number of MNO variable). When combining Capex and GDP per capita both variables are still statistically significant and the adjusted R-squared increases further. This is our preferred specification

(Specification 5), which we use as a basis for the robustness checks shown below. Again there is no statistically significant effect of concentration on prices.

In order to make the impact of accounting for differences in demand and quality transparent, we show figures below that plot each country with respect to the average residuals (after controlling for a linear time trend, mean Capex per subscriber, and GDP per capita) and the average number of MNOs (both averaged over the years covered). The residuals can be interpreted as "cleaned" prices after taking the influence of the listed control variables into account.

To compare with the situation before introducing the statistical analysis we begin by presenting Figure 6 which shows the average number of MNOs over the period 2003 to 2012 and the corresponding EPPM for 25 European countries.[19]

Figure 6: Voice EPPM over number of MNOs, both averaged over time period 2003 to 2012

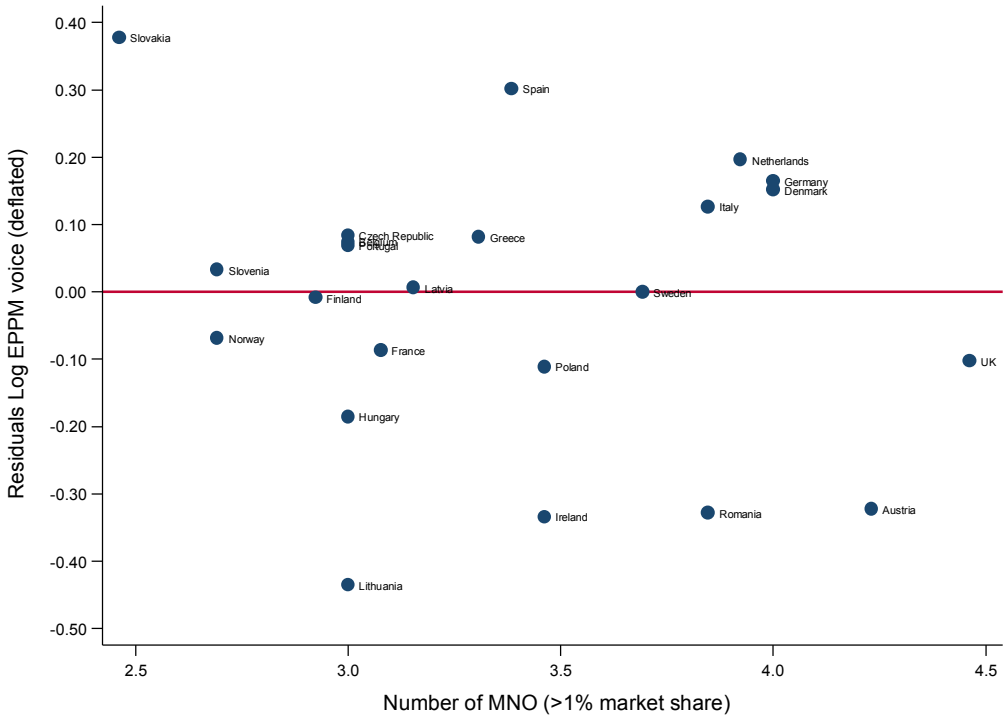


The figure shows that there is almost no relationship between the average number of MNOs and the average EPPM in the countries analysed. Other factors drive differences across countries to a much larger extent. Before we discuss those and other control variables considered, we account for the decrease in costs over time. In fact, if the number of MNOs is regressed on the EPPM (with no further variables included), the number of MNOs explains only 1.4% of the differences of EPPM across countries and over time (see Table 1 above).

Figure 7 shows that after controlling for a linear time trend, mean Capex per subscriber, and GDP per capita there is no clear relationship between concentration and (cleaned) prices. The plot shows for each country, that is included in regression (5) above, the residual logarithms of EPPM voice averaged over the time period 2003 to 2013 over the average number of MNOs not restricting observations to observations with only three or four MNOs.

[19] Switzerland is included in this graph as data is available. It does not appear on the figures that follow as, for reasons explained above, we excluded Switzerland from the regressions.

Figure 7: Mean residual and mean number of MNOs by country after controlling for linear time trend, mean Capex/subscriber and GDP per capita (all observations)



Compared to Figure 7 above, Figure 8 below shows the same averaged residual logarithms of EPPM voice over average number of MNOs for the sample excluding all observations with numbers of MNO different from three or four. Again, a clear relationship between price residuals and concentration cannot be seen.

Figure 8: Mean residual and mean number of MNOs by country after controlling for linear time trend, mean Capex/subscriber and GDP per capita (observations with 3 or 4 MNOs)

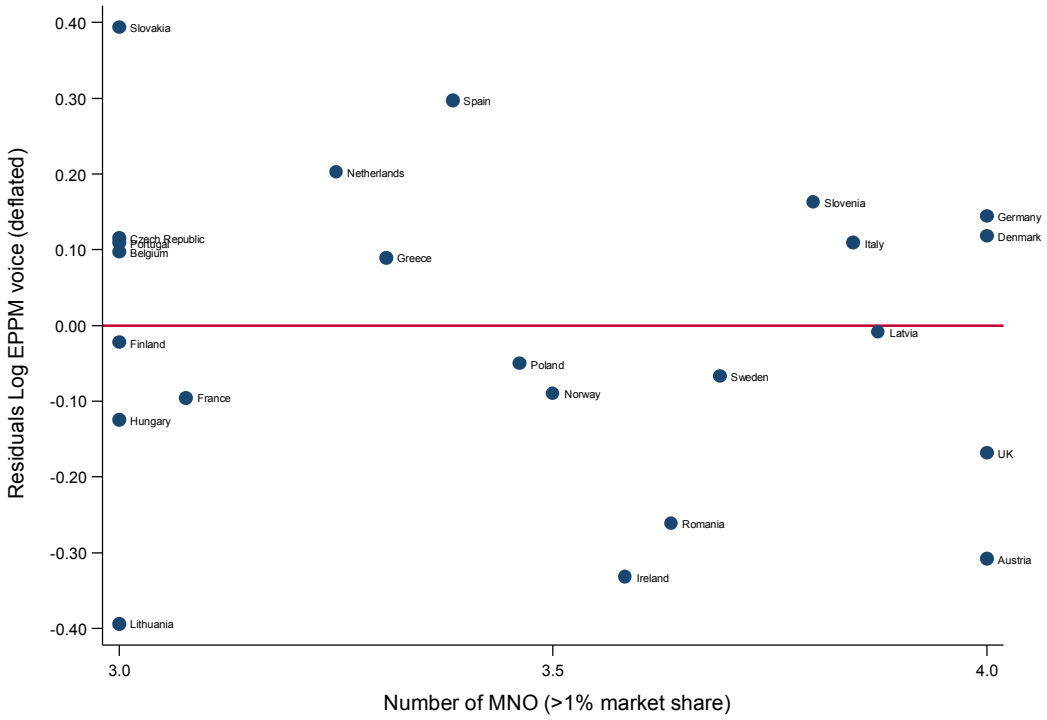


Figure 8 reflects what is shown in the statistical analysis: there is no clear relationship between concentration and prices in this specification. However, the Figure also shows that the result is potentially sensitive to the choice of countries.

We checked the robustness of our regression results of the preferred specification (i.e. no statistically significant relationship between concentration and EPPM) with various robustness checks. In particular, we ran regressions on total ARPUs rather than EPPM, we used the available HHI measure instead of the number of MNOs to measure concentration and we ran various further robustness checks with regard to the explanatory variables included in the preferred specification.

Table 2 summarizes the results of these checks for the preferred specification. As the table shows, we find no relationship between concentration and EPPM in all robustness checks.

Table 2: Robustness checks for cross-country comparison

Robustness check using	Testing robustness with respect to	Sign and statistical significance of concentration parameter in preferred specification
Total ARPU	Price variable	Insignificant
HHI	Concentration measure	insignificant
Excluding individual countries	Countries that drive results	insignificant
Cost index	Time trend	insignificant
Percentage of country area populated by accumulated 50%	Additional cost indicator	insignificant

Robustness check using	Testing robustness with respect to	Sign and statistical significance of concentration parameter in preferred specification
Year fixed effects	Time trend	insignificant
Mean Capex per minute (rather than subscriber)	Quality indicator	insignificant
Mean GDP/capita per country	Demand indicator	insignificant
Eastern countries dummy	Additional control variable	insignificant
Prepaid share	Additional control variable	insignificant
Business share	Additional control variable	insignificant
Regress only for 2007-2012	Quality of data before 2007	insignificant
Include observations with number of MNOs unequal 3 or 4	Selection of observations	insignificant
Include only large countries	Large/small country differences	insignificant
Include MNP indicator	Additional control variable	insignificant

4.2 Focus on comparison over time (country fixed effects)

In this part, we focus on a comparison over time, where we take out differences across countries that are stable over time by introducing country fixed effects.

As for the regressions without country fixed effects, we exclude Switzerland from the regression analysis as it appears to be an outlier. Furthermore, all observations for which the number of MNOs is two or five are excluded from the regression analysis.

Table 3 shows the results for regressions of the logarithm of deflated EPPM voice on the number of MNOs and country fixed effects. In specification (1), we do not control for the time trend. In this specification we find that EPPM voice decrease by 30% if the number of MNOs increases from three to four. However, as explained before, EPPM has a decreasing trend over time due to reductions in costs. It is hence necessary to include a time trend in the regression in order to correctly identify the effect of the number of MNOs on EPPM voice. In specification (2), we include a linear time trend, which is negative and statistically significant in the regression. Once we control for the time trend, the coefficient on the number of MNOs becomes positive and statistically significant at the 5% level, implying that an increase in the number of MNOs from three to four leads to an increase of about 10% of EPPM voice.

Table 3: Regressions of log deflated country EPPM voice on number of MNOs (above 1% market share) – with country fixed effects

Variable	(1)	(2)
Number of MNOs (market share > 1%)	-0.300**	0.098**
Linear time trend		-0.165***
Belgium	0.498*	0.649***
Czech Republic	0.065	0.216**
Denmark	0.587**	0.340***
Finland	0.134	0.284***
France	0.030	0.141*
Germany	0.587**	0.340***
Greece	0.141	0.132
Hungary	-0.227	-0.076
Ireland	0.397	0.269***
Italy	0.371	0.164**
Latvia	-0.186	-0.219***
Lithuania	-0.653**	-0.503***
Netherlands	0.365	0.581***
Norway	0.171	0.452***
Poland	-0.062	-0.150*
Portugal	0.090	0.240***
Romania	-0.535*	-0.535***
Slovakia	0.020	0.500***
Slovenia	0.064	0.309***
Spain	0.477*	0.429***
Sweden	0.188	-0.019
UK	-0.018	-0.018

Variable	(1)	(2)
Constant	-1.354***	328.158***
Observations	199	199
Adjusted R-squared	0.234	0.921

Notes: *** Statistically significant at 1% level. ** Statistically significant at 5% level. * Statistically significant at 10% level.

As for the regression without country fixed effects, we checked the robustness of our regression results of the preferred specification (specification 2 in Table 3) with various robustness checks. In particular, we ran regressions on total ARPUs rather than EPPM, we used the available HHI measure instead of the number of MNOs to measure concentration and we ran various further robustness checks with regard to the explanatory variables included in the preferred specification.

Table 4 summarizes the results of these checks for the preferred specification. As the table shows, we mainly find a negative relationship between concentration and EPPM in the fixed effects regressions: as the number of MNOs increases (or HHI decreases), EPPM increases.

Table 4: Robustness checks for comparison over time (country fixed effects)

Robustness check using	Testing robustness with respect to	Sign and statistical significance of concentration parameter in preferred specification
Total ARPU	Price variable	(+)*
HHI	Concentration measure	(-)*
Excluding individual countries	Countries that drive results	(+) – (+)***
Cost index	Time trend	insignificant
Year fixed effects	Time trend	(+)**
Mean GDP/capita per country	Demand indicator	(+)***
Prepaid share	Additional control variable	(+)**
Business share	Additional control variable	(+)**
Regress only for 2007-2012	Quality of data before 2007	(+)**
Include observations with number of MNOs unequal 3 or 4	Selection of observations	insignificant
Include only large countries	Large/small country differences	insignificant
Include MNP indicator	Additional control variable	(+)***

5 Conclusion

As the roll-out and the operation of mobile telecom networks lead to high capital expenditure (Capex) and operating expenditure (Opex), one expects that a lower number of mobile network operators (MNOs) in a country goes along with lower costs to serve a given number of subscribers at a given quality level. Put in the context of a merger, such and other efficiencies would tend to lead to a downward pricing pressure. At the same time, the reduction in the number of MNOs absent sizeable efficiencies may lead to upward pricing pressure. In order to learn something about the net effect between these two opposing forces, it may be interesting to analyse the relationship between the level of concentration and prices across countries and over time. If a reduced competitive intensity outweighed any downward pricing pressure due to efficiencies, one would expect that a lower number of MNOs tends to go along with higher prices. Such a finding would encourage a particularly critical analysis of proposed mergers in the industry. If the positive effect on competition due to efficiencies compensates or over-compensates any negative effect, one would expect either no relationship between prices and concentration or that a lower number of MNOs would tend to go along with lower prices. Such a finding would lend support to the claim that sizeable efficiencies matter and are passed on to consumers.

In this paper, we present results of our investigation of the relationship between prices and competition in the mobile telecom industry in European countries for the period 2003 to 2012. Overall, our results strongly suggest that there is no robust indication of a positive relationship between concentration and prices. To the contrary, our results weakly suggest that there may even be a negative relationship between concentration and prices. The results therefore support a view that mergers lead to sizeable efficiencies which are passed on to consumers.

In order to isolate the relationship between concentration and prices one has to carefully account for other factors that may differ across countries and over time and that may affect both, prices and concentration or that create a correlation between prices and concentration where there is none. Indeed, over the period investigated, the deflated effective price per voice minute (EPPM) averaged across all countries analysed fell constantly and has more than halved. As is well known in the industry, this is mainly due to a reduction in the costs of providing mobile services, e.g. due to declining equipment costs and increasing number of subscribers for a given area covered. At the same time concentration has – on average across all countries - decreased. If the relationship between concentration and prices is measured without taking into account the decline in costs, one almost certainly finds a relationship between concentration and prices. However, this relationship is spurious as it is only due to omitting an important factor: the declining trend in costs. Indeed, our results show that the relationship between concentration and prices turns from positive to statistically insignificant when we include a linear time trend in the analysis.

Our analysis shows that a large part of the price differences between countries are related to indicators that measure differences in quality and demand (and also to some extent costs). In particular, we find the average Capex per subscriber per country (averaged over all years considered) as well as GDP per capita explain a large part of the price differences across countries. The average Capex per subscriber indicates the quality level (in the widest sense, i.e. including coverage and capacity) and GDP indicates the ability to pay or demand. We find that higher quality goes along with both higher prices and higher concentration. This suggests that omitting quality may lead to a finding of higher prices due to concentration while they may be high due to the higher quality. The direction of causality may go from quality requirements (e.g. coverage objectives set by the regulator) to prices and concentration. It is also possible that higher concentration and nominal prices create investment incentives (e.g. higher return on investment) which improve quality. Finally, concentration may lead to higher prices, which in

turn leads to more investment in quality as competition shifts to quality competition. Thus, when excluding the quality variable, one may overestimate the effect of concentration on nominal prices (as some of the nominal price differences coinciding with concentration may be explained by quality differences). In other words, by excluding a quality variable one compares prices of countries which offer services at different quality levels – where countries with higher concentration may have higher prices and higher quality.

We conduct the analysis with a focus on countries with four or three MNOs. Economic theory suggests that the relationship between concentration and prices may depend on the level of concentration. For example, while a four-to-three merger may on balance lead to lower prices, a three-to-two merger may not, as the negative effect on competition due to a reduction is likely to increase the fewer MNOs are in the market. However, conceptually it could also be the other way round as the relative and absolute cost savings due to a merger will be larger in a three-to-two than in a four-to-three merger. In order to align our results as closely as possible with the question at hand, we consider – in our main and preferred specifications – only observations with either three or four MNOs. As this reduces our sample somewhat, we also present results without this filter as a robustness check.

Data providers offer data from 2003 to 2012 (others even going back to 2000) and covering almost all EEA countries. This allows a panel regression, which makes use of differences across countries and changes over time simultaneously. However, as price changes over time are much smaller (once the falling price trends are accounted for) than the price differences across countries and as some countries have a constant number of MNOs during the period of interest, we consider it useful to distinguish two approaches: One in which differences across countries that are constant over time are "taken out" of the analysis (technically: country fixed effects are introduced, we call it an analysis with a focus on the time based effects) and one in which one tries to take out differences across countries that are not due to concentration using control variables (which leaves sizeable differences across countries that are stable over time in the analysis). In fact, significant effort went into the identification, procurement and testing of indicators that were considered suitable to account for differences in market structure (other than the number of MNOs), demand, costs and quality.

We find the following:

- **Without fixed effects (focus on comparison across countries):** In our preferred specification there is no statistically significant relationship between concentration and prices. In this specification we measure concentration by the number of MNOs (three vs. four) and prices by the effective price per voice minute of use (EPPM). In order to take other factors into account, we include a linear trend (to account for the decline in costs over time), average Capex per subscriber levels in the country (to account for quality differences and also some cost differences), and GDP per capita (to account for differences in demand and also some differences in costs – mainly across countries as shown above). This specification explains a large part of the differences in EPPM in the dataset. The result is robust regarding other measures of concentration (e.g. HHI instead of number of MNOs) and prices (e.g. total ARPU taking into account various usage indicators). It is also robust with respect to a large number of robustness checks considering indicators for demand and cost (see below). However, we find that if we do not account for quality differences (mean Capex per subscriber over the entire period considered) we also find results indicating a positive relationship between concentration and prices. This suggests that countries with higher concentration have systematically higher quality levels as indicated by their mean Capex over the period analysed (e.g. with respect to voice: coverage (indoor and outdoor), call success rate, the time to place the call, average speech quality). Moreover, we find that the results (with and

without Capex) depend on the inclusion of very few countries. We therefore do not consider this result as robust.

- **With fixed effects (focus on comparison over time):** In our preferred specification there is a statistically significant negative relationship between concentration and prices. In this specification we take out differences across countries that are stable over time by introducing country fixed effects and we include a linear trend (to account for the decline in costs over time). The result is robust over a large number of robustness checks, which provides good support for a negative relationship between concentration and prices. However, the result may still be affected by omitted variables as it appears difficult to account for changes in quality and data usage over time.

Graphical inspection (see Figure 6) of the distribution of plotted countries in the price / concentration space suggests no relationship between concentration and prices, as it is shown in the numerical regression results (which include variation over time). However, the figure also shows that one may find such a relationship if only a few countries are excluded. The fact that results depend on a few countries is of particular concern as the measurement of prices and many control variables in mobile telecoms are subject to a considerable number of limitations.

With these limitations in mind, our results suggest that there is no positive relationship between concentration and prices. When interpreting the result for mergers that are filed today, one has to take into account that during a large part of the period covered mobile telecom services where mainly voice services (and SMS). Indeed, in our main specification we use a voice price indicator (EPPM) to analyse the relationship. In the future data services will become more relevant and ultimately dominate consumer welfare differences across countries. Thus, accounting for quality differences and ensuring sufficient incentives to invest will become even more important in the future.

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