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Does the number or the composition of players matter on the mobile broadband markets? – Lessons from a benchmarking study of the large-screen mobile broadband prices in the European Union

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Does the number or the composition of players matter on the mobile broadband markets? – Lessons from a benchmarking study of the large-screen mobile broadband prices in the European Union

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This paper presents preliminary findings of an ongoing research project

Results may change

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Abstract

Cross-country price comparison is a useful, but often deceptive exercise. The paper addresses the underlying methodological challenges, offering a practicable solution, which is both sound enough and meaningful for the comparison of prices on different markets. The simple and methodologically more sophisticated comparisons in turn give valuable insights into how the structural and also other factors associated with the price-differences between national markets.

Need for empirical information about the functioning of the mobile broadband markets

A good telecom regulatory and competition policy must be built on the understanding of and solid evidence on the functioning of the market. Analyzing the effect of market structure, especially the number of competitors shaped by entries and mergers, the market shares and concentration and also the different characteristic strategies and behaviors of the players are important ingredients in gaining empirical knowledge. The evident need for such evidence is especially important in the case of mobile markets where the current industry opinion on the desired market structure and the view of the European Commission and in many cases also the local competition authority, and the assessment of the overall effects of a merger on the consumers are highly divergent. Approved, relatively recent mergers and even entries are rare, it is important to gain empirical support to industrial and competition policy decisions in the current development phase of the

mobile markets. Mobile usage now is more and more data driven which is challenging to the company (and industry) cost structure and the viable business models and also to the assessment of the effectiveness of the competition on the market.

The relatively few recent studies¹ on the effect of entries and mergers, or the number of market players on mobile penetration and price development are valuable from competition policy view but there is a shortcoming that they are capable of providing empirical insight relating to a former stage of mobile market development when voice was evidently the dominant feature of the mobile communication service. The ongoing technology, cost structure and consumption pattern changes require that evidence on the effects of the current functioning of the markets on prices and mobile broadband development must be collected analyzed and used as a foundation of a good competition and regulatory policy on these markets. As controlled experiments are almost impossible, preparing event studies are also aggravated by the rare occurrence of the relevant events, the difficulties of collecting information for the evaluation, and the shortness of the time horizon for the evaluation of the effects. In these circumstances benchmark studies capable of providing comparative information on the mobile markets with different relevant characteristics can be a valuable source of information on the functioning of these markets. Though these comparisons are usually not enough to reveal causal relationships, they can provide some comparative results which can be useful input to policy decisions.

This paper is about the comparison of large screen mobile broadband prices in the EU countries between 2013 and 2015 addressing the underlying methodological challenges and offering a practicable solution, which is both sound enough and meaningful for the comparison of prices on different markets. The comparison in turn gives valuable insights into the structural and also some competitive incentive factors associated with the price-differences between national mobile markets. The results of cross-country comparison, appropriately interpreted can be used as a valuable input for competition and policy decisions.

¹ Csorba G., Pápai Z. (2013): "Does one more or one less mobile operator affect prices? A comprehensive ex-post evaluation of entries and mergers in European mobile telecommunication markets", ITS Conference paper, 24th European Regional Conference of the International Telecommunication Society, Florence, Italy, 20-23 October 2013, available at <http://econstor.eu/bitstream/10419/88503/1/773139184.pdf> ; Affeldt P., Nitsche R., (2014) A price concentration study on European mobile telecom markets, ESMT Working Paper, ISSN 1866-3494, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2526821; Aguzzoni L., Buehler, Di Martile L., Ecker G., Kemp R., Schwarz A., Stil R., (2015): Ex-post analysis of two mobile telecom mergers: T-Mobile/tele.ring in Austria and T-Mobile/Orange in the Netherlands, European Commission; Genakos C., Valletti T., Verboven F. (2015): "Evaluating Market Consolidation in Mobile Communications", CERRE Report, available at: http://cerre.eu/sites/cerre/files/150915_CERRE_Mobile_Consolidation_Report_Final.pdf

Methodological challenges in the comparison of prices

Though it is a well-established exercise by international organizations to collect and provide comparative data on different national markets it is not without challenges. Comparability requires straightforward collection and processing of the raw data inputs and a methodologically sound and transparent calculation of the numbers for comparison and consensual interpretation of the results. There are public sources like OECD, and the European Commission which regularly publish data useful for comparison of different national telecom markets. These publications are presenting preprocessed data supplied by some private provider² or contractor³ for special projects. There are also commercial products providing comparative price information though these are not available to the public and can only be used by their clients in their own internal organization processes or decision making. Transparent and sound methodology is a must have requirement for the proper understanding and interpretation of the results, i.e. taking anything comes out of comparison at all seriously.

Mobile service is a complex bundle of different service elements so the ideal single price for a simple product is not the case with it, and unfortunately we can hardly find a single price tag attached to any of its comprising elements in the practice. In order to make mobile bundles comparable usually some basket comparison methodology is used. The basket method does not come without its merits and risks. Its merit is that it creates comparable bundles comprised from the same quantity of service elements, i.e. consumer “baskets” on the calculated single basket price. It is transparent and sound, however there is a risk that the basket created for comparison is artificial and arbitrary and no consumer who is using anything close them. In this case the basket and any comparison based on that is irrelevant

The other potential weakness of the basket method, is the that if it uses a consumption pattern relevant in a group of countries and less fitted to or totally irrelevant in others, than it shows a distorted picture, favoring one group of the compared countries to another. So the good construction of the baskets is the key. Having these drawbacks as they are, basket comparison seems to be more useful and trusted than other potentially interesting but dubious methods, of which a good example of the Digital Fuel Monitor prepared by Rewheel⁴. The Digital Fuel Monitor compares irrelevant consumption bundles using a preset price keeping minimum quantity thresholds of the arbitrarily considered different bundle elements and focusing only on how much GB of data this price buys. They use another comparator the per GB price calculated as the ratio of the basket price with the identified data quantity minus the price of the same basket but without the data plan to the quantity of the included Gigabytes. Without proving the relevance of the compared baskets as meaningful consumption patterns any comparison result is highly irrelevant.

² Like Strategy Analytics (former Teligen).

³ Like Van Dijk study on Mobile Broadband Prices, prepared for the European Commission in 2015

⁴ www.dfmonitor.eu

For mobile broadband price comparison we intentionally chose a well defined special segment the Large-screen mobile broadband with data only sim cards used with mobile sticks, dongles or any mobile data modems.

Large-screen mobile broadband price data

Large-screen mobile broadband is a distinct segment of the mobile broadband market. Usage goals, circumstances and even pricing is different, and there is no Voice option included in the plans. Large-screen mobile broadband plans offer higher data traffic than small-screen plans. While these plans are not applicable to smartphones, they may also be appropriate for tablets.

Most operators set up different packages for different user groups (low, medium and high-intensity users) with considerable differentiation in plan prices and features. The key element of this differentiation is the monthly data allowance included in the package. There are packages advertised as “unlimited”, however, after a certain data limit, the speed of the connection is significantly reduced (typically to a GPRS speed of 64 or 128Kbps). We do not consider these plans “unlimited” mobile broadband, as the reduced speed is not broadband at all. In some countries, plans with de facto unlimited data traffic are available, but in this case usually the maximum connection speed differs. In the categorization we use the GB data allowances that are included in the monthly price of the plan, as the first identification characteristic of the plan. We use the speed characteristic only if the data allowance in itself is not enough to judge properly which corresponding basket it applies.

In each March from 2013 to 2015, Infrapont collected data from all mobile network operators’ websites of each member states about the actually advertised large screen mobile broadband offers. Only some of the nearly hundred operators did not have offers that could be categorized as large-screen mobile broadband. The table below shows the number of member states, operators and plans in the database for each year.

Table 1. | Database of large-screen mobile plans

year	2013	2014	2015
number of countries	27	27	28
number of operators	90	92	95
number of plans	331	334	356

Methodology

This chapter presents the methodology we used for the LSMBB price comparison. Despite the relative simplicity of the LSMBB offers (at least comparing to the small screen tariff structures) several methodological challenges emerge that can seriously influence the results of the benchmarking and the conclusions can be drawn from it.

First issue concerns the design of the consumer baskets. Plenty of different offers exist on the European market so the prices can be compared only by predefined consumer baskets. If we define too few basket there is a risk that the results of the comparison will be distorted or misleading since the baskets fits to the real consumer pattern of only part of the markets/countries. We can improve the coverage of the real usage patterns by increasing the number of baskets however the comparison can be untreatable after a point. The challenge is to find the right balance between the number of baskets and the relevance of the comparison.

Second task is the calculation of the average monthly prices of the plans in such way that the different tariff structures used by the operators can be comparable. This includes the uniform treatment of the monthly and one-off service price elements, the equipment costs, bundling prices and the different discounts or free of charge extra services.

In case of cross-country comparison from the operators' prices we should select or calculate that price which we use for the benchmarking. Here we have several options such as the cheapest price on the market, cheapest offer of the two major players or some kind of average price.

Finally, there is a frequently emerging question in case of benchmarking studies - which represent several different basket comparison (often with different results/ rankings) - that refers to the overall market prices and the ranking of the countries according to some overall price level.

In this chapter we deal with the first three issues while the fourth will be discussed after the presentation of the results of the basket price comparisons.

Consumer baskets for price comparison

Large-screen mobile broadband plans are highly diverse across countries, which makes it hard to directly compare them. For this reason, we define user baskets which represent certain user profiles, and compare the prices of these user baskets instead of the exact offers. With this method a comprehensive picture will emerge of the overall relative positions of member states on the market.

When the baskets were designed we considered three principles:

- different baskets must describe relevant, realistic usage patterns,
- baskets must be empirically relevant: they must be based on the frequency distribution of the real packages (the modes of the distribution of the plans are the starting points for defining the baskets), and
- it is preferable to use baskets similar to OECD-defined large-screen mobile broadband baskets if there is no particular reason not to.

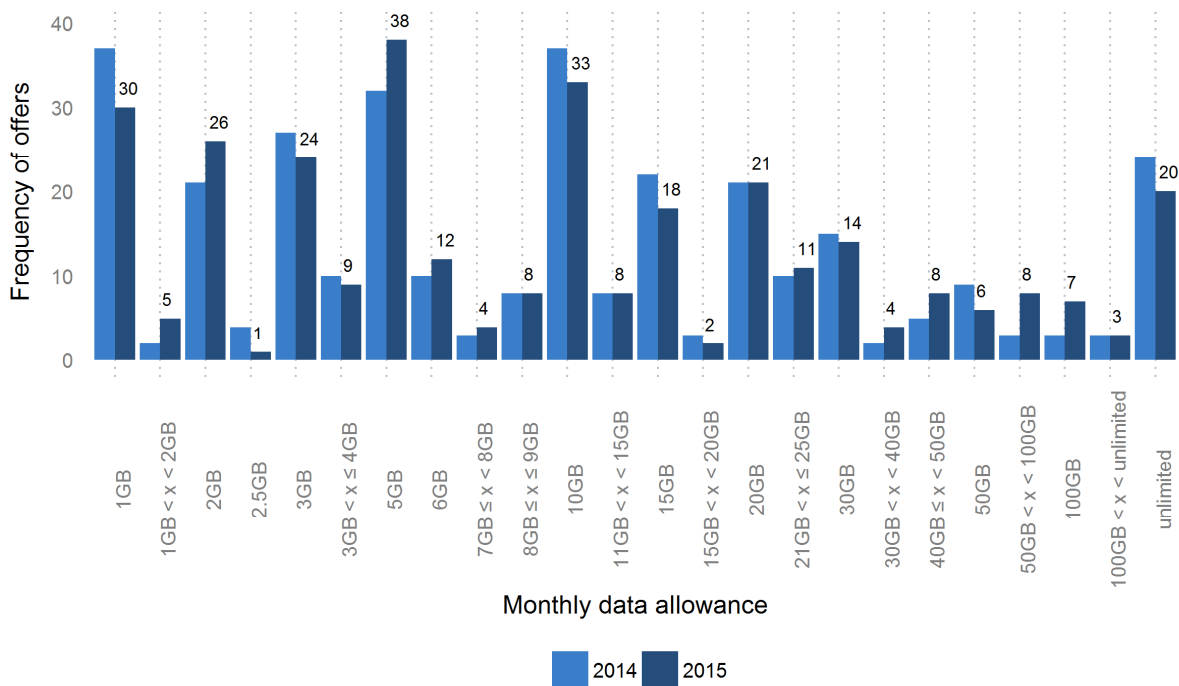
With the first two criterions in mind, we decided to define the user baskets based on the plans’ monthly data allowances. We believe that the first and foremost identifier of how the consumer wishes to use mobile broadband is how big a data allowance she chooses. Different usage patterns describe a low, a medium or a high-intensity user, which most likely materialises in the data limit chosen.

Our consumer baskets are the following:

- three low user baskets: 1, 2 and 3 GB;
- two medium user baskets: 5 and 10 GB;
- three high user baskets: 15, 20 and 30 GB data allowance.

By looking at the frequency of offers by monthly data allowance (Figure ...), it is clear that the above defined user baskets are relevant, as these data allowances are offered by the highest number of plans. Plans in these 8 baskets cover 64% of all offers, which reinforces the relevance of the defined baskets. We cannot overlook, though, the significant increase in the number of offers over 30GB, particularly of 100GB and unlimited offers. However, unlimited offers are available still only in six countries, and out of the 20 such plans 9 is offered in Finland.

Figure 1. | Frequency of offers by monthly data allowance (GB; number of plans)



Source: Infrapont, based on operators' homepages
 Note: Labels are for 2015 frequencies.

Regarding the OECD-defined large-screen mobile broadband baskets 4 out of the 5 is the same as in our examination. The only exception is the OECD basket with 500 MB which is apparently too small compared to the observed usage patterns and has no or marginal

relevance. OECD baskets (500 MB, 1, 2, 5, 10 GB data allowance) seem to be a bit outdated, since do not cover the higher user consumer segments at all while half of the operators' offers are with higher allowance than 10GB.

However the major differentiator used by the operators is the data allowance, there are some market where allowed maximum download speed also play role in the plan design and the segmentation. Especially in countries where plans with very high or unlimited data allowance are prevalent, operators use different download speed to address the different consumer segment.

Therefore in calculations relating to consumer baskets we also used an explicit benchmark for the achievable download speed in the baskets' definitions so that we can handle plans differentiating among consumers not (or not only) in data allowance, but also in the allowed speed which is apparently a steadily increasing trend.

Table 2. | Baskets and the maximum download speed considered appropriate for such a basket

User basket	Monthly data allowance (GB)	Maximum allowed download speed (Mbps)
low user I.	1	≥ 1
low user II.	2	≥ 2
low user III.	3	≥ 3
medium user I.	5	≥ 4
medium user II.	10	≥ 4
high user I.	15	≥ 6
high user II.	20	≥ 6
high user III.	30	≥ 6

We only consider a plan as corresponding to a given user basket if the maximum allowed speed equals or exceeds the level defined in the table above. For example, even if a plan grants unlimited data but the maximum download speed is below 6 Mbps, we do not consider it appropriate for the high user basket.

Calculation of the prices of individual plans

To calculate the prices of the baskets, first the prices of the individual plans offered by mobile operators need to be accounted for. The following elements were considered when we calculated the average monthly price of the plans:

- monthly list price of the plan,

- one-time fees related to the package: activation fees, administrative fees, service fees, etc.,
- price of the stick/modem,
- unambiguously quantifiable discounts.

The average monthly price of plans was calculated according to the following formula:

$$\text{average monthly price} = \text{monthly list price} + \frac{\text{one-time fees}}{\text{contract length}} + \frac{\text{price of the stick/modem}}{24} - \frac{\text{discounts}}{\text{contract length}}$$

which was constructed using the considerations listed below.

- The *monthly list price* of the plan in many cases depends on the length of the accepted loyalty contract. Available contract lengths can vary, however, 12 and 24 months' loyalties are the most frequent. Usually, the longer the loyalty period, the lower the monthly list price. We use the most favourable monthly list price for the price comparison, which is usually the price with the longest loyalty contract.
- *One-time fees* are taken into account by dividing the sum of the fees by the duration of the chosen loyalty contract expressed in the number of months.
- The *price of the stick/modem* varies significantly among operators. Some provide plans with the price of the stick included in the monthly list price, while in other cases, customers need to select a stick/modem from a predefined choice set. In the latter case, the cheapest stick allowing the functional use of the plan is taken into account for the calculation of the price. (That is, we preferred using the cheaper 3G modems until they can allow a bandwidth that satisfies the requirements of a given basket.) The price of the stick/modem is divided by 24 in these cases, because we assume that sticks and modems can be written down over two years⁵.
- Mobile operators offer a wide variety of discounts for their plans. These discounts play a significant role in attracting customers and they are also important tools of differentiation and discrimination. Some of the discounts are well quantifiable and can be expressed in monetary terms, like lower monthly list prices for the first few months, abandonment of a one-time activation fee, or price reductions in the case of online purchase. We take these discounts into account when calculating average prices, and divide them by the length of the contract, to reflect how the discount affects the price of the plan over the entire duration of the contract. Other discounts, like a reduction in the price if the customer has a voice plan with the operator, or services available free or with discounts (e.g. music, hotspot usage, virus protection etc.) are not taken into account.

⁵ In some cases, there is a monthly fee for the stick/modem. When the price is a monthly fee, it is added by the following way: we multiply the monthly price of the stick/modem by the length of the contract and divide it by 24. This way, we get a stick/modem price comparable to those offers where a one-time fee is paid for the stick/modem

Matching plans and consumer baskets

We add each operator's most affordable plan to each user basket defined above whenever possible. Usually, this plan is the one with the exact data allowance that the basket's definition calls for. When an operator does not have an offer corresponding exactly to the size of the predefined basket, we apply the cheaper one of the following two options:

- the price of the plan with the closest, but higher data allowance,
- the price of the package with the closest, but smaller data allowance, plus the charge of the extra data volume the consumer would incur to achieve the data volume specified for the basket.⁶

If there is no exactly matching offer for the smaller user baskets, i.e. the operator's smallest offer contains a higher data allowance than the basket in question, we choose the plan with the smallest data allowance.

For countries where plans with high data allowances are not available, prices for the large user baskets could theoretically be determined by adding the cost of the extra data charge to the monthly list price of the closest available offer. However, this would lead to such high prices in most of the cases that the purchase could not have been considered rational under normal circumstances. These high prices are not presented in our figures, and in rankings, these countries are listed behind the country with the most expensive "real" offer. These markets are considered as having no plans available that corresponds to the high user basket for a rational consumer⁷.

Defining prices for cross-country comparison

From the operators' basket prices we have to select or calculate that price which we can use for the cross-country comparison. We use two methods: first, we make the comparison of the *minimum* prices on national markets corresponding to a given user basket, and second, we compare the *average* prices on the national markets.

Both approaches have advantages and disadvantages. The average price better reflects the market price level⁸ but it can make some countries appear more expensive than

⁶ In fact, extra data volumes in all cases result in significantly higher costs according to our test calculations; therefore principally the first option is preferred and used.

⁷ Our study also ignores the possibility that a user with high data demand can fulfil his or her needs by purchasing two or more plans with smaller data allowances from one or even several operators. In some cases, this arbitrage scenario would in fact be rational as the calculated monthly average cost of two or three combined plans could be lower than the cost of one single plan.

⁸ Correct measure for the average market price would be the operators' average price weighted by their market share. Due to the missing market share data we use simple (unweighted) average.

they actually are to a rational consumer who is able to find the cheapest offer. For example, in the case of high user baskets, if four operators supply the market with a corresponding plan and three of them advertise the service with a high price and one at a lower price, the average price will be higher than it would be if only one operator offered the plan at a relatively modest price.

Conversely, in the case of low user baskets it can occur that only one operator has a low-priced offer that corresponds exactly to the data allowance specified for the given basket, while the other operators' monthly data allowances are larger and their prices are higher. Thus the average price would be higher than in the situation where every operator supplied the same "appropriately sized" package.

Comparing the minimum prices avoids these problems, but leads to another: minimum prices are more volatile or contingent on some special issues than average prices, as they often reflect discounts available for a limited time period only (e.g. if a consumer orders the plan online by March 31, 2015 she gets a discount from the monthly list price for some months). The other possible drawback of the minimum price comparison is that in some cases these prices are based on plans offered by the smallest and newest operators with the poorest coverage, so they are not really comparable with full-fledged plans. For these reasons, we use both the results of the minimum price and the average price in cross-country comparison.

Prices are compared in euros. Prices in national currencies are converted to euros at the average Eurostat exchange rates as of March 2013, 2014 and 2015. Price comparisons often use exchange rates based on purchasing power parities (PPP) instead of nominal exchange rate values. These comparisons reflect the relative expensiveness of the service for the consumers filtering out the overall price level differences among the countries.⁹ Therefore, price comparisons based on PPP can be suitable for evaluating the market from the residential consumer's point of view. Using the available purchasing power parity indices¹⁰ we calculated all the prices to euro PPP.

Features of advertised large-screen mobile broadband plans in the EU

The main intention of building the database was to make it appropriate for an international comparison of the large-screen mobile broadband prices in the EU.

⁹ "PPPs serve both as convertors and as spatial price deflators. They convert different currencies to a common currency and, in the process of conversion, equalize their purchasing power by eliminating the differences in price levels between countries. (...) In their simplest form, PPPs are nothing more than price relatives that show the ratio of the prices in national currencies of the same good or service in different countries." Eurostat-OECD Methodological Manual on Purchasing Power Parities, European Union / OECD, 2012, p.13.

¹⁰ Purchasing power parities (PPPs), price level indices and real expenditures for ESA2010 aggregates (prc_ppp_ind). Last update: 15-06-2016

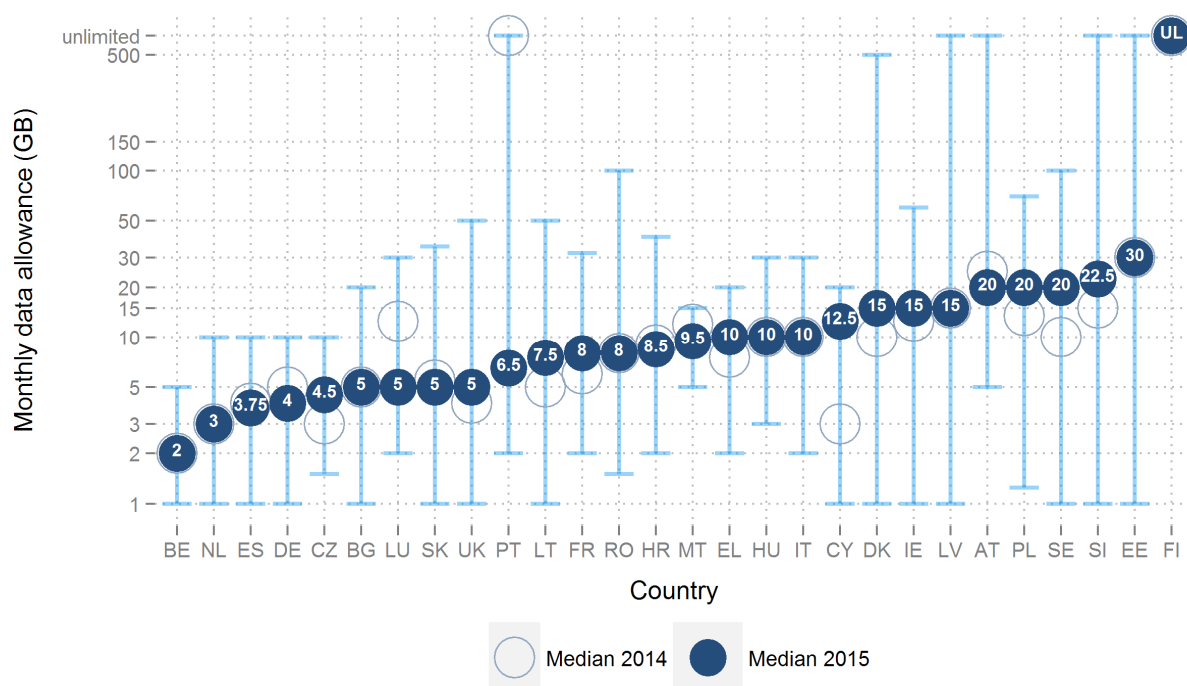
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=prc_ppp_ind&lang=en

However our data base enables us to paint a picture on the availability of offers with various data allowances and other features of the large-screen mobile broadband offers.

Mobile operators typically offer plans targeted at different users: low, medium and high-intensity, and sometimes extra-heavy users. Therefore, an operator usually offers three or four plans. Operators within a given country tend to provide plans similar to their competitors', but the offers vary significantly between countries.

In Belgium, for example, the plan targeted at high users offers only a 5 GB data limit (the lowest across the observed countries), while 5GB data allowance in some other countries are at the lower end of the spectrum. Figure 2 gives an overview of the minimum and maximum data allowances provided by mobile operators in the 28 observed countries in March 2015

Figure 2. | The minimum, maximum and median offers by country



Source: Infracore, based on operators' websites

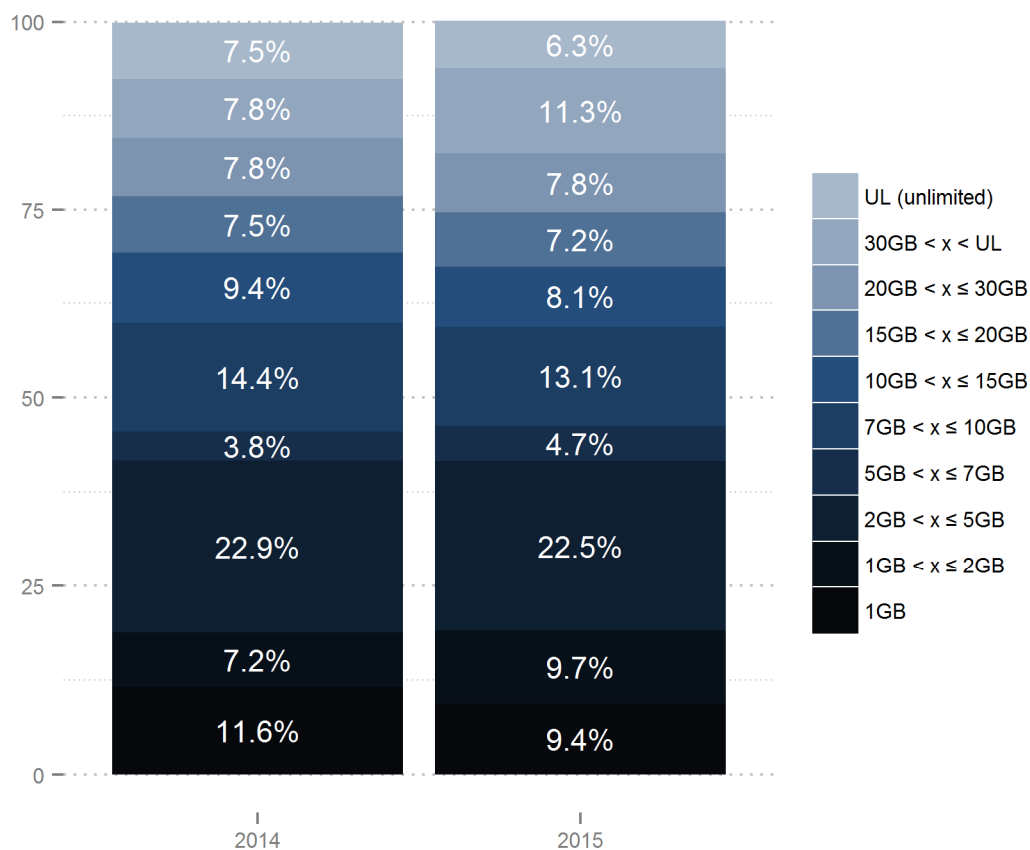
The range of data allowances across countries is quite large. 20 countries have plans both with low (1, 2, or 3GB) and high (more than 15GB) data allowances, while in Austria and Malta the smallest available offer is 5GB, and in Finland operators provide only unlimited plans. Belgium still offers the lowest maximum data allowance at only 5GB; no operator has introduced a plan with a higher data limit as of March 2015. In every other country, there are plans available offering at least 10GB. However, compared to 2014, the number of countries where the 10GB data allowance is the highest has doubled: in 2014 only the Netherlands and Spain were in this group, but by 2015, the maximum data limit was cut to 10GB in the Czech Republic and in Germany, as well. In Cyprus, Luxembourg and Romania the maximum

data allowance also decreased compared to 2014. The maximum data allowance increased in only five countries, out of which four are Central and Eastern European (Croatia, Poland, Slovakia and Slovenia, and Lithuania). Out of the 28 countries, 19 have plans with a 30GB or higher data allowance. The number of countries where unlimited offers are available increased from five in 2014 to six in 2015. After Austria, Estonia, Finland, Latvia, and Portugal, Slovenia introduced unlimited packages, too.

Comparisons based on the maximum data allowances, however, may not provide the best representation of the relative positions of countries. To provide a better description of the supply situation, Figure 3 also depicts the median offers in each Member State. The median allowance across the EU is 10GB, an increase of 1GB compared to 2014. This increase is clearly not driven by Western European countries. Compared to 2014, by 2015 median data allowances decreased in Austria, Germany and Luxembourg, with no improvement in either Belgium or the Netherlands, where the median data limit is still 2 and 3GB, respectively. The most notable change is in Portugal, where in 2014 the median data allowance was unlimited, and by 2015 it decreased to 6.5GB, as most unlimited offers were withdrawn by the operators. The increase in European median data allowance is driven by the increase in Poland, Sweden and Slovakia,¹¹ who along with Estonia and Finland provide the highest median data allowance.

¹¹ Data allowance seemingly increased in Cyprus, too, however, one operator (MTN) does not provide mobile broadband offers anymore, so the median data allowance shows only one operator. This does not represent an overall improvement on the Cypriot market.

Figure 3. | Distribution of offers by data allowance (GB), March 2014, March 2015



Source: Infrapont, based on operators' homepages

The distribution of plans by data allowance has remained virtually unchanged. Most of the plans (22.9% in 2014, and 22.5% in 2015) provide a data allowance between 2GB and 5GB inclusive. In 2013, we expected to see an increase in the share of the offers with high data allowances during the subsequent years; however this trend does not seem to appear in the collected data. The percentage of plans with a higher than 10GB data allowance increased only slightly from 40.1% in 2014 to 40.6% in 2015. The only trend visible across the three years of the study is that the number of plans with the smallest (1GB) and the highest (unlimited) data allowances, that is, both “ends” of the data allowance scale, are slightly decreasing. The share of 1GB offers decreased from 13.5% in 2013 to 11.6% in 2014 and to 9.4% in 2015, and the share of unlimited offers fell from 10.7% in 2013 to 7.5% in 2014 and to 6.3% in 2015.

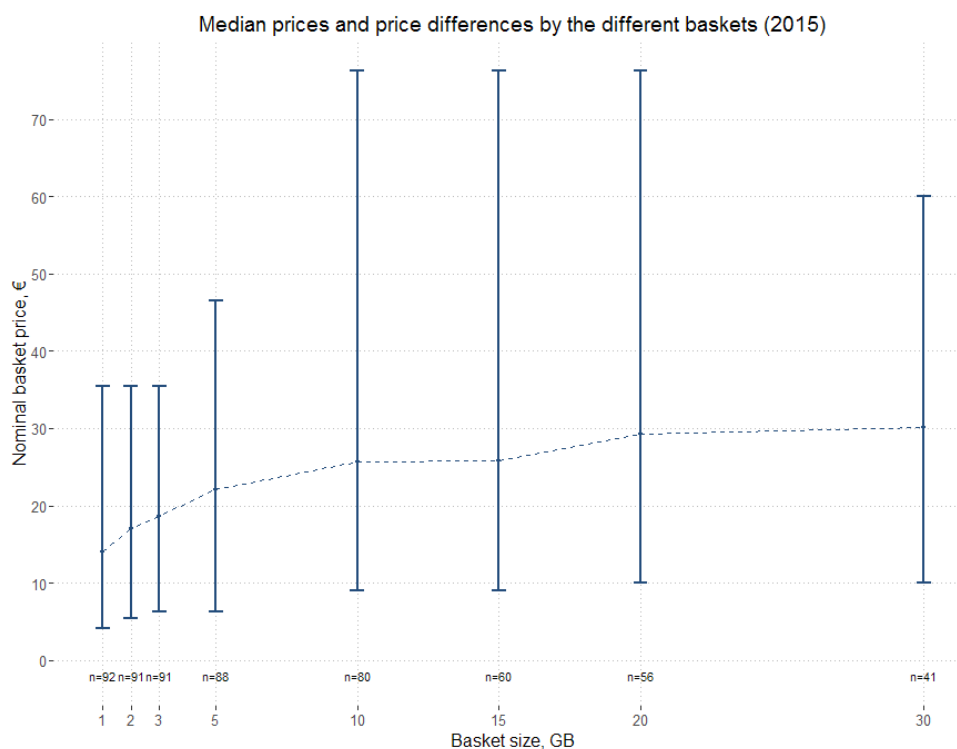
Price differences in the EU

There are large differences between countries and operators in the prices of the respective baskets. The ratio of the most expensive operator offer to the cheapest one in 2015 in the EU28 was the highest in case of the 5 GB plan, it was 14.8. The cheapest price for 5 GB is

€3.38 compared to the maximum of €49.96. Differences measured with this ratio are smaller at the lower and especially at the higher end of the basket range. Possible reason is that significant price differences of 5GB plans reflect the different service positioning of the operators: in some countries 5GB plan is positioned as a high user basket while on other market it is only a low user offer.

Nominal prices on average only slightly decreased from 2013 to 2015, but the differences in general have remained still as high as in 2013. However the number of relevant baskets in each category increased, so the whole basket range becomes more and more available in the different national markets. There are only some countries where the supply still does not cover the whole basket range, i.e. there is no at least one operator with a corresponding offer.

Figure 4. | The range of price differences by basket 2015



In order to give a flavor of the results of basket comparison we present the price rankings of the member states in case of the typical rather low user 3GB basket here. First with the nominal average price and second with the PPP adjusted average price.

Figure 5. | Country rankings by the nominal price of the 3GB basket of 2015

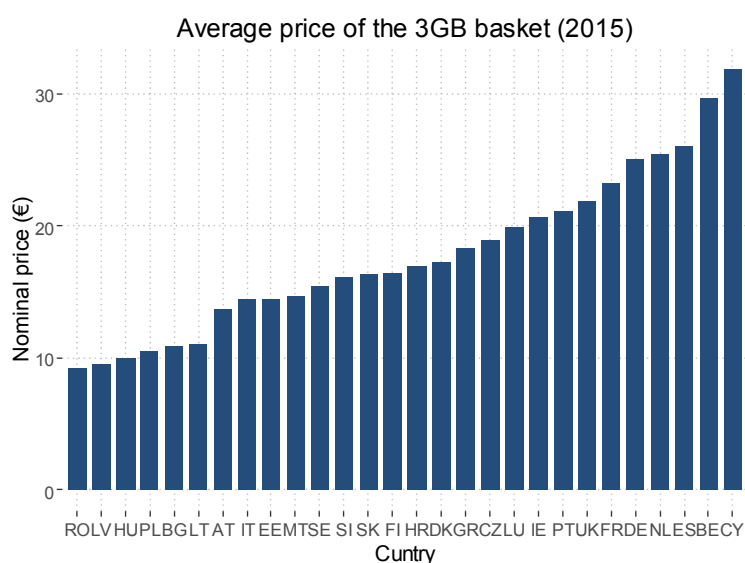
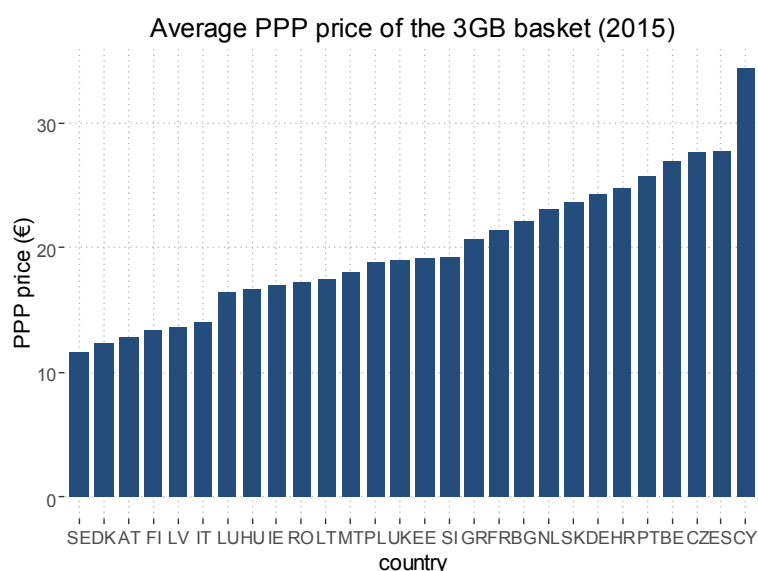


Figure 6. | Country rankings by the PPP adjusted price of the 3GB basket of 2015



Similar differences can be shown by using the country minimum price.

Our data shows that price differences within countries are smaller than between them. For example in 2015 in case of the 3GB basket the smallest ratio between the most expensive and the cheapest offer was 1.03 in case of Hungary. The highest ratio was 4.58 in its neighbor Slovenia. This ratio was below 2 in 20 of the 28 EU member states.

Differences between countries are fairly higher if the minimum price is considered. The ratio of the most expensive and the cheapest 3 GB offer was 9.14 in 2015. In case of the average price the ratio was only 3.44. This difference was still among the highest of the between country differences. With PPP adjustment which is relevant for cross-country comparison the ratio of the maximum and minimum of the minimum price offer was 5.27,

which was considerably lower, than at the nominal price comparison. The relevant ratio for average price is also significantly lower.

The tendency is the same for every basket, though the measured differences can be slightly higher or smaller. Based on the comparison of the quantity and price characteristics it seems clear that the large screen mobile broadband markets are national. There are large differences between even neighbor countries. The 3 year time span is not enough to judge whether there is a tendency of convergence between countries. However the differences between the country average prices decreased significantly from 2013 to 2015.¹²

The Large-Screen Mobile Broadband Price Index

It is useful to study and compare the prices of the different baskets, however it is too complex, and difficult to comprehend the whole picture and hard to discover the different patterns of pricing. It is reasonable to look for some simple tool for comparison, a single index value for each country, which is an aggregate overall price level for large-screen mobile broadband. With such an index we can present a comprehensive picture of large-screen mobile broadband price levels prevailing on each national market.

Basket price comparisons provide information about the relative positions of the national markets in relation to different consumer segments. These rankings reveal partial comparative positions, but the overall picture is also of interest, as are the relative price levels of the member states over all consumer segments. The task at hand is to create a measure which enables this comparison, hiding accidental differences but highlighting important, structural or country specific ones.

A solution for comparing the overall price level would be to calculate some type of average price per GB for each member state. In the case of mobile voice services, for instance, ARPM (average revenue per minute) provides the standard measure of the overall price level on the market. Similarly, average revenue per GB could serve as a measure for the large screen mobile broadband market. Unfortunately, revenue data or traffic information even for the total mobile internet usage is not available. Based on the basket prices, however, we can create a measure, as a workable proxy solution.

One approach, applied in some studies, would be to calculate an average or sum of the baskets' prices. This method may lead to misleading results, however, since the sum or the average would be dominated by the high user baskets (whose prices are three or four times higher than those of the low user baskets). Without any information of the quantity of consumption corresponding to the predefined baskets, it is without any justification to

¹² The most expensive/cheapest ratio decreased from 4.0 to 3.44 in case of the nominal price comparison, With PPP adjustment the corresponding decrease was from 4.38 to 2.95.

grant larger weight to any of the packages in the aggregate price level indicator. For example, if the prices of low and medium user baskets are fairly low in a country, and the prices of the high user baskets are high, an indicator based on summing or averaging prices will show this country as an expensive one. These price averaging of the baskets methods, therefore, cannot give a balanced picture of the general relative price level because they are biased toward exactly those (higher) baskets which currently represent only a very limited portion of the whole customer base. The differences in the relative positions of medium and low users, who represent the majority of the customers, could completely disappear in the sum or in the average.

In order to avoid this evident bias, we first calculate indices as a comparative measure of price differences between countries by baskets than calculate the average of these same scale indices. This method gives a more balanced result in comparisons by taking into account the relative price differences in each particular basket with equal weight. Unlike the simple average indicators, our price index is still keeping the information on the relative position but not influenced by the magnitude of the prices of the various baskets¹³.

The Large Screen Mobile Broadband (Comparative) Price Index is calculated as follows:

- A score of 100 is assigned to the entity (operator or country) with the highest price in a given basket. Other entities' scores with respect to a particular basket are then calculated as a percentage of the highest basket price. The overall Price Level Index for a particular entity is calculated as the simple average of the individual basket scores. For each entity (operator or country) the index is thus between 0 and 100 and gives an indication of how expensive is an entity's offer compared to the most expensive EU level. 100 is a theoretical maximum which could be the result if a country were the most expensive in each and every basket. It can be interpreted as a benchmark for the highest European price level. An index score shows that entity's achievement compared to this benchmark. The lower the score, the lower the price level.
- For intertemporal comparison we use 2013 as a base year, so the 100 point of the index is calculated only for 2013, and consecutive data from years are benchmarked toward this base level¹⁴.
- Since on country level we have a minimum and an average price for each basket, the index can be calculated for both cases.

¹³ Take the following example of two hypothetical countries, A and B. If A's prices exceed B's by 20% in the low user baskets, and the converse is true in the high user baskets, and their prices are equal in the medium user baskets, then their index will be identical, irrespective of the baskets' absolute price levels. While it is still possible that certain segments will be over- or underweighted compared to their real consumption weights on the market, we believe these results will still be more balanced and more reasonable than the averaging of basket prices alternative.

¹⁴ Compared prices are nominal. It might happen that the value of the index for the most expensive operators or countries rises above 100 in case the basket price was higher than the highest corresponding 2013 value.

- There can be two approaches in the calculation of the price index of an entity without supplying the full range of baskets:
 - a) averaging all basket indices, but imputing an index value of 100 for the missing baskets. This calculation takes into account the structural differences in the supply, punishing those entities where at the higher end there are missing elements on the higher end of the basket portfolio.
 - b) averaging only the indices of those baskets of which plans with the appropriate data allowance are available in the particular entity. This calculation might show those countries in a slightly more favorable position where not all of the baskets are available on the market.

Both methods have their pros and cons and produce different outcomes in the rankings. In vain a correlation check of the indices and the rankings based on the indices shows that the correlation between the two index versions is above 0.95, both in case of the operators and the countries. In the presentation of the results we mostly use option *a*), where all baskets considered relevant, but for the missing ones, we use an imputed 100 point index value.

At the end of the calculation we get an interval scale, with 0 index value at the zero price. If an index value is double of another, we can conclude that the price level of the first entity is twice the others'.

Main results of index based country comparison

We calculated the price indices for each predefined basket for each entity (operator or country). Then, with the averaging methods *a*) and *b*) calculated the aggregate index for entities (operators and countries too). This one dimensional scale based on the level of prices serves us well in making the comparisons of entities, being operators or countries.

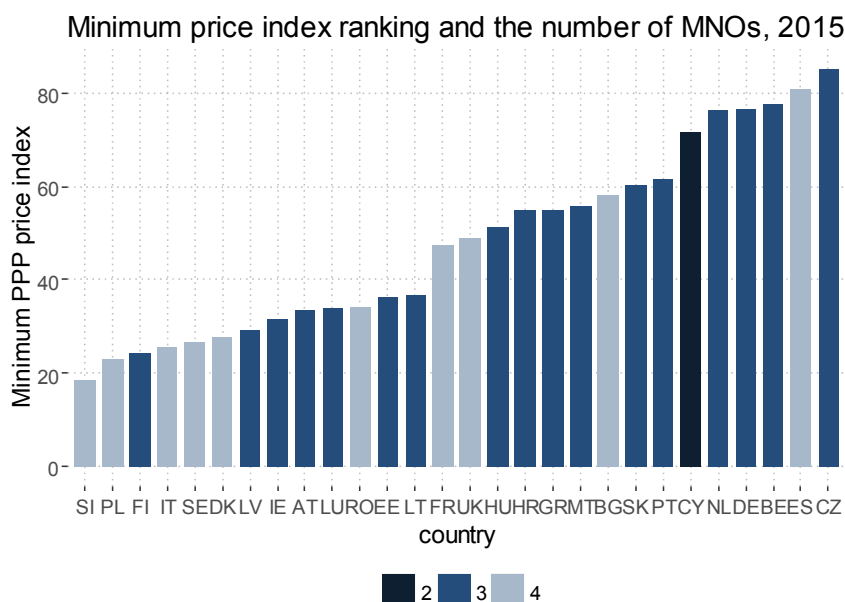
The first thing of interest is what the overall ranking of countries is with respect to the large-screen mobile broadband prices. For the presentation of the country ranking we use the price index based on the minimum price, ie. calculated by using the lowest basket price available on each national markets¹⁵. For the comparison we use the PPP adjusted price. We use the index type *a*) which punishes a little the lack of a full basket portfolio. Now, in order to make the figure more informative, the number of mobile network operators on the market is signaled with different colors.

The picture is fairly similar to what we have seen on the figure about the country price rankings of the 3 GB basket. There are countries where large-screen mobile broadband is fairly cheap, like the Scandinavian countries, Italy, Ireland, Austria and the Baltic countries.

¹⁵ The picture is very similar when we use the country average price as a basis of index calculation. Both the Kendall and the Spearman rank correlation is above 0.9.

There are other markets where this service is rather expensive and/or some baskets are not available at all. These are Germany, The Netherlands, Belgium, Cyprus, the Czech Republic, and Spain.

Figure 7. | Country ranking by the Large-screen Mobile Broadband Price Index based on the PPP adjusted minimum price, and the number of MNOs on the national market 2015



From policy point of view the causes of the differences between countries or at least other identifiable factors associated with the differences are at least as interesting as the ranking itself. This presentation with the help of the coloring seems to reveal information about the association of the price level and the number of players. Most of the 4 player markets are in the first half of the ranking order, and most of the 3 player countries are in the second, together with the single 2 player market, Cyprus.

There are other factors which are measurable and their association with the results is worth to study in order to gain more insights into the background of the differences. With the PPP adjustment the general country price level differences are taken into account, and we present the comparison with regard to the index calculated with PPP adjusted prices.

A short list of other potentially influential factors is the following:

- economic environment: GDP per capita, population density
- market characteristics: number of MNOs on the market, position of an operator, type of the operator as challenger/non-challenger, subsidiary of the fixed incumbent,
- availability of the new technology: presence of LTE, LTE coverage,
- penetration of different communication technologies: fixed broadband penetration, mobile penetration, mobile broadband penetration
- usage environment: internet usage characteristics, internet capabilities

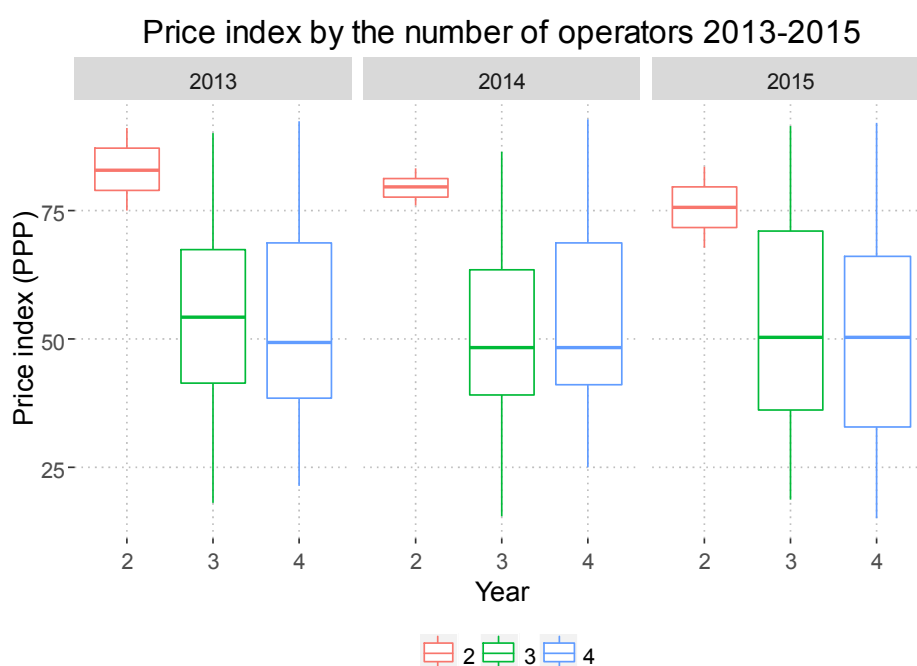
As we have input data for some of these factors we can study their effects on or at least their associations with the level of the index.

Comparisons of price levels by different market characteristics based on operator price indices

First we present in a visually comprehensive form with boxplots the relationships between one or more of these factors and the large screen mobile broadband price level. The change in time is also an interest, so we present the distributions for each year.

On the next figure the average individual operator price level distribution is shown between 2013 and 2015, measured by the index, with grouping according to the number of MNOs in the markets.

Figure 8. | The Large-screen Mobile Broadband Price Index by the number of MNOs, 2013-2015



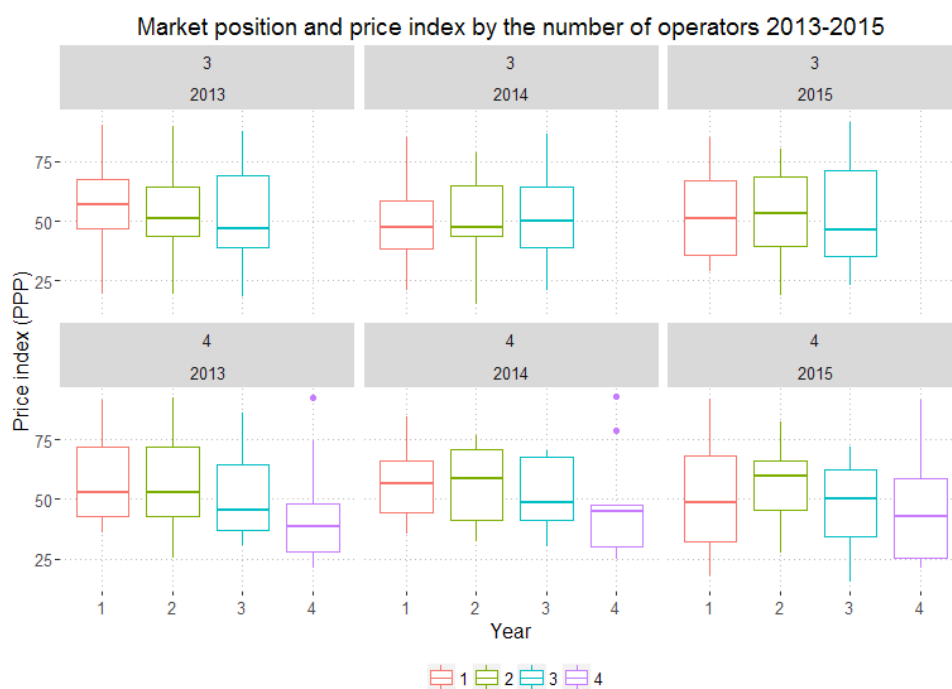
There is no significant difference between the operator price index at the 3 and 4 player markets¹⁶, but they quite significantly differ from the 2 operator markets. As Cyprus is the only 2 operator country, and from policy point of view we are interested in comparing the 3 and 4 player markets, Cyprus is intentionally left out from the further comparisons.

It is a relevant question whether the players in different positions on the market are pricing differently. Unfortunately, we do not have market share data neither in subscriber number,

¹⁶ As 4-to-3 mergers happened in Austria, Ireland and Germany, and as a consequence the composition of the 3 and 4 player groups changed, it does not make significant bias in the picture.

nor in revenue. We have information only about the position in ranking order by subscribers. The next figure shows the distribution of price level values by the position of the operators.

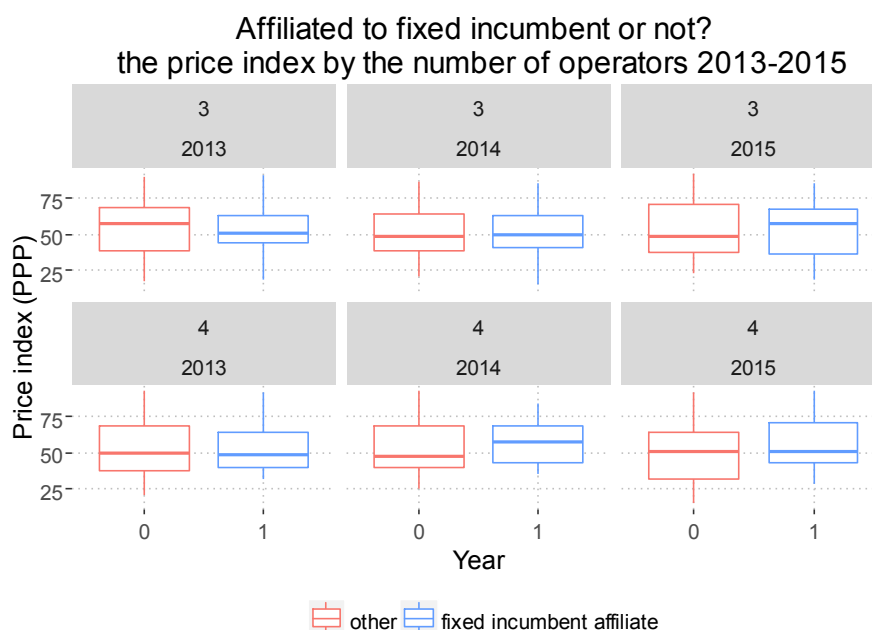
Figure 9. | The Large-screen Mobile Broadband Price Index by the ranking position of the of the MNOs and by the number of MNOs operating on the market, 2013-2015



Neither market position nor the change in time makes much difference in the pricing behavior of the first 3 players on the 3 and 4 players markets. In this comparison the first 3 players' pricing are close to each other. In contrast, the fourth players' price seems to be somewhat lower than the prices charged by the first three.

The next figure shows the distribution of the price level index values by the affiliation of the MNOs to the fixed incumbent.

Figure 10. | The Large-screen Mobile Broadband Price Index by the MNO affiliation with the fixed incumbent and by the number of MNOs operating on the market, 2013-2015



This figure does not disclose much relationship with regard to the price differences by affiliation to the fixed incumbent operator. Fixed incumbents' subsidiaries does not seem pricing very differently in general than the others.

There is another important group of MNOs which are very interesting from competition policy point of view, the challenger players. It is very difficult to identify players by challenger type of strategy.

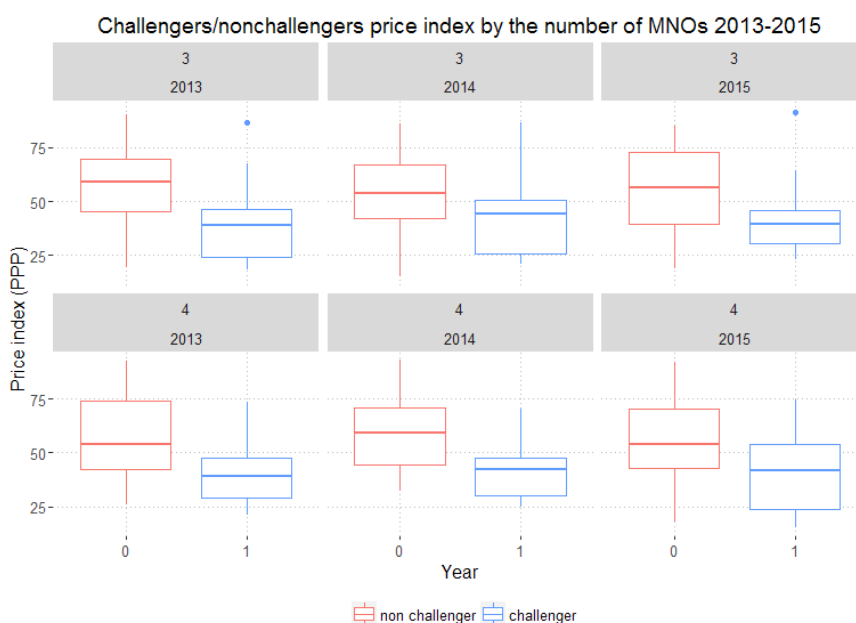
It is a popular idea that the presence of a "challenger", a non-mainstream player on the market is expected to make a difference in the intensity of price competition on a market. However it is hard to give a good definition for a challenger. At first, it seems tempting to define it on the basis of observable a behavioral characteristics like playing an aggressive price strategy. Though a challenger usually plays a different strategy than established players and focuses on other market segments, especially on more price sensitive customers, this type of behavior is not easily observable and identifiable on all of the markets; moreover, it requires deep insight into the companies' strategies and decisions, and involves a considerable amount of subjective judgements. Avoiding these pitfalls and difficulties we choose another way of identifying an MNO as a challenger. Fixed incumbents mobile subsidiaries are trivially not challengers. Generally the other players who started their operations in the beginning of the 2G era are rightly considered as incumbents on the mobile market now. Challengers are usually the latecomers, arriving no earlier than the end of the 2G era; and are not subsidiaries of an incumbent.

In our practical definition, the challenger is a player whose parent is not an incumbent in any of the EEA countries. Typical challengers are Hutchison, Tele2, and some other more

local players, like Bite in Latvia and Lithuania, Play in Poland, or Digi in Romania. According to this classification, there are 21 markets among the 28 member states where there is at least one challenger.

The advantage of such a technical categorization is that it is objective, based on observable facts and does not involve judgement on the part of the researcher. The drawback may be that an operator can fall in this category despite it is not really behaving as challenger on the market. This risk seems much less a burden, but it is a clear advantage that arbitrariness of judgement is avoided at its cost.

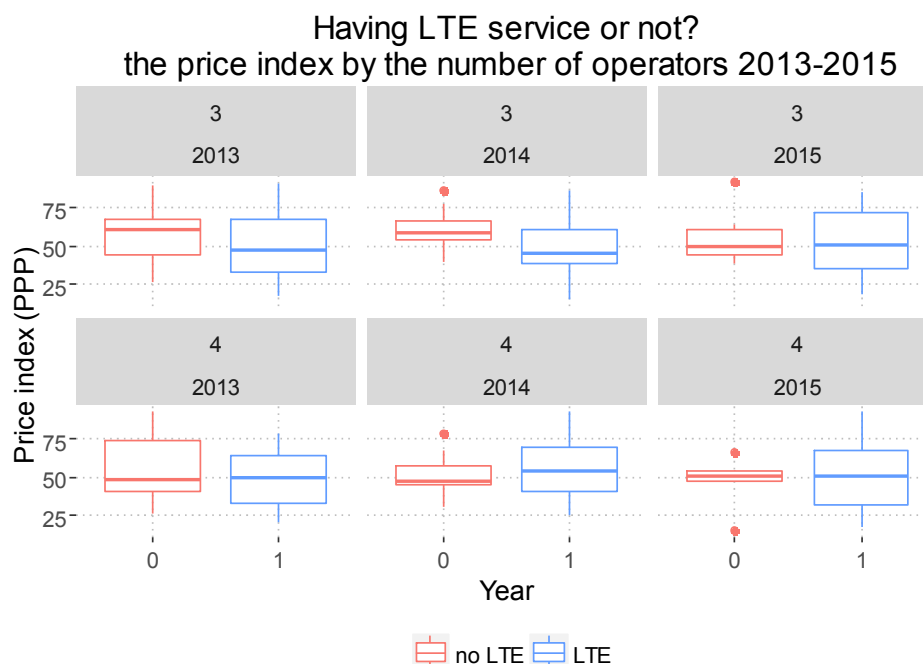
Figure 11. | The Large-screen Mobile Broadband Price Index by the MNO type (challenger/non-challenger) and by the number of MNOs operating on the market, 2013-2015



Though the result is not very surprising but it is striking enough that our data shows that challengers are pricing more aggressively than the other players. But it is also striking that there seems to be no significant difference between 3 or 4 player markets. This is a good policy question to study further.

As the last of this series of visually manageable basic comparisons we can show whether the launching the commercial LTE service by an operator makes difference in its large-screen mobile broadband pricing behavior?

Figure 12. | The Large-screen Mobile Broadband Price Index by the provision status of the LTE service, and by the number of MNOs operating on the market, 2013-2015



Note, while in 2013 about half of the operators had launched LTE service, by 2015 this rose to the 86% level, so the composition of the groups changed significantly. Though we originally might have expected it differently, according to our data, having LTE service or not does not seem making difference on average in pricing.

Having no other handsome categorical variables we reached our limits of this visual discovery. These results gave some insights, and we can see our data from different angles, but their common limit is that we can always only look at a small part of a rather complex picture.

Using econometric tools, we can study the effects of more variables and their partial effects controlled for the others. The challenge of econometric analysis is whether we can find and measure all of the relevant explanatory variables, and can avoid the omitted variable problem. Though we cannot be sure whether we have all relevant variables for the model, it has to be tested and handled accordingly. In the next section we present and discuss the result of the 2015 year cross-section analysis, and also discuss shortly the results from the analysis panel of the 2013-2015 data.

Cross-section econometric results

We have some continuous variables beside the formerly introduced categorical variables. The most relevant explanatory variables are: GDP per capita, population density, mobile penetration, mobile and fixed broadband penetration and overall broadband penetration, LTE coverage indicator, and internet usage penetration data. In case of the mobile or overall broadband development it is the case that the effect is rather bidirectional. We can mitigate this problem partly by using the 1 year lagged data for these variables¹⁷. For the presentation of the model results we choose to present the results of the operator level index regression. The country level regression produces similar results, but with a more aggregated data. Operator-basket level analysis is finer, but the result does not differ much for the most important variables. Also we could use basket price as the dependent variable but only on operator-basket level or after aggregation a minimum or average basket price at the country level.

We want to estimate the following population equation for year 2015:

$$price\ index = \beta_0 + \sum_{i=1}^k \beta_i * x_i + u$$

The choice of the x_i explanatory variables is limited by the availability of information on operator and country level. We are interested mostly in those variables which can be a concern of competition policy and/or sectoral regulation, namely: number of network operators, operator types, new technology and network deployment. Other variables are used to control other relevant differences between countries like GDP per capita, population density, overall broadband penetration, etc.

There are clear limits of the cross-section analysis, especially the omitted variable problem. In spite of this problem the cross-section analysis can shed some light on which variables are more associated with, or influencing the level of the price index in a static approach.

In the cross-section model the explained variable is the operator level price index, of which we have 2 types: the *a*) and *b*) method of calculation¹⁸. We use the index based on PPP adjusted price, in order to control the country specific general price level. In the regressions we always use GDP per capita in log form. Since in case of the cross-section results homoscedasticity is not rejected by the Breusch-Pagan test, the regular standard errors are reported in table.

¹⁷ Practically we use all continuous explanatory variables with a 1 year lag.

¹⁸ See page 20 for the details

Table 3. | Cross-section regression results

Cross-section regressions models with the PPP based price index, 2015				
	<i>Dependent variable:</i>			
	op_agrindex		op_agrindex2	
	(1)	(2)	(3)	(4)
log(gdppopppp)	-12.8* (7.5)	-13.1* (7.4)	-14.7** (5.7)	-13.5** (5.3)
log(popdens)	6.1** (2.8)	5.7** (2.8)	2.2 (2.2)	2.1 (2.1)
opnum4	-0.2 (3.7)		-2.1 (2.8)	
challenger	-7.3* (4.1)	-10.8** (4.8)	-5.6* (3.1)	-4.2 (3.7)
posifact2		2.5 (4.5)		-3.0 (3.5)
posifact3		5.9 (5.0)		-1.2 (3.8)
posifact4		8.8 (7.2)		-6.7 (5.5)
is_lte	5.9 (5.9)	6.7 (6.1)	6.4 (4.5)	7.3 (4.6)
mbbpen	-0.2 (0.1)	-0.2 (0.1)	-0.1 (0.1)	-0.1* (0.1)
mob_penet	-0.1 (0.1)	-0.1 (0.1)	-0.1 (0.1)	-0.1 (0.1)
bb_penet	0.7 (0.4)	0.7* (0.4)	0.4 (0.3)	0.5 (0.3)
mbb_ltecov	-12.0 (16.3)	-13.1 (16.3)	5.4 (12.4)	
Constant	164.9** (62.9)	166.2*** (62.3)	182.3*** (48.1)	173.3*** (45.7)
Observations	90	90	90	90
R ²	0.4	0.4	0.3	0.3
Adjusted R ²	0.3	0.3	0.2	0.3
Residual Std. Error	16.0 (df = 80)	16.0 (df = 78)	12.2 (df = 80)	12.2 (df = 79)
F Statistic	5.9*** (df = 9; 80)	5.0*** (df = 11; 78)	4.3*** (df = 9; 80)	4.0*** (df = 10; 79)
<i>Note:</i>			*p<0.1; **p<0.05; ***p<0.01	

- From the group of variables of interest the challenger variable is the only one, which is significant in three of the four models. Being a challenger associated with significantly lower pricing on average, with between 4 to almost 11 index points.
- GDP per capita is significant and negative.

- It is interesting from policy point of view that the effect of the number of MNOs on the market is not significant.
- Market position of the players is not significant in the models where they are tested together with the challenger variable. Unfortunately the sign and size of this variable is intuitive only when the *b*) type of index is used.
- Providing LTE service does seem to increase the prices, though the result is not significant. In 2015 when most of the operators are providing 4G services, this may be the result of the efforts to recoup the costs of building the new networks. The sign of country LTE coverage is ambiguous with respect to the *a*) and *b*) types of explained variables.
- Mobile broadband penetration and mobile penetration are not significant but have negative effect sign as expected.
- Overall broadband penetration is positive, so it may be associated with slightly higher prices with larger broadband penetration.
- Population density is significant in two of the models, and its sign is positive in each model.

Cross-section results are interesting because they suggest that the type of the competitor associated with lower prices in case of the challengers, while the number of operators does not matter. The association of the market position measured with the ordinal ranking is not conclusive, if we differentiate between challengers and not challengers. The drawbacks of the cross-section results, that we can be sure that some variables which play role in the level of prices were not handled in the models. VAT and other tax differences was not controlled for, neither the effect of one-time and regular spectrum fees, which can differ significantly between countries.

Results of the time and country dummy variable panel estimates

Since the time span of our database is 3 years, and we have observations of each operator entity in each year, we have a well-established panel. It is worth to study the effects of time and of the changes in some variables in this data panel, although we know that the prices and the indices did not change much in general.

Pooled regression with year dummies can be an option to start but it could not help much in the problem of unobserved heterogeneity with respect to the observed national markets. Moreover changes between years were rather small on average.

Our panel is somewhat specific because the annually observed entities are the MNOs of which 3 or 4 players are on the same mobile broadband market and their market behavior, pricing included, is in close interaction with each other, but not much with other countries' operators. In this case it is reasonable to estimate a fixed effect model with country and time dummy variables with OLS regression. The equation is very similar to the cross-

section, with the difference that besides the variables of the cross-section model, now the coefficients of country and time dummy variables are also estimated. The advantage of this approach is that unobserved time independent country specific effects are controlled for.

The next table presents the main results of the regressions. As each model is heteroskedastic, HC3 robust standard errors are reported in the table. Ordinal market position variable was not used here because of its clear insignificance revealed in the model selection. Besides the other formerly used variables, we estimated in two models the effects of the affiliation relationship to the fixed incumbent on the national market.

We omitted from the reported table the coefficients of the country dummies.

Table 4. | OLS country and year dummy regression results

OLS dummy regression results				
	<i>Dependent variable:</i>			
	op_agrindex		op_agrindex2	
	(1)	(2)	(3)	(4)
log(gdppopppp)	39.9* (23.5)	40.0* (24.0)	20.4 (25.9)	20.7 (26.9)
opnum3	-347.6 (247.2)		-181.2 (271.7)	
opnum4	-346.9 (247.3)		-179.5 (271.7)	
fix_incumbent		1.6 (1.7)		4.0** (1.7)
challenger	-5.1** (2.0)	-4.2* (2.3)	-5.0*** (1.8)	-2.4 (2.1)
is_lte	-2.5 (2.1)	-2.7 (2.1)		0.8 (2.0)
bb_penet	-1.3 (1.3)	-1.3 (1.3)		
mbb_ltecov	-4.0 (6.0)	-4.0 (5.9)	-3.5 (5.7)	-4.0 (5.6)
factor(year)2014	0.6 (2.4)	0.7 (2.4)	-0.9 (2.0)	-1.1 (1.9)
factor(year)2015	1.7 (4.3)	1.8 (4.3)	-0.5 (3.0)	-0.7 (2.9)
Observations	268	268	268	268
R ²	0.969	0.969	0.958	0.959
Adjusted R ²	0.965	0.965	0.952	0.954
Residual Std. Error	10.536 (df = 233)	10.516 (df = 233)	9.713 (df = 235)	9.587 (df = 234)
F Statistic	209.173*** (df = 35; 233)	210.023*** (df = 35; 233)	163.425*** (df = 33; 235)	163.028*** (df = 34; 234)
<i>Note:</i>			* p<0.1; ** p<0.05; *** p<0.01	

We found, similar to the cross-section results, that the challenger role is associated with lower prices. It is significant, even when country specific factors are controlled for, except the 4th model.

It seems that the number of players does not matter. This is not only the result of insignificance of the coefficients, but the insignificance of the difference between the 3 and 4 player markets which can be measured as the difference of the coefficients.

Our estimates show that the affiliates of the fixed incumbent on the respective national markets tend to price even slightly higher than the others who are non-challengers, though this is significant only in one of the two models.

The effect sign of the LTE coverage is negative, but statistically not significant. Having LTE service is also not significant and has different sign with regard to which type of price index was the explained variable in the model.

Overall broadband penetration has a slightly negative effect here, but it is not significant.

It is interesting but not surprising (knowing the data), that there is no significant time effect in pricing.

Discussion

As having and using empirical knowledge is a must have for telecom competition and regulatory policy making, it is very important, though also challenging to study the mobile markets in the new data era. It is also important constantly challenging the unfounded and widely referred common sense of that having four players is unconditionally better than having only three on the mobile markets. Our study addresses this issue in case of comparing the 27 3 or 4 player national large-screen mobile broadband markets of the European Union.

The first challenge a researcher faces is how to collect and prepare the data which is appropriate and meaningful for comparison. We used the basket method for ensuring comparability, because it has its own merits, as it can be transparent and also can handle both the price and quantity features of the large-screen mobile broadband plans. The only arbitrariness in this exercise is the choice of the quantities defining the baskets. However the studied basket structure can be well adapted to the typical supplied quantities. Though the difference between countries is large with respect to the supplied plans, but the range of baskets is mostly appropriate to cover this differences.

The basket system is good to measure and compare “fixed” quantity products, but it is hard to form an overall comparative judgement of the markets based on pure basket comparison because the picture is rather complex. For a better and streamlined comparison we prepared basket specific price indices and with their averaging calculated an overall index which is capable of aggregating the general pricing tendencies of the individual operators. We also could use a similarly constructed index for country level comparisons. In vain using purchasing parity adjustment is appropriate for comparison of consumer prices because the large differences between the countries’ price levels are handled by this tool.

Simple price or index comparisons revealed some general tendencies of pricing on the large-screen mobile broadband markets. The number of market players seemed differing only between 2 and the others, but not between 3 or 4 player markets. Challenger player's pricing seemed different from the others. 4th players are pricing lower, than the others, though it is true that most of them are being a challenger too.

In a deeper analysis we studied the effects of some policy related variables on the pricing of the operators and controlled for other influential factors. Both the cross-section analysis and a country and the time dummy variable panel regression seems to confirm that challenger players are pricing below the others on average. Our results do not support the widely shared view that the pricing in 4 players market is below the 3 player markets on average, everything else being constant. Other factors are also influence or associated with the level of large-screen mobile broadband like GDP per capita, broadband penetration, mobile penetration, mobile broadband penetration, LTE coverage, but only GDP per capita proved to be significant in most of our models.

There are lots of questions for further, more elaborated research. Measurement error and endogeneity problems still can be an issue which must be addressed in the further analysis.