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BEREC Report on Post-Merger Market Developments - Price Effects of Mobile Mergers in Austria, Ireland and Germany

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Contents

Executive Summary

Over the past ten years, several mergers or acquisitions (M&As) have taken place in the telecommunications sector in Europe. Such M&As can have a significant effect on market structure and competitive dynamics, which is particularly the case in the mobile market, where the number of operators with their own network (mobile network operators, or MNOs) is generally quite low (three to five in most cases) and entry barriers are high.

Market consolidation in the EU is generally subject to merger control by national competition authorities or, if it is beyond a certain size, by the European Commission, in order to avoid consumer harm due to reduced competition. It is difficult to predict future behaviour in the ex-ante assessment of mergers and there is therefore is an increasing interest in ex-post merger evaluation studies.

This report contributes to the literature on the estimation of post-merger price effects. The price effects of three mergers in the European mobile market are estimated:

- The Hutchison/Orange (brands Drei and Orange/Yesss!) merger in Austria in 2013,
- the Hutchison/Telefónica (brands: “3· and O2) merger in Ireland in 2014, and
- the Telefónica/KPN (brands: O2 and E-Plus) merger in Germany in 2014

In doing so, two approaches are used: a differences-in-differences (DiD) approach and the so-called synthetic control group approach. In these methodologies, price effects are estimated on the basis of a comparison of the price trends in the ‘treated’ country (the country affected by the merger) and the prices in several unaffected countries (the control group). Detailed tariff data from MNOs in 13 European countries, as well as other control variables (MTRs and GDP), are used in this study.

In all of the three cases, there is at least some evidence that retail prices for new customers increased due to the merger compared to the situation without the merger (the counterfactual). However, the patterns differ across countries:

For Austria, where data from two years prior to the merger and three years post-merger is available, there is evidence that the merger led to significant price increases in 2014 and 2015. In 2016 H1 (first half of 2016), the effect became considerably smaller and statistically insignificant in most specifications (although, for the medium usage basket, some effect in 2016 H1 cannot be ruled out completely). This is likely caused by competitive pressure from MVNOs, which gained significant market share since entry at the beginning of 2015. This also suggests, however, that the MVNO remedy took more than three years to actually become effective for Austrian consumers.

For Ireland and Germany, data are available for only one and a half years after the merger and therefore only short to medium run effects can be estimated.

In the Irish case, the results of the estimations suggest that the merger led to a statistically significant price increase in all three baskets (low, medium and high usage), but that the magnitude and persistence of this effect varies across baskets. It is only for the high basket that the price effect is sustained across the entire period under study. Although the size of the coefficients and the statistical significance vary across specifications, most specifications show at least one significant price increase in at least one post-merger period for each of the three baskets. The impact of the MVNO remedy was small: two MVNOs entered the market in the second half of 2015, but their market share remained below 1% each by mid-2017 and one of the MVNOs left the market in 2018.

There is also evidence of price increases for all three baskets in the basic specification for the German case. However, the results are not very robust across specifications for the high and the medium baskets. In the case of the low basket, it should also be noted that no data is available for the MVNO and service provider segment or for sub-brands of MNOs. The MVNO and service provider segment of the German market is quite large (approx. 20% of the market). The possibility that pricing in this segment differs systematically from MNO pricing or that the merger affected pricing in different ways cannot be excluded.

This study also discusses some evidence on the quality effects of the mergers in Austria and Germany. In BEREC's view, there are a number of difficulties with measuring quality in the first place and even more so for determining the effects of mergers on quality. The data from a comprehensive network test that are analysed in this report suggest that there are some negative consequences for consumers of the merged entity, which may be due to (technical) issues with network integration in the short to medium run. The long-run effects are uncertain.

In conclusion, this study confirms that a careful approach should be taken with 4-to-3 mergers. Structural remedies might not be possible to implement at all and MVNO remedies may take considerable time to become effective or might not be sufficiently effective (or at least not in all parts of the market). This report provides some evidence that, even with such remedies, the studied mergers led to price increases compared to a situation without the mergers in the short to medium run (even up to three years after the merger in the Austrian case).

1 Introduction and objectives

Over the past ten years, several mergers or acquisitions (M&As) have taken place in the telecommunications sector in Europe. Such M&As can have a significant effect on market structure and competitive dynamics, which is particularly the case in the mobile markets, where the number of operators with their own network (mobile network operators, or MNOs) is generally quite low (three to five in most cases) and entry barriers are high.

M&As can have either positive or negative consequences for competition and consumers. A merger can result in a stronger, more competitive, innovative or efficient entity. If competition in the market remains sufficiently high, efficiencies may be passed on to the end user and prices may decrease. However, a merger can also result in an increase in market power by one or several firms, which may lead to higher prices, as well as a decrease in quality and innovation.

Takeovers in the EU are generally subject to merger control by national competition authorities or, if the merger is beyond a certain size, by the European Commission, in order to avoid consumer harm due to reduced competition. Where negative outcomes of a certain transaction are expected, the merger can be prohibited or can be allowed only with commitments (remedies), such as wholesale access agreements or divestment of parts of the merged entity.

Such ex-ante merger control tries to gauge the effects of a merger on prices or quality based on past data and assumptions about future behaviour. Since it is difficult to predict future behaviour, there is an increasing interest in ex-post merger evaluation studies. Such studies attempt to estimate the actual effect of a merger on prices, investments or quality. In doing so, the developments after the merger are usually compared to some kind of counterfactual, such as how certain metrics would have developed without the merger. Such studies are important, since they show how the decision actually influenced the market and allow lessons to be learned for future cases.

This report contributes to the literature on the estimation of post-merger price effects. The price effects of three mergers in the European mobile market are estimated:

- The Hutchison/Orange[1] (brands Drei and Orange/Yesss!) merger in Austria in 2013,
- the Hutchison/Telefónica (brands: ”3” and O2) merger in Ireland in 2014, and
- the Telefónica/KPN (brands: O2 and E-Plus) merger in Germany in 2014

In doing so, two approaches are used: a differences-in-differences (DiD) approach and the so-called synthetic control group approach. This is similar to the analysis in previous studies on earlier mergers by ACM, the EC and RTR.[2] In these methodologies, price effects are estimated on the basis of a comparison of the price trends in the ‘treated’ country (the country affected by the merger) and prices in several unaffected countries (the control group). Data from 13 EU countries are used in this study.[3]

For the three mergers considered, sufficient time has passed in order to be able to estimate short and medium run price effects. For Austria, a study on the price effects in the two years

[1] The merger consisted of the transaction between Hutchison and Orange and a second transaction in which Hutchison spun off the Orange sub-brand Yesss! to A1 Telekom Austria (see section 5.1).
[2] See Aguzzoni et al (2015) and Aguzzoni et al (2017).
[3] In addition to Austria, Germany and Ireland these countries are: Belgium, Czech Republic, Denmark, Spain, UK, Greece, Italy, Poland, Portugal and Sweden.

after the merger has already been conducted.[4] Now, as more time has elapsed, further developments that might have been influenced by the entry of mobile virtual network operators (MVNOs) in late 2014 and 2015 can also be observed.[5]

This study focuses on price effects of the mergers, with potential effects on quality discussed briefly for Austria and Germany only. The estimated effects are the impact of the mergers as modified by the imposed remedies. However, – as describes in the country sections – remedies might only have become effective with significant delay (Austria) or might be unlikely to have a significant impact in the period considered (Ireland).

The report is structured as follows: Section 2 gives an overview of the mergers and acquisitions (M&A) in telecommunications markets in the EU since 2010. Section 3 briefly summarises previous studies on the effects of mergers in mobile markets. In Section 4, the methodology, as well as the data used in this analysis, is described. In Sections 5 to 7, the merger cases in Austria, Ireland and Germany are described and estimated results for each of the three countries are presented. Section 8 discusses the potential effects on quality of service following the mergers in Austria and Germany. Section 9 concludes. The Annexes contain further information on the basket price calculation, the empirical approach, as well as summary statistics and robustness checks.

2 Mobile-Mobile mergers in the EU

Markets for mobile electronic communications have been subject to a wave of consolidations over the past decade. In all cases, the mergers have been national in scope, strengthening firms' market position in European national markets by acquiring other operators in the same country, rather than extending their footprint to cover additional countries. Figure 1 shows the main Mobile-Mobile (MNOs) M&As since 2010 that were assessed by the European Commission. Of these, six were cleared on the condition that various remedies were implemented to mitigate potentially negative market implications. Two potential mergers were blocked by the European Commission.

[4] See RTR (2016) and Ecker et al (2017).

[5] An MVNO is a wireless communications services provider that does not own the network infrastructure over which it provides services. Instead, it enters into a business agreement with an MNO to obtain access to network services at wholesale rates.

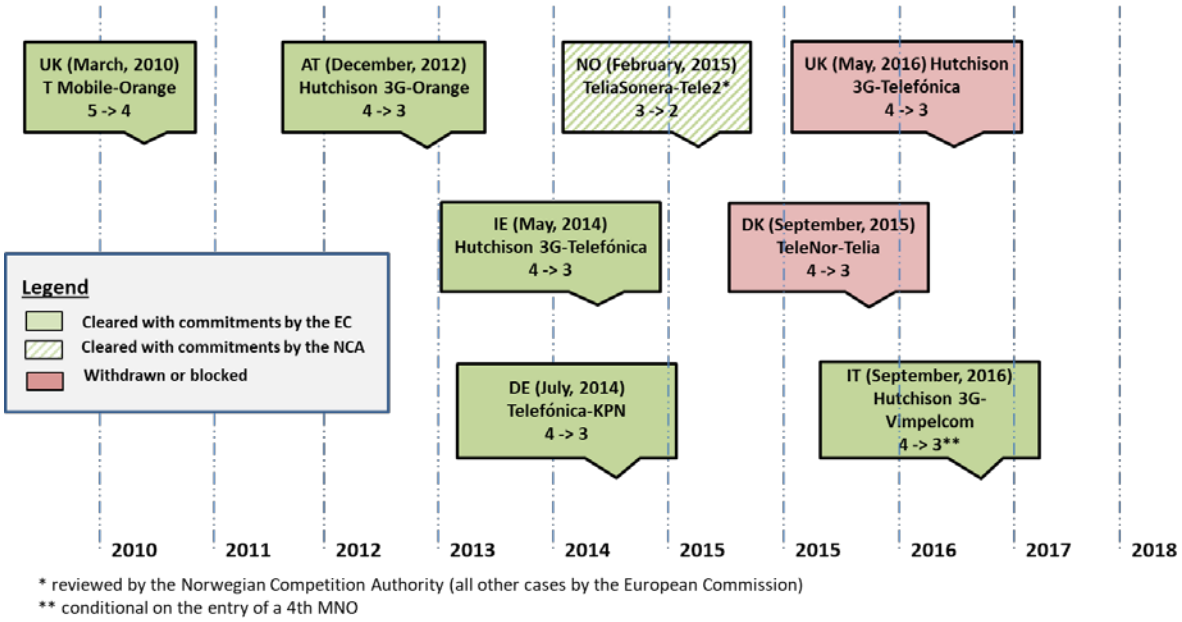


Figure 1: Mergers and Acquisitions in Europe, 2010-2018 (by date of approval)

Most of the transactions were 4-to-3 mergers, i.e. mergers which reduced the number of MNOs from four to three (Austria in 2013, Ireland in 2014, Germany in 2015 and Italy in 2016). The two mergers which were withdrawn or blocked (Denmark in 2015 and UK in 2016) would also have been 4-to-3 mergers. Only the merger in the UK in 2010 was a 5-to-4 merger.

The approval of the cleared transactions was made conditional on commitments or remedies offered by the merging parties. These commitments have ranged from opening the merged network to MVNOs, to commitments aimed at facilitating the entry of a new operator. The three mergers studied in this report fall in the period of 2012-2014. The remedies in these cases are described in more detail in the country-specific sections of this report (Sections 5 to 7).

In the period from 2015-2016, two transactions were blocked and the most recent consolidation cleared by the EC, Hutchison/Vimpelcom in Italy in 2016, was cleared conditional on the divestiture of spectrum, sharing or selling base stations and coming to a national roaming agreement with Iliad, thus maintaining a market structure with four MNOs.

3 Literature review

In recent years, a body of literature has emerged on the impact of the structure of mobile markets (usually measured as the number of MNOs) on outcomes, in terms of prices, quality and investment. Different studies come to different conclusions on this issue, resulting in a mixed picture. Below we present an overview of this literature, sorted by the studies' conclusions on the effects of 4-to-3 and 5-to-4 mobile mergers.

Studies that indicate price increases due to 4-to-3 mergers[6]

Li and Lyons (2012) find that a market with more MNOs reaches a higher penetration rate more quickly (mobile users as a percentage of the total population). They also find that the optimum number of MNOs to quickly reach higher rates of penetration is four or five.

Using data from 28 European countries from 2002-2014, the Centre on Regulation in Europe (CERRE, 2015) investigates the effect of market structure on prices and investment. The paper finds that 4-to-3 mergers on average result in price increases and more investment per operator. The combined effects of higher investment per operator and the reduction from four to three operators result in no significant effect on total investment by all operators in the market.

Csorba and Pápai (2015) investigate the effects of entry and mergers in the EU from 2003 to 2010 and find a range of effects on prices, depending on whether the market activity was an entry or merger, the nature of the entry (big multinational firms or disruptive players), the number of MNOs and whether the short- or long-term effects are investigated. They conclude that there are no price-increasing effects of 5-to-4 mergers, but long-run price-increasing effects are observed in the only 4-to-3 merger in their sample.

Aguzzoni et al (2015) – a collaboration among experts of the European Commission, ACM and RTR – analyse the effects of two mobile mergers in Austria and the Netherlands using a Difference in Difference (DiD) framework. For the Netherlands, they assess the 4-to-3 merger of T-Mobile and Orange that was unconditionally approved in 2007, which was preceded by a 5-to-4 merger between KPN and Telfort in 2005. The study finds price increases due to the merger between T-Mobile and Orange of 10% to 15% relative to the control countries. The effect could be a combined effect of both mergers (5-to-4 and 4-to-3). In the case of Austria, the investigated merger is the 5-to-4 merger between T-Mobile and tele.ring that was approved with remedies in 2006. For this merger, the study does not find evidence that it resulted in higher prices.

Using a similar approach to Aguzzoni et al (2015), RTR (2016) finds a strong price-increasing effect of the Hutchison/Orange 4-to-3 merger in Austria in 2013 (this is one of the mergers that is also investigated in this report). Using a structural approach, BWB (2016) also finds a significant price increase following this merger.

Ofcom (2016) focuses on the effect of disruptive MNOs ('mavericks') on prices and finds that prices in countries with a disruptive MNO are on average about 11% to 12% lower than prices in countries without a disruptive MNO. Besides this, prices are about 7% to 9% lower in countries that have one additional MNO. Both effects combined mean that in countries with four MNOs, one of which is a disruptive MNO, prices are 17% to 21% lower than in countries with three MNOs of which none is a disruptive MNO. This implies that a 4-to-3 merger in which a disruptive MNO disappears would result in a price increase of 22% to 27%.

Studies that find no effects of 4-to-3 mergers

Frontier Economics (2015), in research conducted for GSMA, finds no clear relationship between competition (concentration), prices and investment.

WIK (2015), in research conducted for Ofcom, ranks twelve countries based on the best outcome for users in terms of price, quality, and the extent of usage of services. WIK looks at

[6] Some of these studies also investigate 5-to-4 mergers.

whether the best outcomes are related to investment and market concentration, and does not find a relationship between concentration, investment and outcomes for users.

Studies that indicate price decreases due to 4-to-3 mergers

Affeldt and Nitsche (2014), in research conducted for Telefónica, do not find higher prices in markets with three MNOs compared to markets with four MNOs. They even find indications of lower prices in markets with three MNOs.

Houngbonon and Jeanjean (2014), in a study financed by Orange, find an inverted U relationship between competition (using EBITDA[7] margin as a proxy) and investment. They find investment is maximised at an EBITDA between 37% and 40% (of revenue). This approach is also used by HSBC (2015), which finds a maximum level of investment at an EBITDA of 38% and notes that the actual average EBITDA of the mobile sector in Europe is significantly below this (on average 31% to 32%). Therefore, HSBC (2015) expects that 4-to-3 mergers would result in EBITDA closer to the optimal 38% and would lead to higher investment with better outcomes for users.

Houngbonon (2015), also in a study financed by Orange, finds a price-increasing effect of the entry of a fourth MNO in France and a price-decreasing effect of the 4-to-3 merger in Austria. HSBC (2015) follows this approach and confirms the results.

GSMA (2017) analyses the effects of the 2012 merger between Hutchison and Orange in Austria on innovation and quality in mobile services. The study uses 4G coverage data in order to measure the level of innovation and download/upload speeds of 4G and 3G networks as indicators of quality of service. The estimates suggest that the merger accelerated the rollout of Hutchison's 4G network and that the network quality also increased. Further comments on this study are provided in Section 8.

Studies that indicate price decreases due to 5-to-4 mergers

Lear, DIW Berlin and Analysys Mason (2017) examine the effects of a 5-to-4 merger in 2010 in the UK between T-Mobile and Orange. The econometric analysis (a DiD approach, similar to Aguzzoni at al, 2015) indicates that the prices of mobile services fell (between 2% and 18%) because of the merger, in particular for medium-consumption and high-consumption profiles. The study suggests that the impact on capital expenditure (CAPEX) was also positive, so that the merger led to an increase in total investment. However, the estimates obtained using the ratio of CAPEX to the number of subscribers are not significant, which is probably due to the growth in subscriber numbers that offset the rise in CAPEX.

Table 1 gives an overview of the studies described above. It is clear that the evidence from the literature on the effects of 4-to-3 mergers is mixed (which is not surprising given the heterogeneity of the approaches and the events investigated). While there are studies which find significant price increases, there are also studies finding no price effects or even a decrease in prices or positive quality effects. The evidence on 5-to-4 mergers so far does not suggest that the cases investigated had negative effects for consumers. It should be noted that the only mergers that can be studied are those which have been approved by competition authorities (possibly with remedies) because they were considered not likely to impede competition significantly.

[7] Earnings Before Interest, Taxes, Depreciation and Amortisation

There are four European mergers for which an ex post analysis has been conducted: the T-Mobile/tele.ring merger in Austria (2006), the T-Mobile/Orange merger in the Netherlands (2007), the T-Mobile/Orange merger in the UK (2010) and the Hutchison/Orange merger in Austria (2013). The Hutchison/Orange merger in Austria from 2013 is the most investigated mobile merger in terms of ex-post analysis: there are five studies, four of which use different approaches and cover quality as well as price effects. In this report we analyse price developments of this merger up to the first half of 2016. The German and the Irish mergers from 2014 that are also analysed in this report have not yet been the subject of an ex-post study.

Table 1: Overview of Related Literature

					Effects of 4-to-3 Mergers on			Effects of 5-to-4 Mergers on	
No.	**Study by**	**Prepared For**	**Scope**	**Specific Merger Examined?**	**Price**	**Invest-ment**	**Quality**	**Price**	**Invest-ment**
1	Affeldt/Nitsche (2014)	Telefónica	EU, 2003-2012	no	~/- [1)]				
2	Houngbonon/Jeanjean (2014)	Orange	World, 2000-2014	no		+			
3	CERRE (2015)		≥28 countries, 2002-2014	no	+	+/~ [2)]		~	+/~ [2)]
4	Csorba, Pápai (2015)		27 countries, 2003-2010	no	+			~	
5	Frontier Economics (2015)	GSMA	EU, 2010-2014	no	~	~			
6	Houngbonon (2015)	Orange	40 countries, q1/13-q3/14	AT, 2013	-				
7	HSBC (2015)		see 2) and 6)	AT, 2013 (price)	-	+			
8	WIK (2015)	Ofcom	12 countries	no	~	~	~	~	~
9	Aguzzoni et al / ACM, EC, RTR (2015)		AT, NL and 12 controls, 2004-2010	AT, 2006, NL, 2007	+			~	
10	RTR (2016)		AT and 10 controls, 2011-2014	AT, 2013	+				
11	BWB (2016)		AT, 2011-2014	AT, 2013	+				
12	Ofcom (2016)		25 countries, 2010-2015	no	+				
13	GSMA (2017)		AT and 17 controls, 2011-2016	AT, 2013			+		
14	Lear/DIW Berlin/Analysys Mason (2017)	EC	UK and 9 controls, 2007-2014	UK, 2010				-	+/~ [3)]

+: increasing effect, -: decreasing effect, ~: no significant effect

[1)] No evidence for positive relationship between concentration and prices; some indications that the relationship may be negative

[2)] positive effects at the operator-level, no effects at the market level

[3)] increase in total investment, no effect on investment per subscriber

4 Data and Methodology

4.1 Data

This section describes the data and data sources used in this analysis, as well as the approach to the calculation of price baskets.

Mobile telecom services do not generally consist of a single tariff, but of several tariff elements, which together result in a monthly price that a user pays based on her or his usage. Such tariff elements include the connection fee, the monthly fee, prices per minute, per SMS and for data inside and outside of a bundle, allowances, minimum revenues, etc. In this study, to derive a one-dimensional price index for each operator and then for each country, consumption baskets are defined for high, medium and low users. Tariff data is used to calculate monthly costs for users in each basket. Data on the actual number of customers using each tariff is not available. As such, we consider the cheapest tariffs to be the ones most likely to be chosen by consumers with a given usage profile. The basket is thus calculated as the average of the cheapest four tariffs per operator. By taking an average of the four cheapest tariffs per basket we allow for the fact that consumers may not always be fully informed or rational and we cover a wider range of tariffs compared to an approach based only on the cheapest tariff per basket.

The calculation of the price baskets is further explained in Annex 1. We consider a basket approach is best suited to analysing changes in prices over time, since it clearly separates changes in prices (tariffs) from changes in quantities.[8]

Detailed data was gathered on various components of the tariffs of MNOs in Austria, Ireland and Germany and ten control countries over the time period from 2012 to 2016 H1 (first half of 2016). The control countries were BE, CZ, DK, ES, EL, IT, PL, PT, SE, UK (European countries where no MNO merger and no MNO entry occurred in the period 2011 to 2016). Such data was provided by IDATE/Tarifica on a quarterly or semi-annual basis. Tariff data for the Irish operator, Meteor, for the years 2012 and 2013 were provided by ComReg. For the Austrian analysis, RTR combined the data with tariff data from the previous analysis (RTR, 2016, for which the tariff data was also provided by Tarifica) in order to obtain observations for the period 2011-2016 H1 for eight countries (AT, BE, DK, ES, EL, IT, PT, SE). The analysis for Ireland and Germany is therefore based on data from eleven countries (the treated country and the ten controls mentioned above) while the analysis for Austria is based on eight countries.

The dataset is described in more detail in Annex 1. It covers the largest brands of each country, which are typically all MNOs. MVNOs and sub-brands of MNOs are not included (with the exception of the sub-brand tele.ring of T-Mobile Austria).[9] Also, handset subsidies are not included in the dataset and therefore cannot be considered in the analysis. This report focuses

[8] Alternative measures, such as the average revenue per user (ARPU) or average revenue per unit (minute, SMS and MB) have several weaknesses. Both ARPU and ARPUnit only react to actual price changes in the market with significant delay, due to long-term contracts and do not separately measure changes in price and quantity, the ARPU is usually distorted by inactive SIM cards and the ARPUnit does not reflect actual consumer valuations because voice and SMS services are usually translated into data volumes based on technical, rather than economic parameters.

[9] T-Mobile Austria took over the MNO tele.ring in 2006 and has been running it as a sub-brand since then.

on tariffs for residential customers. Where easily identifiable, business tariffs and data-only tariffs were excluded from the dataset.

The data were checked for time consistency. For Austria they were also compared to a tariff database.[10] For Ireland and Germany they were compared to other publicly available tariff information.

Since the data are partly quarterly (in particular for the years 2012 and 2013) and partly semi-annual (2014-2016 H2), they were converted into half-yearly data, with Q2 and Q4 used for the years where all quarters were available.

In order to reflect different market segments and include a larger number of tariffs, we identified different usage baskets based on actual usage of national voice minutes, national SMS and domestic data as provided by BEREC (2016) for the years 2013 and 2014:

- The “medium user” (basket med) uses exactly the average number of minutes, SMS and data[11] per month. As such, this represents the average user per country.
- The “low user” (basket low) consumes half of the average number of minutes and SMS and does not use data services.
- The “high user” (basket high) uses double the average number of minutes, SMS and data per month.

We use country-specific usage data in order to better reflect the actual prices paid by users in a certain country, given their usage profile and the available tariffs. The usage data are described in Annex 1.

The names of our price variables reflect the basket and the number of tariffs used per operator per period, e.g. when four tariffs are used the price variables are denoted as low4, med4 and high4. For the country averages, the basket values of the operators are averaged with weights determined by market shares.

In our basic specification, we use country-level data based on the four cheapest tariffs per operator per period and we keep usage constant at the 2013 level. Keeping usage constant over the whole period avoids distorting price changes through changes in quantity. We make the following robustness checks:

- Using only the two cheapest tariffs per operator per period, rather than the four cheapest tariffs. This assumes more rational consumers, and might, in some cases, exclude more expensive tariffs, which may only be chosen by a small share of consumers. On the other hand, the share of tariffs covered, and thus the sample size, is reduced.
- Using usage data from 2013 for the years up to 2013 and usage data from 2014 thereafter to take into account increasing usage (in particular of mobile data) over time.[12] This comes at the cost of not clearly separating changes in prices from changes

[10] RTR built up a database with detailed tariff data from all mobile operators based on a tariff data collection from the Austrian Chamber of Labour (Arbeiterkammer).
[11] As for mobile data, we only use half of the average usage as reported in BEREC (2016) to exclude usage from data-only products. (There are usually less data-only SIM-cards than bundles with Minutes, SMS and data. However, the average usage by data-only SIM cards is likely to be significantly above the one for bundled tariffs).
[12] Usage data are only available for 2013 and 2014.

in usage (since changes in usage are likely to depend on changes in price, amongst other things).
- Excluding the UK as a control for the analysis for Germany and Ireland.[13]
- Estimating the DiD-effects with operator-level (instead of country-level) data.

In addition to tariff and usage data, the following data is used:

- Inflation and PPP exchange rates to deflate prices and make them comparable across countries.
- Market shares to calculate country averages or as weights in operator-level regressions.
- Further country-specific control variables in order to be able to measure the effect of changes in cost and demand on prices. For this purpose we use mobile termination rates (MTRs) and the GDP growth of each country.

These data were also provided by IDATE/Tarifica.

4.2 Methodologies for assessing the impact on prices

Two different approaches are used to estimate the effect of the mergers on prices:

(i) A differences in differences (DiD) approach; and
(ii) A synthetic control group approach.

Both approaches are described and discussed in detail in Aguzzoni et al (2015), with the DiD approach also covered in Aguzzoni et al (2017). Here, only the main aspects of the methodologies are summarised. For further details and further related literature, the reader is referred to Annex 2 and the studies mentioned above.

The differences in differences (DiD) approach

The DiD approach compares the price level of the country where the merger took place (treated country) to the price levels in other countries where no merger took place (control group). The difference in prices between the treated country and the control group after the merger is compared to the difference in prices before the merger. The difference between these differences (therefore DiD) is interpreted as the merger effect.

The DiD approach is based on the assumption that the price change over time observed in the control group approximates the price change that would have occurred in the country where the merger took place, absent the merger. The DiD approach can therefore be applied if the control group satisfies two requirements: firstly, it is affected by similar unobserved factors as the treated country (common trends) and, secondly, it is not affected by the studied merger (no spillover effects). Figure 2 illustrates the DiD approach with a simple graphical example.

[13] The merger between T-Mobile and Orange (to create Everything Everywhere, or EE) occurred in 2010, but the rebranding only happened in 2014-2015. Our price baskets show some potential price effects of this rebranding in 2014, so a robustness check is made by excluding UK.

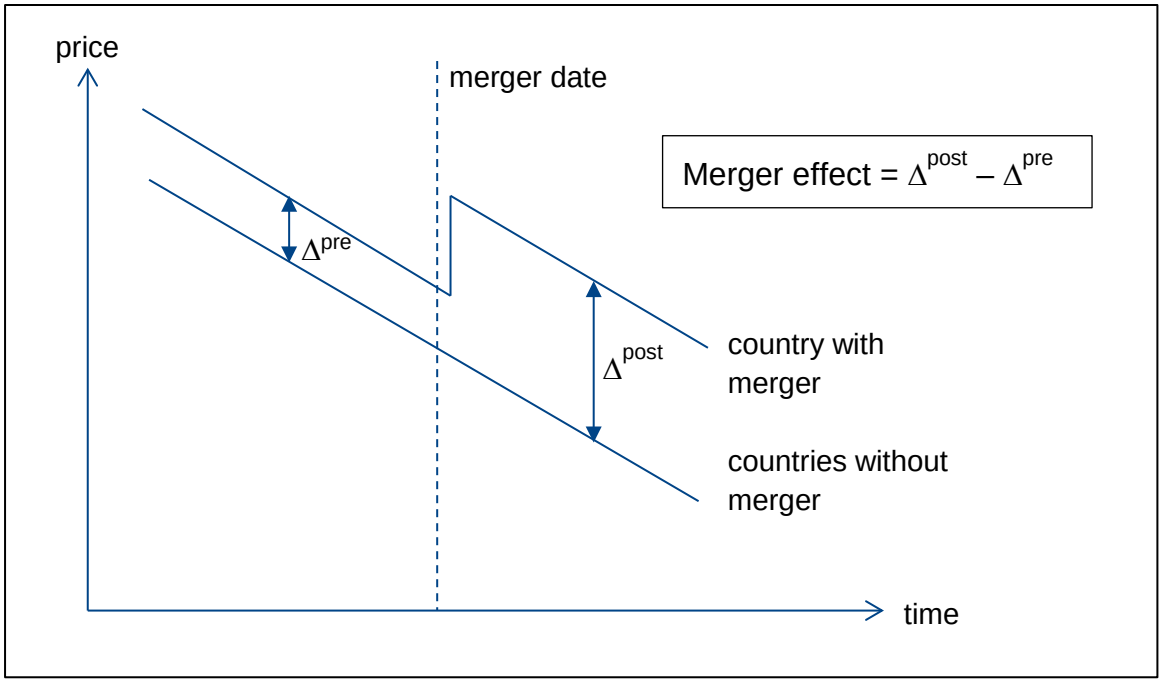


Figure 2: Illustrative example of the DiD approach

In order to be able to take into account other factors that may influence the price of mobile services, such as the level of MTRs (a supply related factor) and GDP growth (a demand related factor), regression techniques are used to estimate the effect of the merger. This also facilitates statistical inferences, i.e., the determination of whether any observed effect is significantly different from zero.

DiD estimators are unbiased if the average outcomes of the treated and control groups would – in the absence of the merger – follow the same parallel trend over time. We therefore test if the pre-merger trend of each of the affected countries is similar to the average trend of the control countries. When this test fails, country specific linear trends are included in the DiD model to control for differences in trends (trend specification). However, since we only have four pre-merger observations, there is some uncertainty about the correct specification of the pre-merger trend. Also, assuming that diverging trends will continue in the post-intervention periods may not be appropriate, as trends often converge in the long run.[14]

Further details on the estimation can be found in Annex 2.

The analysis for Ireland and Germany covers two years before and one and a half years after the merger. The analysis for Austria covers two years before and three and a half years after the merger. In the estimations, the merger period is excluded (the period during which the merger was actually accomplished, i.e., 2013 H1 for Austria and 2014 H2 for Ireland and Germany) since it is uncertain whether any merger effect can be observed in this period.[15]

[14] On the other hand it is questionable whether the four-year period we consider in the German and the Irish cases and the six-year period in the Austrian case can be considered to be "the long run".

[15] It is common in event studies to exclude the period of the event. Further, this approach was also taken in Aguzzoni et al (2015) and RTR (2016).

The synthetic control group approach[16]

The synthetic control group approach was developed by Abadie and Gardeazabal (2003) and was later extended by Abadie, Diamond and Hainmüller (2010 and 2014). In the context of ex-post merger evaluation, the same approach, along with a standard DiD analysis, is used by Hosken et al. (2012).

The synthetic control group approach is a quantitative procedure which chooses an optimal control group. The optimal control group is the weighted group of control countries which is most similar to the treatment group before the treatment with regard to a set of variables (predictors). In our case, the following predictors are used: GDP growth, termination rates and prices prior to the merger.

In the period after the merger, the price development in the synthetic control group is used to statistically illustrate the theoretical development of the treatment group without the merger (the counterfactual). The effect of the merger can then be calculated as the difference between the actually observed and the synthetic price in a certain post-merger period. An illustrative example is provided in Figure 3.

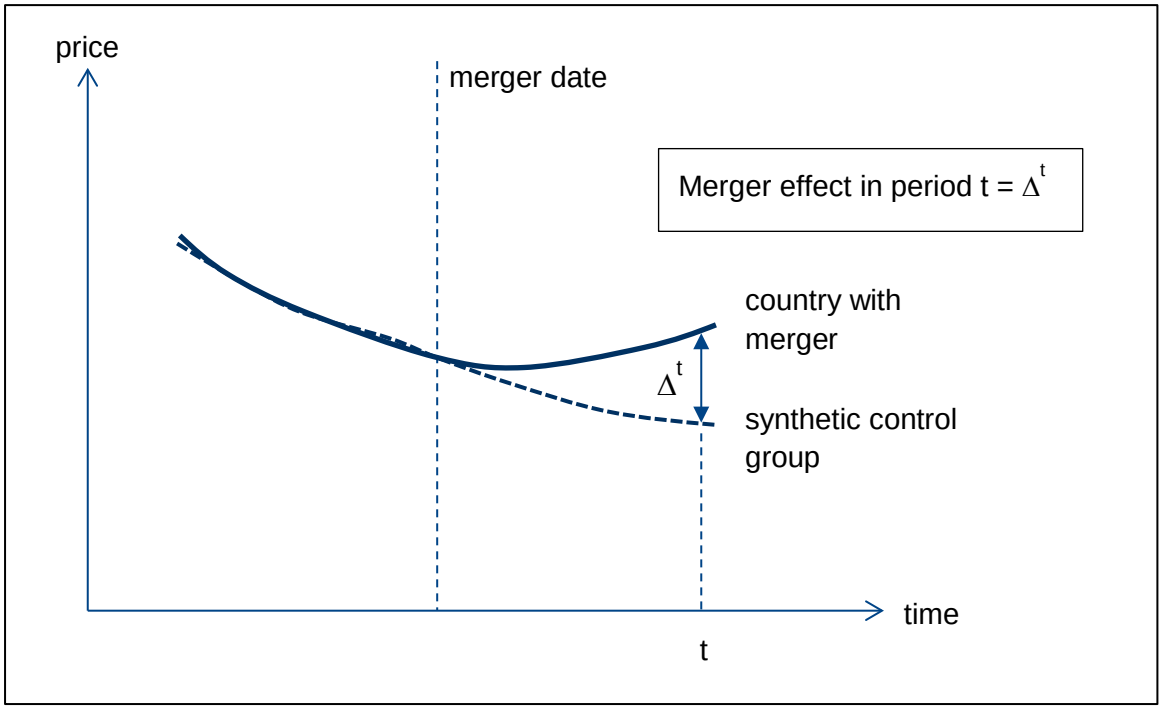


Figure 3: Illustrative example of the synthetic control group approach

Statistical inference is based on so-called placebo tests. For each of the control group countries, a 'merger effect' is calculated using the other countries (but not the actual treated country) as controls. Comparing the effect of the "true" merger to the effects of the placebo mergers allows us to assess whether the effect estimated for the treated country is large compared to the effects estimated for the countries not subject to a merger. To assess this we follow Abadie, Diamond and Hainmueller (2014) and calculate the ratio between the post-merger Root Mean Squared Prediction Error (RMSPE) and the pre-merger RMSPE for

[16] This section draws on RTR (2016), p. 13.

Austria, Ireland and Germany, as well as for their respective placebos. The RMSPE is the root of the average of the squared difference between prices in the treatment country and prices of the synthetic control group in the pre-merger or post-merger period.[17] If the placebo mergers have a smaller RMSPE ratio than the treated country, it can be argued that the effect measured for the treated country is unlikely to be driven by random factors.

As a measure of significance, we use the p-value as described in Galiani and Quistorff (2016). This p-value is equal to the number of countries with a higher RMSPE-ratio than the treated country divided by the total number of placebo tests. It has to be interpreted with caution, however, since we only have a relatively small number of controls (and therefore the p-value can only be 0 or ≥0.1). In our results tables, we therefore use the † sign to mark those estimates as significant where the treated country has the highest RMSP-ratio (instead of the usual ***, ** and * notation for p<0.01, ** p<0.05 and * p<0.1).

The synthetic control group approach has the advantage that the weights for the control group are chosen so that the pre-merger price level, as well as the pre-merger price trend, can be matched. Also, the assumption that a pre-merger trend continues post-merger does not have to be met. These are advantages compared to the DiD approach. On the other hand, if a good pre-merger fit cannot be achieved, the results of the synthetic control group approach have to be interpreted with caution.[18] While the DiD approach is very well established in the treatment evaluation literature, the synthetic control group approach is fairly new. Still, we consider it a good complement to the DiD analysis and therefore present both results in the country sections (Sections 5 to 7).

We use the synth routine[19] and the synth runner package[20] in Stata to estimate the merger effects with the synthetic control group approach.

5 The Austrian case: Hutchison/Orange 2013

In this section we discuss the Hutchison/Orange merger from late 2012/early 2013 in Austria. We first describe the market situation and the merger process, then show how prices developed in Austria compared to the control group countries and finally present the results of our estimations.

5.1 Market situation and the merger process[21]

At the time of the merger, there were four mobile network operators (MNOs) active in the Austrian market: the Austrian fixed network incumbent A1 Telekom Austria (with its main brands A1 and bob), T-Mobile Austria (with its main brands T-Mobile and tele.ring), Orange Austria (with its brands Orange and Yesss!), and Hutchison Three Austria (with its brand Drei).[22]

[17] The RMSPE ratio hence weights the post-merger effect (the difference between the actual series and its synthetic series in the post-merger period) by the "fit" of the synthetic control in the pre-merger period. For a given pre-merger RMSPE, a higher RMSPE ratio indicates a larger price effect of the merger (either positive or negative).
[18] This, however, also applies to the DiD analysis.
[19] See https://web.stanford.edu/~jhain/synthpage.html.
[20] See https://github.com/bquistorff/synth_runner and Galiani and Quistorff (2016).
[21] This section draws on RTR (2016), p. 6-7.
[22] There were also two independent MVNOs and a number of resellers on the market. However, these did not have significant market shares.

The merger consisted of the transaction between Hutchison and Orange and a second transaction in which Hutchison spun off the Orange sub-brand Yesss! to A1 Telekom Austria. These transactions led to a more symmetric market structure in the Austrian mobile market (see Table 2). While A1 Telekom Austria strengthened its position as market leader due to the purchase of Yesss!, Hutchison came closer to T-Mobile in terms of subscriber-based market shares.

Table 2: MNO subscriber-based market shares Austria

	A1 Telekom Austria	T-Mobile	Orange	Hutchison
Market share before merger (Q4/2012)	39.7%	30.7%	17.1% (incl. Yesss!)	12.6%
Market share after merger (Q1/2013)	45.5% (incl. Yesss!)	30.4%	-	24.1%

Both transactions (Hutchison-Orange and A1 Telekom Austria-Yesss!) were notified to the authorities in May 2012. The Austrian Cartel Court approved the Telekom Austria/Yesss! transaction on November 26, 2012.[23] The transaction between Hutchison and Orange was authorised by the European Commission on December 12, 2012 subject to commitments.[24] The merger was concluded in January 2013.

The commitments offered by the merging party consisted of:

(i) A commitment to facilitate MNO market entry by divesting spectrum to a potential new MNO as well as providing national roaming, preferred co-location rights and the possibility for this new entrant to purchase sites.
(ii) A commitment to facilitate MVNO market entry. This commitment package consisted of an upfront agreement with one MVNO and a reference offer for up to 16 MVNOs with wholesale access of to up to 30% of Hutchison's network.[25] The wholesale pricing scheme is volume-dependent (and not capacity based).

The first commitment did not become effective, as no new MNO entered the market, and the second commitment only became effective with significant delay. The MVNO which signed the up-front agreement, UPC, entered the market in December 2014, about two years after the approval of the merger. Significant competitive pressure from MVNOs only arose after the market entry of further MVNOs during 2015. MVNOs entered the market not only based on the offer of Hutchison but also based on (voluntary) offers from T-Mobile and A1.

In RTR (2016) the price effects of the merger in the two years following the merger (2013 and 2014) were estimated. This study concluded that prices increased significantly due to the

[23] See http://www.bwb.gv.at/Zusammenschluesse/Zusammenschluesse_2012/Seiten/BWB_Z-1735.aspx.
[24] See "Commission decision of 12 December 2012 declaring a concentration to be compatible with the internal market and the EEA Agreement (Case No COMP/M.6497 – HUTCHISON 3G AUSTRIA/ORANGE AUSTRIA)", http://ec.europa.eu/competition/mergers/cases/decisions/m6497_20121212_20600_3210969_EN.pdf.
[25] The reference offer is available at https://www.drei.at/portal/media/bottomnavi/ueber_3/wholesale/2012h3greferenceoffer.pdf.

merger from the second half of 2013 onwards. In this report we can look one and a half years further, until mid-2016, a period which includes several MVNO entries.

5.2 Price developments

Figure 4 to Figure 6 show the price developments in Austria compared to the average of the seven control group countries (BE, DK, ES, EL, IT, PT, SE). The price trend of the control group cannot be compared to RTR (2016), since the analysis of the Austrian case in this report is based on fewer countries.[26]

For all three baskets, the price level in Austria was significantly below the average price level in the control group countries in the pre-merger period. The pre-merger (linear) trends appear to be fairly similar.

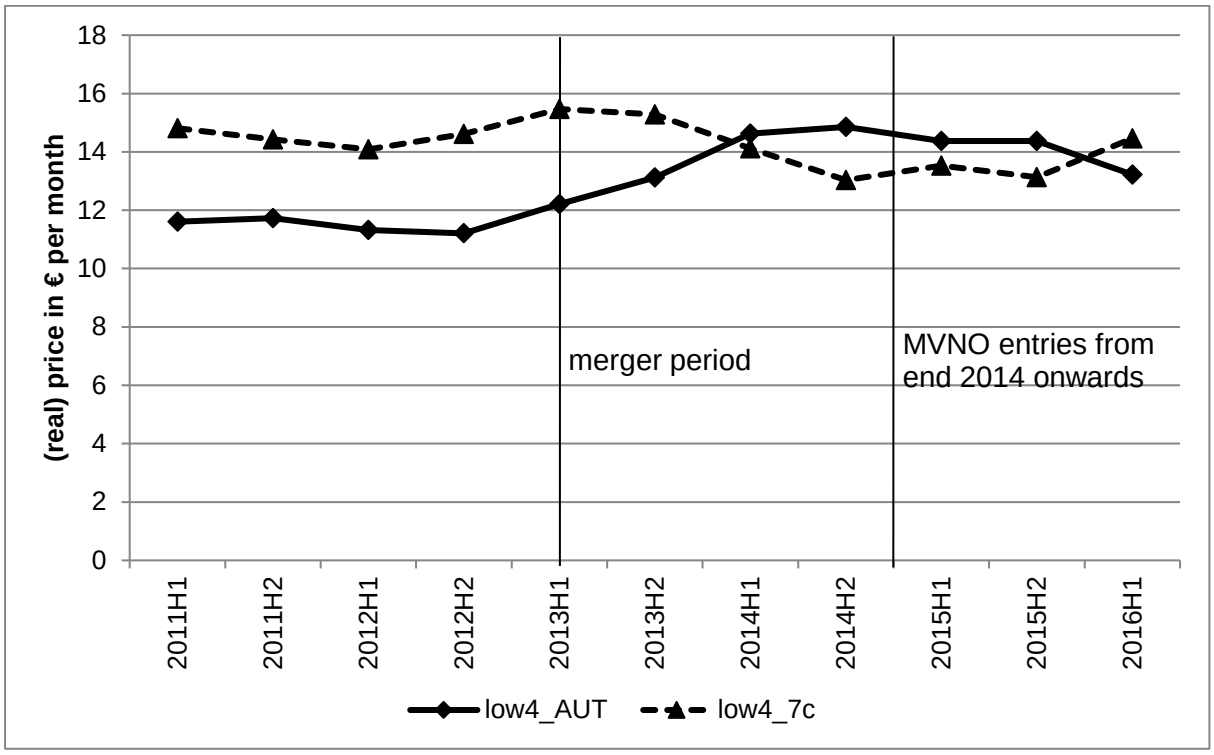
In the two years after the merger, prices in Austria increased and reached the level of the control group (or surpassed it) in 2014. They remained more or less on the same level in 2015. Only in 2016 is there a significant decrease, while the prices in the control group remained at about the same level or increased somewhat (low4).

It therefore appears to be the case that the effects of MVNO entry (or, more precisely, the reaction of MNOs to MVNO entry, since MVNOs are not part of our sample) only became visible in 2016.

With regard to the high usage basket it should be noted that it is (almost) identical to the medium basket (i.e., the tariffs chosen for the medium basket seem to include a sufficient amount of Minutes/SMS/MB to also accommodate higher usage). Also, the pre-merger price level in Austria for the high basket was significantly lower than in almost any of the control group countries (see also the individual country price trends in Annex 1). It is therefore questionable whether the counterfactual in the DiD approach is appropriate, since it cannot be expected that Austria (without the merger) would follow the significant downward trend of the control group. The DiD results may therefore overestimate the price increases which can be attributed to the merger. This is also suggested by the results of the synthetic control group approach, which generally exhibit lower (and statistically insignificant) price effects compared to the DiD approach. However, for the high basket, the results of the synthetic control group approach should also be interpreted with caution, since they are mainly driven by a comparison of Austria with Denmark, which is the only country with a pre-merger price level close to Austria.[27]

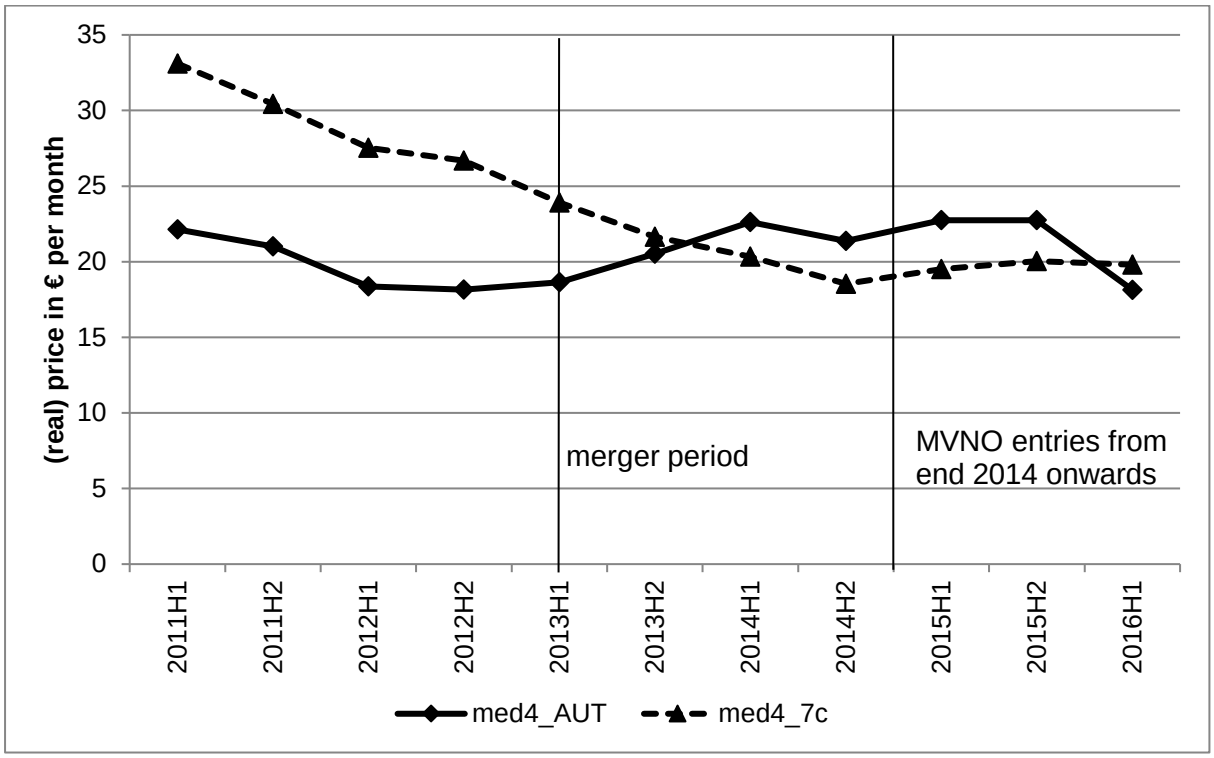
[26] Finland, Hungary and the Netherlands, which were part of the control group in RTR (2016) cannot be used for this study due to MNO entries in the year 2015. On the other hand, no 2011 data are available for the Czech Republic and the UK and therefore these countries cannot be used either.

[27] For the medium basket, the pre-merger price differences are significantly smaller in absolute as well as relative terms and therefore the concerns about the high basket do not apply. Also, the synthetic control group is generally composed of several countries, each with significant weight, and the results of the synthetic control group approach exhibit roughly comparable values to the DiD analysis for the medium basket.



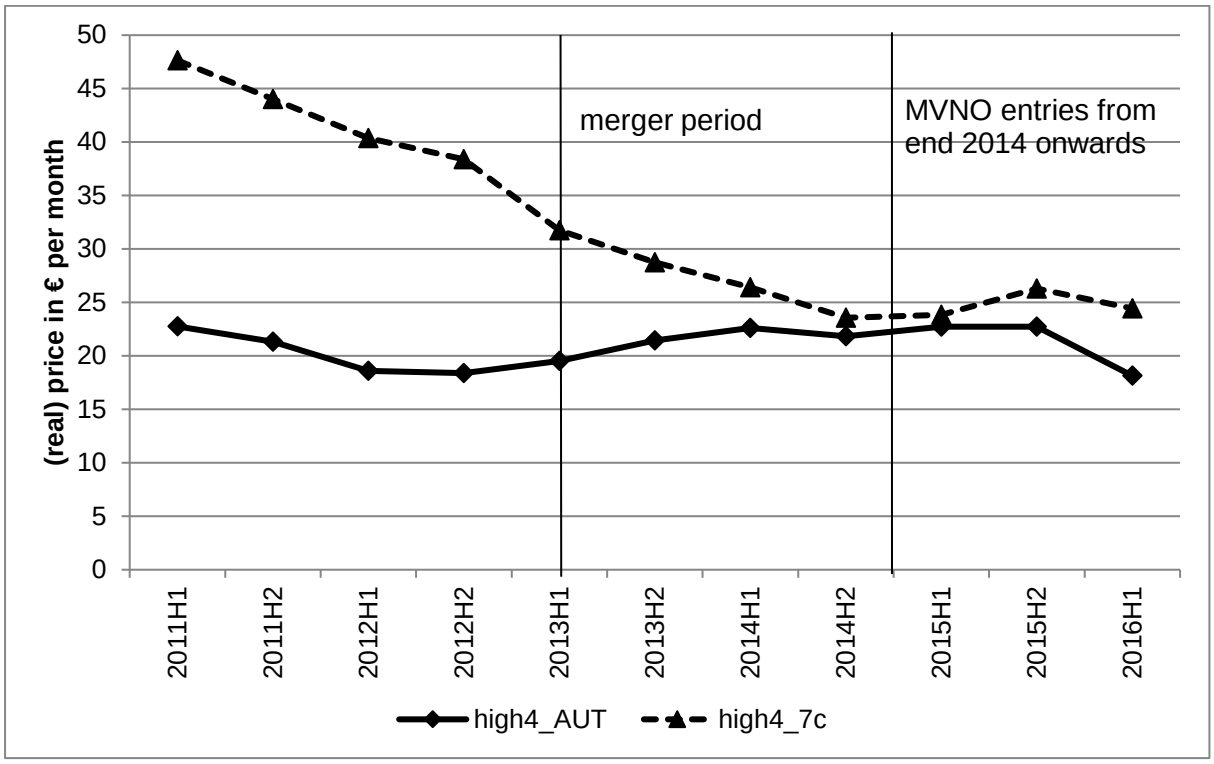
7c refers to an average of the seven control group countries BE, DK, ES, EL, IT, PT, SE

Figure 4: Price trends for users with a low usage profile in Austria



7c refers to an average of the seven control group countries BE, DK, ES, EL, IT, PT, SE

Figure 5: Price trends for users with a medium usage profile in Austria



7c refers to an average of the seven control group countries BE, DK, ES, EL, IT, PT, SE

Figure 6: Price trends for users with a high usage profile in Austria

5.3 Estimation results

The results for the country level estimations based on constant 2013 usage data are depicted in Table 3. The results are shown for the basic specification (DiD basic), the trend specification (DiD trend) and the synthetic control group approach.[28] As the trend test does not suggest that there is a significant difference in pre-merger trends between Austria and the control group countries, we can rely on the basic specification. We therefore only present the trends specification in grey without further discussion.

Table 3 reports the coefficients on the merger-effect dummies (2013 H2 – 2016 H1) as well as the coefficients on the controls (GDP growth and MTRs). The prices, as well as the MTRs, were deflated and presented on a logarithmic scale. Therefore, the coefficients can roughly be interpreted as percentage changes, at least for smaller values.[29]

In the basic specification, there are no statistically significant effects in 2013 H2 but positive and significant effects for 2014 H1 and H2 for the low and medium basket. The effects are stronger for the medium usage basket, where they range from 0.42-0.52, compared to the low usage basket (0.26-0.33). These results are qualitatively similar to the results of RTR (2016).[30] The DiD results for the high usage basket are even stronger (larger price effects) than for the

[28] Please see Section 4.2 for details on the methodologies.

[29] The exact percentage values can be calculated by (exp(coefficient)-1)*100.

[30] Small differences in the estimates are to be expected due to differences in the composition of the control group (see section 5.2). The results are in contrast to Houngbonon (2015), who, however, uses tariff data only from the largest 2-3 operators per country (also for Austria) and the observation period is limited to q1/2013-q3/2014 (which means that there is no pre-merger period against which the post-merger developments can be compared).

medium basket. However, as explained in the previous section, the price effects are likely to be overestimated.

In 2015, despite MVNO entry, the coefficients remain at a similar level. Only in 2016 H1 do they decrease significantly and become statistically less significant (or even insignificant in the case of the low basket). The coefficients on GDP growth and MTRs are statistically insignificant.

Table 3: Results for Austria, country-level, 2013 usage

	Low (4 tariffs)			Medium (4 tariffs)			High (4 Tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2013 H2	0.179	0.244**	0.098	0.254	0.372***	0.246	0.423***	0.477***	0.187
	(0.182)	(0.023)	(0.571)	(0.132)	(0.007)	(0.143)	(0.003)	(0.002)	(0.286)
2014 H1	0.261***	0.223*	0.280†	0.418***	0.483***	0.449	0.520***	0.532***	0.298
	(0.004)	(0.070)	(0.000)	(0.000)	(0.000)	(0.143)	(0.000)	(0.000)	(0.429)
2014 H2	0.328***	0.258**	0.247†	0.518***	0.545***	0.456†	0.661***	0.664***	0.452
	(0.000)	(0.024)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.286)
2015 H1	0.248***	0.178	0.153†	0.493***	0.561***	0.617†	0.662***	0.671***	0.474
	(0.002)	(0.186)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.286)
2015 H2	0.277***	0.168	0.138†	0.549***	0.564***	0.533†	0.666***	0.663***	0.463
	(0.007)	(0.300)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.143)
2016 H1	0.100	-0.004	-0.038	0.230*	0.301*	0.117	0.381***	0.387*	0.142
	(0.379)	(0.982)	(0.714)	(0.067)	(0.076)	(0.429)	(0.000)	(0.063)	(0.429)
GDP growth	0.621	-0.321		4.614	2.114		4.141	3.690	
	(0.830)	(0.848)		(0.132)	(0.411)		(0.107)	(0.219)	
MTRs	-0.114	-0.232*		0.097	-0.020		0.034	-0.022	
	(0.287)	(0.088)		(0.444)	(0.898)		(0.763)	(0.901)	
constant	2.443***	7.596***		2.660***	10.813***		2.497***	5.910**	
	(0.000)	(0.000)		(0.000)	(0.000)		(0.000)	(0.012)	
Obs.	80	80		80	80		80	80	
R^2	0.845	0.927		0.813	0.922		0.906	0.943	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 17.8%, PT: 30.0%, SE: 52.2%

Weights synth. control group med: BE: 3.8%, DK: 56.2%, ES: 37.7%, SE: 2.3%

Weights synth. control group high: DK: 99.4%, ES: 0.6%

The results of the synthetic control group approach are qualitatively quite similar to that of the basic DiD. They also show significant price increases in 2014 and 2015 compared to the control group for the low and medium basket while the differences are smaller and not statistically significant in 2013 H2 and 2016 H1. The price effects for the high basket are smaller than in the DiD specifications and not statistically significant (although there are a number of periods where only one or two control group countries have a higher RMSPE ratio

– the placebo merger effect – than Austria). The results for the high usage basket should be interpreted with caution, since they rely mainly on a comparison with Denmark (see previous section).[31] Figures with the development of the prices in Austria compared to the synthetic control group are shown in Annex 4. The pre-merger trend seems to fit the synthetic control group's trend rather well. After the merger, the gap between Austria and the synthetic control group widens. They reach a similar level again in 2016 H1.

The results are fairly robust to a change in the number of tariffs used to calculate the basket (2 instead of 4), a change in usage from 2013 to 2014 data and estimation at the operator level (instead of the country level) (See Annex 5).

5.4 Conclusions on the Austrian case

The results of the estimations suggest that the merger led to a significant price increase in 2014 for the low and the medium usage baskets,[32] which is largely consistent with the results of RTR (2016). We also find significant price effects for the high usage basket in the DiD specifications, although these effects are likely to be overestimated. The results also show that, despite MVNO-entry, the price effect of the merger in general remained at a similar level in 2015. Only in 2016 did the effect became considerably smaller and statistically insignificant in most specifications (although for the medium basket some effect in 2016 H1 cannot be ruled out completely). This is likely caused by competitive pressure from MVNOs, which gained significant market shares in this period.[33] This also suggests, however, that the MVNO remedy took more than three years to actually become effective for Austrian consumers.

6 The Irish case: Hutchison (3)/Telefónica (O2) 2014

In this section we discuss the Hutchison (3)/Telefónica (O2) merger of 2014. We begin by describing the market conditions before the merger and the impact of the merger on the Irish mobile market. We then show how prices developed in Ireland compared to the control countries and conclude by presenting the results of our estimation.

6.1 Market situation and the merger process

At the time of the merger, there were four MNOs active in the Irish market. Telefónica's Irish subsidiary, O2, was Ireland's second largest MNO by revenue and subscriber share. As well as O2, Telefónica also operated O2's sub-brand, 48, which targeted consumers in the 18-22 age bracket. Hutchison (3) was the Irish branch of the international conglomerate Hutchison Whampoa, and was considered a maverick, or disruptive operator, in the Irish market by the EC.[34] It was the most recent entrant into the Irish market and had been rapidly gaining market share. In 2014, it was the fourth largest MNO by both revenue and subscriber market share. In its branding it had positioned itself as an upstart competitor, and it was offering innovative

[31] Denmark has a weight of 99.4% in the synthetic control group.

[32] Or traditional and smartphone users (this terminology was used in RTR (2016)).

[33] The largest MVNO, Hofer Telekom for example, gained around 500,000 customers within 15 months of market entry in early 2015 (see https://medianet.at/news/technology/hofer-telekom-verzeichnet-schon-540000-kunden-9698.html).

[34] Recall Ofcom (2016), as discussed in Section 3, which found that prices in countries with a maverick MNO are on average about 11% to 12% below the price level in countries without a disruptive MNO.

new deals, such as "All You Can Eat" Data. Hutchison (3)'s rise in market share by subscription and revenue nearly mirrored O2's corresponding decline in both of these measures.

The two MNOs that were not directly involved in the merger were Vodafone and Meteor. Vodafone originally acquired the mobile business of the incumbent fixed line operator, Eircom, in 2001 and was the market leader according to both subscriber and revenue share before the merger. Its lead in the share of subscribers had been declining steadily for several quarters before the merger, although its revenue share had been holding steady, reflecting the higher ARPU of Vodafone subscribers compared to subscribers of other MNOs. Ireland's third largest player in the retail mobile market, Meteor, represented a re-entry into the mobile market by Eircom, which acquired Meteor in 2005. Meteor's market shares had remained steady in the years preceding the merger and it was the first of Ireland's MNOs to offer 4G services. Meteor took part in a network sharing agreement with O2.

There were also four MVNOs present at the time of the merger. By far the largest of these was Tesco Mobile, which had a 4% subscriber and 2% revenue market share. O2 owned a 50% share in Tesco Mobile and hosted it on its network. The other half of Tesco Mobile was owned by the eponymous retailer. The four MVNOs in the market together had roughly 7.5% subscriber share and 4% revenue share. Tesco Mobile had been the only MVNO up to this point to gain more than 2% subscriber share.

Hutchison and Telefónica entered into a sale and purchase agreement on the 22nd of June 2013. Under this agreement, Hutchison (3) would acquire sole ownership of O2 through the purchase of shares. Telefónica's customers in Ireland on both the O2 and 48 brands would be transferred to Hutchison (3). This merger moved Hutchison (3) from fourth position in a four-player market to second in a three-player market (see Table 4).

Table 4: MNO subscriber-based market shares in Ireland

	Vodafone	Meteor	O2 (incl. 48)	Hutchison (3)
Market share before merger (3rd quarter 2014)	39.2 %	20.2 %	23.3 %	8.9 %
Market share after merger (4th quarter 2014)	38.8 %	20.5 %	32.0 %	

The EC was formally notified of Hutchison's intention to acquire O2 on the 1st of October 2013. The Commission gave notice that it was allowing the merger to go through on the 28th of May 2014. Although the EC granted permission for the merger to take place, it only did so on the basis of Hutchison honouring a set of commitments it had proposed to the Commission. Note that the European Commission characterised Hutchison (3) as having had a maverick role in the market.

These commitments were:

1. The provision of capacity-based wholesale access to two MVNOs before it acquired O2 ("upfront MVNO commitment"). These MVNOs would have the option of eventually taking up to 15% each of the merged entity's network capacity. One of these MVNO's would acquire the subscribers to O2's youth demographic targeting sub-brand, 48. Additionally, one of the two MVNOs would gain access to spectrum divested by Hutchison (3) if it could show a Monitoring Trustee a credible business plan to become

an MNO within a reasonable period of time. This spectrum divestment option would remain open to the two MVNOs for ten years.

2. The amendment of the network sharing agreement which had been agreed between Meteor and O2, such that Meteor would not be competitively disadvantaged by the merger of O2 and Hutchison (3).

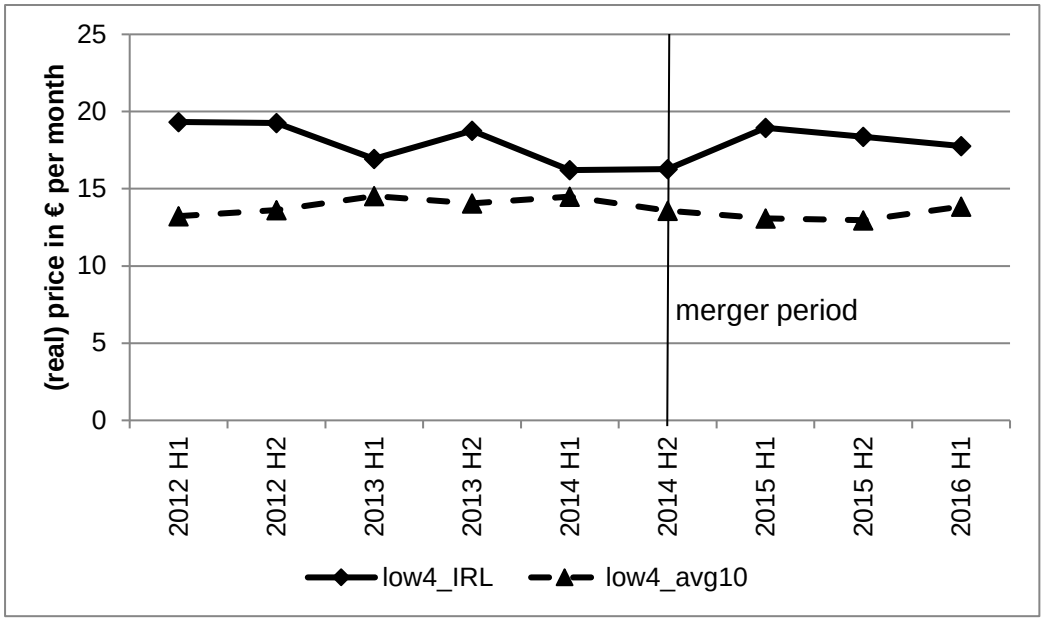
iD Mobile was the first MVNO to enter the Irish mobile retail market on the Hutchison (3) network as a result of these commitments. It launched on the 20th of August 2015, intending to have captured a subscriber share of 6% within five years of entry. As of Q3 2017, iD had only captured a subscriber market share of 0.7%. Finally, iD Mobile ceased to provide service on 6th April 2018 and exited the market.

The second MVNO, Virgin Mobile, launched its services on the 5th of October 2015. Virgin grew from a revenue share and subscriber share of 0.2% in Q2 2016 to a revenue and subscriber share of 0.9% in Q3 2017. Unlike iD, Virgin Mobile is not a standalone MVNO, but is a division of the larger Virgin Media Corporation, which also offers fixed broadband, TV services, and landline services.

6.2 Price developments

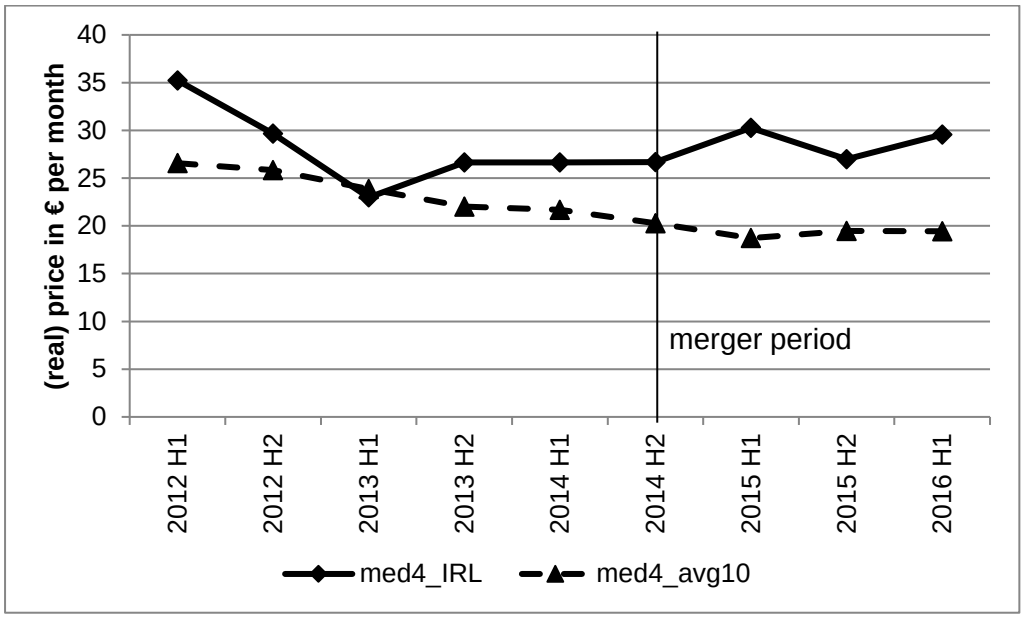
Figure 7 to Figure 9 show the prices of the low, medium and high usage baskets in Ireland between the first half of 2012 and the first half of 2016. These price developments are compared to a simple average of the ten control group countries, BE, CZ, DK, ES, EL, IT, PT, PL, SE and UK.

For each of the three baskets, the price level in Ireland was consistently either above the average or equal to the average in the pre-merger period. In the post-merger period, prices in Ireland seem to diverge further from the average, with an increase evident for all three baskets in H1 2015, which is the first observation after the merger. In each case, the control group remained relatively stable.



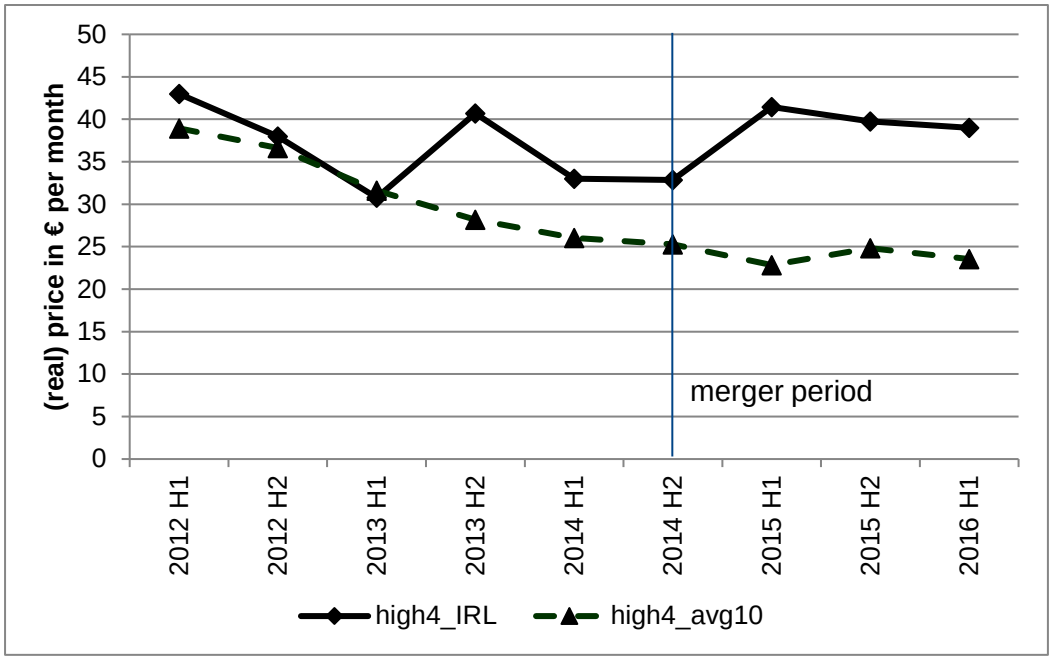
avg10 refers to a simple average of the ten control group countries

Figure 7: Price trends for users with a low usage profile in Ireland



avg10 refers to a simple average of the ten control group countries

Figure 8: Price trends for users with a medium usage profile in Ireland



avg10 refers to a simple average of the ten control group countries

Figure 9: Price trends for users with a high usage profile in Ireland

6.3 Estimation results

The results for the country level estimations for the low, medium and high usage baskets, based on constant 2013 usage data, are presented in Table 5. The results are shown for the basic specification (DiD basic), the trend specification (DiD trend) and the synthetic control group approach.[35]

As the trend test does not suggest that there is a significant difference in pre-merger trends between Ireland and the control group countries, we can rely on the basic specification (DiD basic). We therefore only present the trends specification (DiD trend) in grey without further discussion.

Table 5 reports the coefficients on the merger-effect dummies, as well as the coefficients on the controls (GDP growth and MTRs). As in the Austrian case, the prices and MTRs were deflated and presented on a logarithmic scale. Therefore, the coefficients can roughly be interpreted as percentage changes, at least for smaller values.[36]

The DiD results show statistically significant price increases for all three baskets in the first period after the merger, i.e. the first half of 2015. This effect disappears in the second half of 2015 for the low and medium baskets but persists for all three periods for the high basket and emerges again in the final period (the first half of 2016) for the medium basket. The magnitude and persistence of the price effect is strongest in the high basket, for which the estimated coefficients vary between 0.31 and 0.44 in the three half-year periods after the merger.

[35] Please see section 4.2 for details on the methodologies.

[36] The exact percentage values can be calculated by (exp(coefficient)-1)*100.

Table 5: Results for Ireland, country-level, 2013 usage

	Low (4 tariffs)			Medium (4 tariffs)			High (4 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2015 H1	0.163** (0.042)	0.351*** (0.000)	0.244 (0.400)	0.398*** (0.000)	0.402** (0.011)	0.444 (0.300)	0.436*** (0.000)	0.279* (0.063)	0.829 (0.300)
2015 H2	0.121 (0.167)	0.414*** (0.002)	0.229 (0.400)	0.156 (0.136)	0.235 (0.312)	0.239 (0.400)	0.360*** (0.002)	0.154 (0.439)	0.682 (0.500)
2016 H1	0.052 (0.664)	0.329*** (0.009)	0.197 (0.400)	0.370*** (0.004)	0.346 (0.107)	0.167 (0.900)	0.305** (0.027)	0.063 (0.774)	0.644 (0.500)
GDP growth	0.256 (0.798)	-0.358 (0.731)		1.078 (0.312)	0.198 (0.866)		-0.420 (0.752)	-0.353 (0.766)	
MTRs	-0.118 (0.131)	-0.063 (0.440)		-0.058 (0.484)	-0.065 (0.440)		0.041 (0.623)	0.005 (0.956)	
constant	2.394*** (0.000)	6.723*** (0.000)		2.675*** (0.000)	9.131*** (0.002)		3.036*** (0.000)	6.112*** (0.000)	
Obs.	88	88		88	88		88	88	
R^2	0.873	0.926		0.877	0.915		0.903	0.931	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: CZ: 15.0%, UK: 30.3%, PT: 54.7%

Weights synth. control group med: CZ: 59.8 %, ES: 40.2%

Weights synth. control group high: BE: 14.9%, CZ: 6.2%, IT: 73.5%, PL: 5.4%

The results of the synthetic control group methodology are insignificant for each of the baskets. Figures in Annex 4 show the development of the prices in Ireland compared to the synthetic control group. The pre-merger trend seems to fit the synthetic control group's trend rather well, but not as closely as in the Austrian case. This might explain the lower level of significance. After the merger, the gap between Ireland and the synthetic control group widens for all baskets, but to different degrees.

6.4 Conclusions on the Irish case

The results of the estimations above suggest that the merger led to statistically significant price increases, but that the magnitude and persistence of these effects varies across usage baskets. It is only for the high basket that the statistically significant price effect is sustained across the entire period under investigation. A range of robustness checks were run, with the output shown in Annex 5. Although the size of the coefficients and the statistical significance vary across specifications – especially for the high and medium baskets – most of the

robustness checks do show at least one statistically significant price increase in at least one post-merger period for each of the three baskets. Statistically significant negative effects are not observed in any of the specifications. This indicates that the merger led to price increases compared to the counterfactual. Due to the fact that we only observe the first three half-year periods after the merger, the results should be interpreted as a short- to medium-run effect of the merger in Ireland. Regarding the long-run effects, not enough time has passed since the merger to draw meaningful conclusions.

7 The German case: Telefónica (O2)/KPN (E-Plus) 2014

In this chapter we discuss the merger of Telefónica (O2) and KPN (E-Plus) in Germany, which took place in the second half of 2014. In the first section we describe the market situation before and after the merger, as well as the merger process. This is followed by an analysis of the price developments in Germany compared to a control group of countries. Lastly, the results of our estimations are described.

7.1 Market situation and merger process

Telefónica completed the acquisition of E-Plus in October 2014 after clearance by the European Commission, subject to commitments. At the time of the merger, there were four mobile network operators (MNOs) active in the German market: Telekom Deutschland, Vodafone, Telefónica and E-Plus. Table 6 reflects the subscriber market shares of the MNOs[37] before and after the merger.

Table 6: **MNO subscriber-based market shares in Germany**

	Telekom Deutschland	Vodafone	Telefónica	E-Plus
Market share before merger (Q3/2014)	33.8 %	27.0 %	22.4 %	16.7 %
Market share after merger (Q4/2014)	34.6 %	28.0 %	37.40 %	

The merger brought together the third and the fourth largest MNOs and led to more symmetric market shares of the remaining three MNOs, with Telefónica becoming the operator with the largest market share. The transaction was notified to the European Commission in October 2013 and was authorised on July 2nd, 2014, conditional upon the full implementation of a commitment package submitted by Telefónica.[38] These commitments were the following:

(i) First, Telefónica was to sell up to 30% of the merged entity's network capacity to one or several (up to three) MVNOs in Germany before the acquisition was completed ("upfront MVNO commitment", capacity based).

[37] This is based on the number of subscribers in terms of SIM cards, broken down by MNO and quarter, in accordance with operators' publications. This also includes SIM cards attributable to Mobile Virtual Network Operators (MVNOs) using the respective MNOs' networks.

[38] For a more detailed overview of the Commission's decision, see http://europa.eu/rapid/press-release_IP-14-771_en.htm.

(ii) Second, Telefónica committed to divest radio-wave spectrum and certain assets either to a new MNO or new MVNO(s) entering the market.

(iii) Third, Telefónica was to extend existing wholesale agreements with Telefónica's and E-Plus' partners (i.e. MVNOs and service providers) and to offer wholesale 4G services to all interested players in the future.

The first commitment became effective when, in July 2015, the MVNO Drillisch was given exclusive access to Telefónica's mobile network in Germany, granting Drillisch the right to acquire 20% of the network capacity of Telefónica over a period of 5 years, with an option to acquire an additional 10% until 2020. These conditions were intended to give Drillisch the ability to act in a similar way to an MNO. Instead of paying for network access on a per usage basis (pay-as-you-go model) Drillisch obtained a fixed capacity from the merged entity's network and thus could be more flexible in the mobile market than other MVNOs and service providers in Germany. In the years following the merger, Drillisch significantly increased its number of subscribers, from 2.07 million at the end of 2014 to 3.43 million at the end of 2016 (+ 65%).[39] The total number of SIM cards in the German market increased by roughly 15% over the same period.[40] In June 2017, and unrelated to the conditions imposed on Telefónica for the original merger, the German competition authority (Bundeskartellamt) cleared the takeover of the MVNO Drillisch by United Internet AG.[41] The competition authority stated that this could have a stimulating effect on the mobile market as United Internet was already a well-known player in the German fixed market. However, as this is beyond our investigation period, we will not discuss this in further detail.

Furthermore, the German market is characterised by a broad range of MVNOs and service providers, in sum having a relatively high retail market share compared to other European markets. This is reflected by the share of the total external revenues of service providers/MVNOs in mobile communications in 2016, where they generated around 19% of total revenue.

Table 7 shows the development of MNO and MVNO market shares in Germany. The market share of MVNOs and service providers in Germany was quite high (compared to the other cases considered in this report) before the merger took place in 2014. As the figures show, the MVNO market share in Germany increased in the observation period from 2012 to 2016 by approximately 4 percentage points.

[39] See Drillisch's annual reports for the years 2014 and 2016 (https://imagepool.drillisch.de/v2/download/berichte/2015-03-20_Drillisch_GB-2014_english.pdf and https://imagepool.1und1-drillisch.de/v2/download/berichte/2017-03-23-Drillisch_GB_2016_ENGLISH.pdf).

[40] See https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2017/TB_Telekommunikation20162017.pdf?__blob=publicationFile&v=3, Figure 19, p. 39.

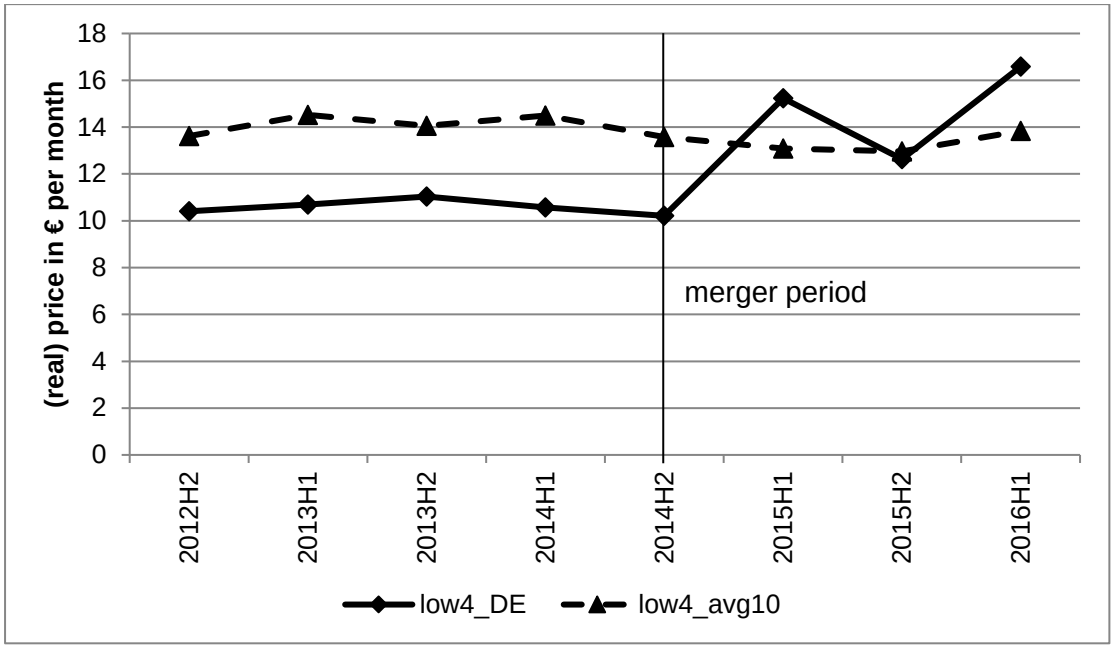
[41] See http://www.bundeskartellamt.de/SharedDocs/Meldung/EN/Pressemitteilungen/2017/09_06_2017_Drillisch_United Internet.html;jsessionid=5E5C76FA080726E3F8B44204D8BC663D.2_cid362?nn=3591568.

Table 7: Development of MNO and MVNO/service provider revenue-based market shares in Germany[42]

	2012	2013	2014	2015	2016	2017e
MNO share of the total external revenues	84.9%	83.5%	84.0%	82.0%	81.0%	80.8%
MVNO/SP share of the total external revenues	15.1%	16.5%	16.0%	18.0%	19.0%	19.2%

7.2 Price developments

In this section, price developments in Germany are presented compared to a control group of countries. The price developments are shown for the low, medium and high usage profiles.[43] The presented prices for the control group are the average of ten countries (BE, CZ, DK, EL, ES, IT, PL, PT, SE, UK).[44]



avg10 refers to a simple average of the ten control group countries

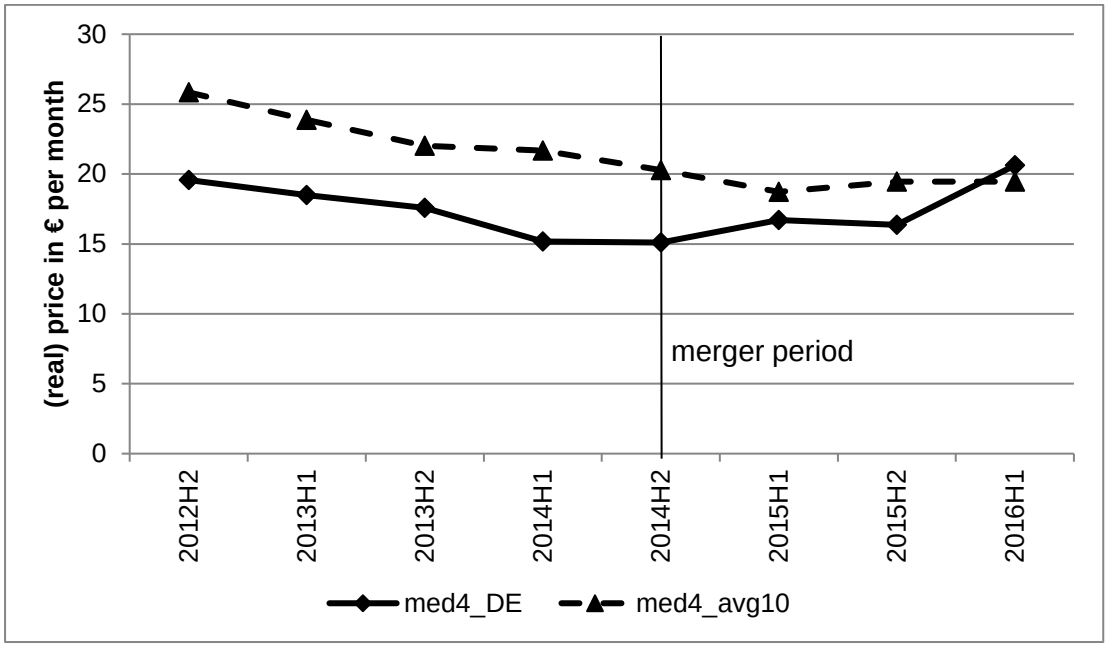
Figure 10: Price trends for users with a low usage profile in Germany

[42] See https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2015/TB_TK_2015.pdf?__blob=publicationFile&v=3, p. 20 and https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2017/TB_Telekommunikation20162017.pdf?__blob=publicationFile&v=3, p. 20.

[43] For further details on the usage profiles see Annex 1.

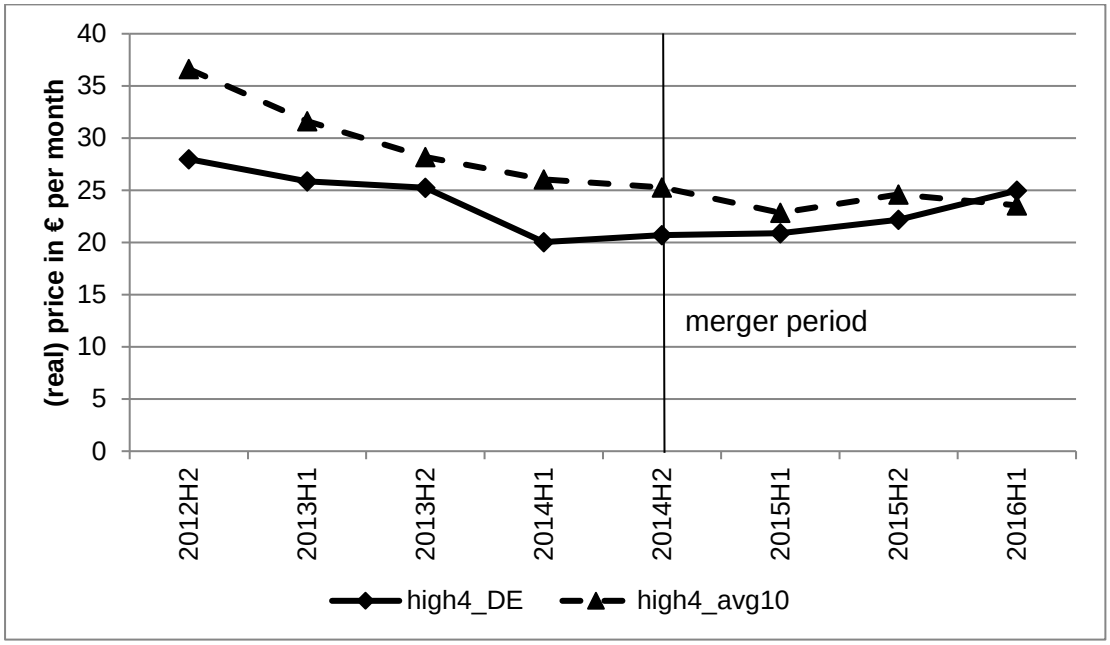
[44] It can be argued that data from the UK should also be excluded from the group of control countries as there might also be effects from a merger on prices during the period of study. Although the merger in question between T-Mobile and Orange (to create Everything Everywhere, or EE) had been concluded in 2010, the rebranding did not take place until 2014. Excluding the UK from the sample slightly increases the price level of the control group countries. However, the price trend over time is unchanged. In a robustness check (Annex 5) the UK is also excluded in the econometric estimations.

Figure 10 shows that, for the low usage profile, the pre-merger trends appear to be similar for Germany and the average of the control group. However, the price level in Germany before the merger was significantly below the average price level in the control group countries. The level of both (DE and the control group) stayed roughly constant over the pre-merger period. In the post-merger period, the price level in Germany increased from the second half of 2014 to the first half of 2015 by 50% and thus exceeded the price level in the control group countries.



avg10 refers to a simple average of the ten control group countries

Figure 11: Price trends for users with a medium usage profile in Germany



avg10 refers to a simple average of the ten control group countries

Figure 12: **Price trends for users with a high usage profile in Germany**

As Figure 11 shows, the price level of the medium usage profile in Germany before the merger was significantly below the control group countries and the pre-merger trends were similar. After the merger was completed in the second half of 2014, there was an increase in the price level for Germany, while a drop in prices continued for the control group countries until the first half-year of 2015 and then more or less remained at the same level. In the first half of 2016, the prices in Germany and the control group countries reached approximately the same level.

In the case of the high usage profile (Figure 12), the pre-merger and post-merger trends follow the same pattern as for the medium usage profile, namely falling pre-merger trends and then, post-merger, the development of the price trends differs between Germany and the control group. The price trend for Germany slightly increased, while the trend for the control group countries flattened compared to the pre-merger period.

7.3 Estimation results

The results for the country level estimations, based on constant 2013 usage data, are presented in Table 8 for each of the low, medium and high usage baskets. The results are shown for the basic specification (DiD basic), the trend specification (DiD trend) and the synthetic control group approach.[45] The control group includes ten countries, as mentioned in Section 7.2.

[45] Please see section 4.2 for details on the methodologies.

Table 8: Results for Germany, 4 cheapest tariffs, country-level, 2013 usage

	Low (4 tariffs)			Medium (4 tariffs)			High (4 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2015 H1	0.434***	0.458***	0.461	0.202***	0.270*	0.088	0.136**	0.180	0.154
	(0.000)	(0.000)	0.100	(0.004)	(0.083)	0.200	(0.039)	(0.304)	0.400
2015 H2	0.248***	0.277**	0.212	0.139*	0.219	0.043	0.131*	0.181	0.181
	(0.000)	(0.034)	0.300	(0.050)	(0.249)	0.200	(0.071)	(0.402)	0.100
2016 H1	0.454***	0.506***	0.431†	0.348***	0.470**	0.126	0.250***	0.327	0.124
	(0.000)	(0.002)	0.000	(0.000)	(0.048)	0.200	(0.001)	(0.219)	0.400
GDP growth	1.017	-0.000		2.484*	0.480		2.762**	1.362	
	(0.483)	(1.000)		(0.097)	(0.800)		(0.047)	(0.461)	
MTRs	-0.094	-0.002		-0.064	-0.022		0.041	0.062	
	(0.274)	(0.975)		(0.472)	(0.820)		(0.662)	(0.576)	
constant	2.375***	4.555***		2.647***	6.071*		3.022***	4.686*	
	(0.000)	(0.006)		(0.000)	(0.086)		(0.000)	(0.055)	
Obs.	77	77		77	77		77	77	
R^2	0.863	0.922		0.877	0.913		0.899	0.919	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 62.5%, UK: 14.1%, PL: 19.2%, SE: 4.3%

Weights synth. control group med: CZ: 22.2%, DK: 71.3%, ES: 3.7%, PT: 2.8%

Weights synth. control group high: CZ: 18.8%, DK: 43.1%, ES: 32.7%, GR: 5.5%

We find positive and significant effects over all usage profiles for all three post-merger periods under investigation. The low usage profile shows the strongest difference between the price trends for Germany compared to the control group countries. The estimated coefficients vary between 0.25 and 0.45 in the three half-year periods after the merger. Compared to these results, the effects for the other usage profiles are smaller in magnitude, ranging from 0.14 to 0.35 for the medium usage profile and from 0.13 to 0.25 for the high usage profile, respectively. As the trend test does not suggest that there is a significant difference in pre-merger trends between Germany and the control group countries, we can rely on the basic specification (DiD basic). We therefore only present the trends specification (DiD trend) in grey without further discussion. The coefficients on GDP growth are positive and statistically significant, except for the low usage profile. The coefficients for MTRs are statistically insignificant over all usage profiles.

The results of the synthetic control group approach show a positive effect on prices for Germany compared to the control group for all periods and over all usage profiles. Comparing the synth results to the basic DiD specification, the effects are closest in magnitude for the low

usage profile. We only find a statistically significant effect for Germany compared to the control group countries in the first half of 2016 for the low usage profile.[46]

Figures in Annex 4 show the development of prices in Germany compared to the synthetic control group for the low, medium and high usage baskets. The trends in the pre-merger period appear to fit the synthetic control group's trend rather well. In the post-merger period, a gap between Germany and the synthetic control group emerges for the low and high usage profiles. For the medium usage profile, the post-merger trends for Germany seem to be only marginally higher than for the control group countries.

As robustness checks, we also tested a change in the number of tariffs used to calculate the baskets (two instead of four), a change in the assumed average usage (from 2013 to 2014) and estimation at the operator level (instead of the country level). Further, we excluded the UK from our sample, as the rebranding of the merger that took place in the UK in 2010 was only fully completed in 2014. The results of the analysis vary across specifications. Not only do the magnitudes and patterns of the results vary, in one specification we even found significant negative effects on prices for the medium and high usage profiles. The robustness checks are presented in Annex 5.

7.4 Conclusions on the German case

The estimation results for Germany differ across the usage profiles under investigation. While the results for the low usage profile show a significant price increase over all specifications, the picture is quite mixed in the cases of the medium and high usage profiles. Thus, the results of the different usage profiles have to be interpreted differently.

For the low usage profile, the estimation results show a significant price increase for MNO tariffs when comparing the post-merger trends in Germany to the control group countries. The significant differences in post-merger trends are robust across specifications. However, as mentioned in Section 7.1, the market structure in Germany is characterised by a large number of MVNOs and service providers, together accounting for a roughly 19% market share of total revenues. The increase in revenue-based market shares of MVNOs and service providers after the merger can partly be attributed to Drillisch, which benefited from the first commitment under which the merger was cleared. This is indicated by the significant increase in Drillisch's number of subscribers after the merger (an increase of 65% between 2014 and 2016).[47] As data on MVNOs, service providers and sub-brands of MNOs is not included in the underlying sample, whereas this data would be especially important for the lower priced segment of the market, it is unclear if the price increase for the underlying MNO tariffs can be generalised to the whole lower priced segment in Germany. If the assumption holds that MVNOs and service providers in Germany exert pressure on the price setting of MNOs, the estimated results could be generalised to the whole lower priced segment. However, if it is the case that the MNOs do not respond to the MVNO price setting or only respond with their sub-brands that are also missing in the underlying sample, and do not try to compete in the lower priced segment with the tariffs that are under investigation in this report, the estimated results for the MNO tariffs should not be generalised to the whole lower priced segment.

[46] See Section 4.2 for details on significance levels in the synthetic control approach.

[47] See Drillisch's annual reports for the years 2014 and 2016 (https://imagepool.drillisch.de/v2/download/berichte/2015-03-20_Drillisch_GB-2014_english.pdf and https://imagepool.1und1-drillisch.de/v2/download/berichte/2017-03-23-Drillisch_GB_2016_ENGLISH.pdf).

For the medium and high usage profiles, the results presented in this section appear to be significant and show a price increase when comparing the post-merger trends in Germany to the control group countries. Generally, the coefficients for the first half of 2016 (the latest date in our analysis, one and a half years after the merger) show the highest levels of significance. However, the results for these two usage profiles are not very robust across specifications and show even a significant price decrease in one of the robustness checks that are presented in Annex 5.

Concluding, we observe a price-increasing effect for the German market after the merger compared to other European countries in our regression results. In the case of the low usage profile, it is uncertain if the estimated results can be generalised to the whole low budget segment, as we cannot rule out that the pricing behavior of MVNOs and sub-brands in Germany differs systematically from the observed pricing of MNOs. For the high and medium usage baskets, the results are not very robust across specifications. However, overall, the results show a price-increasing, rather than a price-decreasing, effect. Due to the fact that we only observe the first three half-year periods after the merger, the results should be interpreted as a short- to medium-run effect of the merger in Germany. Regarding the long-run effects, not enough time has passed since the merger to draw meaningful conclusions.

8 Quality effects

Changes in consumer prices are only one of the potential effects mergers of network providers can have on market outcomes. Market consolidations may also influence the quality of the offered services. This chapter gives a general overview of potential effects of mobile mergers on quality and provides some evidence on quality effects of the Austrian and German mergers.

8.1 Potential effects of mobile mergers on quality

Mergers can potentially have negative or positive effects on quality. The most immediate effects can be expected for the merged network provider, but a merger can also affect competing providers that are not directly involved in the merger, either directly through merger remedies (e.g. selling of infrastructure or spectrum rights by the merging parties) or indirectly by changes in strategies and competitive interactions.

Short- and long-term quality effects can differ substantially. In the short to medium term, the network and service quality of the merging parties could be negatively affected as the integration of two separate companies and, in particular, separate network structures, can be complex and take a considerable amount of time.[48] However, the effect in the long run may differ. On the one hand, the decreased level of competition, with fewer competitors present in the market, could lead to fewer incentives to invest in network quality and/or quality of service delivery. This could mean that customers would not experience a positive effect from the merger.

[48] For example, approximately 40,000 mobile sites were affected by necessary network integration following the merger between Telefónica and E-Plus in Germany (see https://blog.telefonica.de/2017/11/netztests-2017-telefonica-deutschland-treibt-netzintegration-mit-hochdruck-voran). Telefónica has announced that it will finish most of the network integration by the end of 2018, which would indicate that the integration process for such a large network and market can take several years to complete (see https://www.teltarif.de/telefonica-netzintegration-zeitplan/news/70804.html).

On the other hand, increased efficiency of the merged network provider could lead to quality improvements. The merged entity might benefit from scale economies and increased bargaining power when negotiating with equipment or content providers. Moreover, due to higher potential margins and thus profitability, earnings expectations could also increase for all remaining providers, including the merged provider. Depending on the pre-merger level of competition, this in turn could encourage providers to invest more.[49] Furthermore, the merging of two separate network operators (and therefore base stations) can result in overall coverage improvements or increased network capacity of the merged entity. These effects could potentially mean that customer welfare, in terms of quality measures, increases due to a merger.

8.2 Potential issues with measures of quality

Quality of service delivery is not easily measureable and thus it is not easily usable in econometric analyses. Additionally, quality consists of several dimensions that have varying degrees of measurability. Coverage of different generations of mobile technology is an example of one of the dimensions for which, in general, sufficient data might exist. However, once coverage is already at a high percentage in the country in question, changes to such a measure are relatively small and might not be as relevant to customers. Other aspects of quality, such as the quality of a phone call or a data connection seem to have more relevance in such a case. Several companies and public institutions try to gather such data by designing and performing network tests themselves[50] or by asking users to collect or report quality parameters via specific applications.[51]

Furthermore, quality can also be partially determined by the customer service itself, meaning how well network providers cater their services to customers' needs, how clear and user-friendly their contracts are or how providers deal with complaints from their customers. This dimension is very subjective and it is difficult to collect comprehensive datasets on such measures.

In general, suitable data for quality measures is very limited. Therefore, this report focuses on an analysis for one of the dimensions of quality (network quality) and one method (network tests) to measure it.

[49] The relation between competition and investment/innovation is often described as an inverted U-relation. Therefore, an increase in investment after a merger may only be expected if pre-merger competition was sufficiently high.

[50] Examples are network tests performed by German print magazines *connect* (among others for Austria and Germany), *CHIP* (for Austria and Germany) or *Futurezone* (for Austria).

[51] Several entities gather data on speed tests which are performed using mobile network connections. For example, data for many European countries from Ookla's speed test (http://www.speedtest.net/mobile) is used in GSMA's study on "Assessing the impact of mobile consolidation on innovation and quality". German print magazine *COMPUTER BILD* also generates and publishes data on the speed of data connections for Germany. BNetzA also gathers data on the speed of data connections for the German mobile market (https://breitbandmessung.de/mobil-testen) and publishes yearly reports of its findings.

8.3 Potential effects in Austria and Germany

To give an indication of the possible effects mergers might have on network quality, results of a comprehensive network test performed by *connect* and their partner *P3* are presented.[52] The analysis focuses on these results as they are available for the same time period as the data used in the price analysis. Data is available for Austria and Germany, but not for Ireland.

Figure 13 and Figure 14 show the development of the overall results of the network tests in Austria and Germany in the timeframe 2011 to 2017 (Austria), and 2012 to 2017 (Germany). The results are based on various parameters, mainly voice quality, speed and reliability of data transfer, as well as network coverage. The overall results are based on voice telephony tests (2017: 40% of the total score) and data connectivity tests (2017: 60% of the total score). The values in the graphs represent the percentage of the maximum points each operator achieved in the test in a certain year. The development of test scores for data and voice are shown in Annex 6.

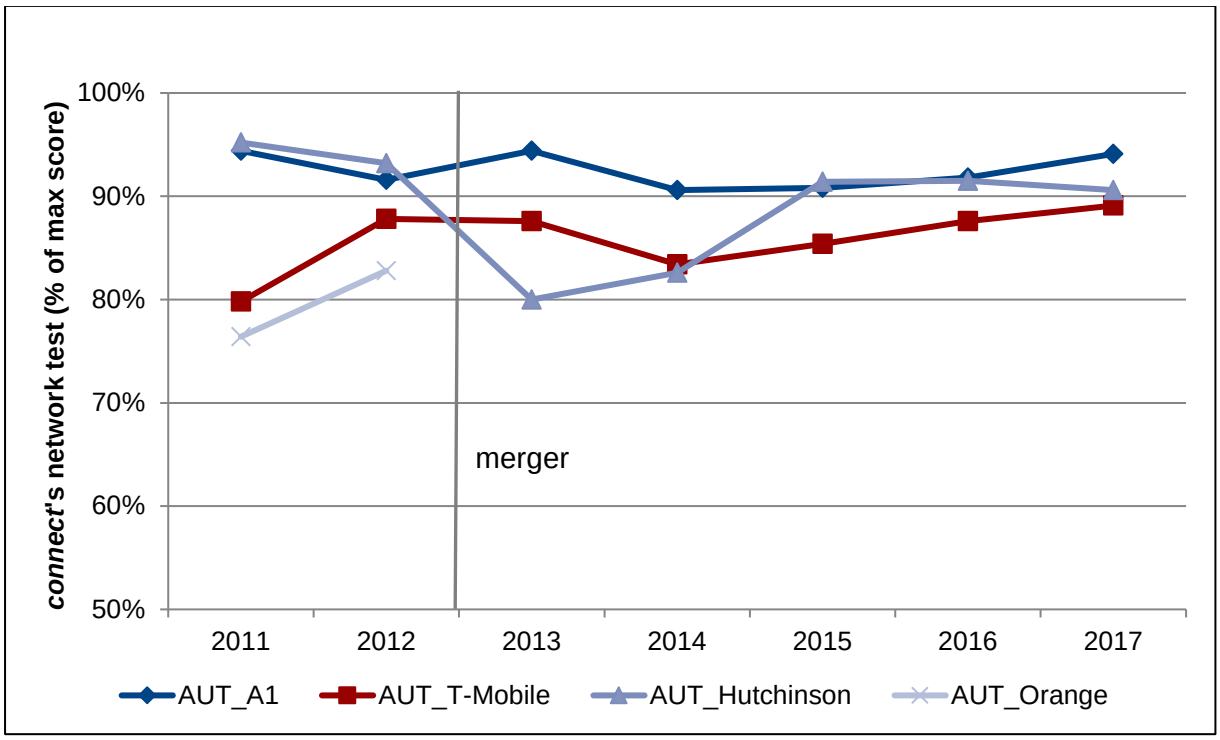


Figure 13: Overall results of *connect*'s network test, Austria 2011-2017

[52] *connect* is a German print magazine which reviews telecommunications products and services. The network tests are performed in larger cities and towns and on roads connecting cities or towns. The method makes use of drive tests, walk tests as well as tests on public transport. For a more detailed description of *connect*'s method to collect data, see information published for the 2015/16 network test as an example: http://www.connect.de/filedownload/documents/118649468/public-benchmark-2015-dach-information-package.pdf. Furthermore, some additional information on the methodology is also covered in Annex 6. The results of the tests are published online (see for example http://www.connect.de/vergleich/mobilfunk-netztest-2018-bestes-handy-netz-connect-3197967.html) and in the print magazine.

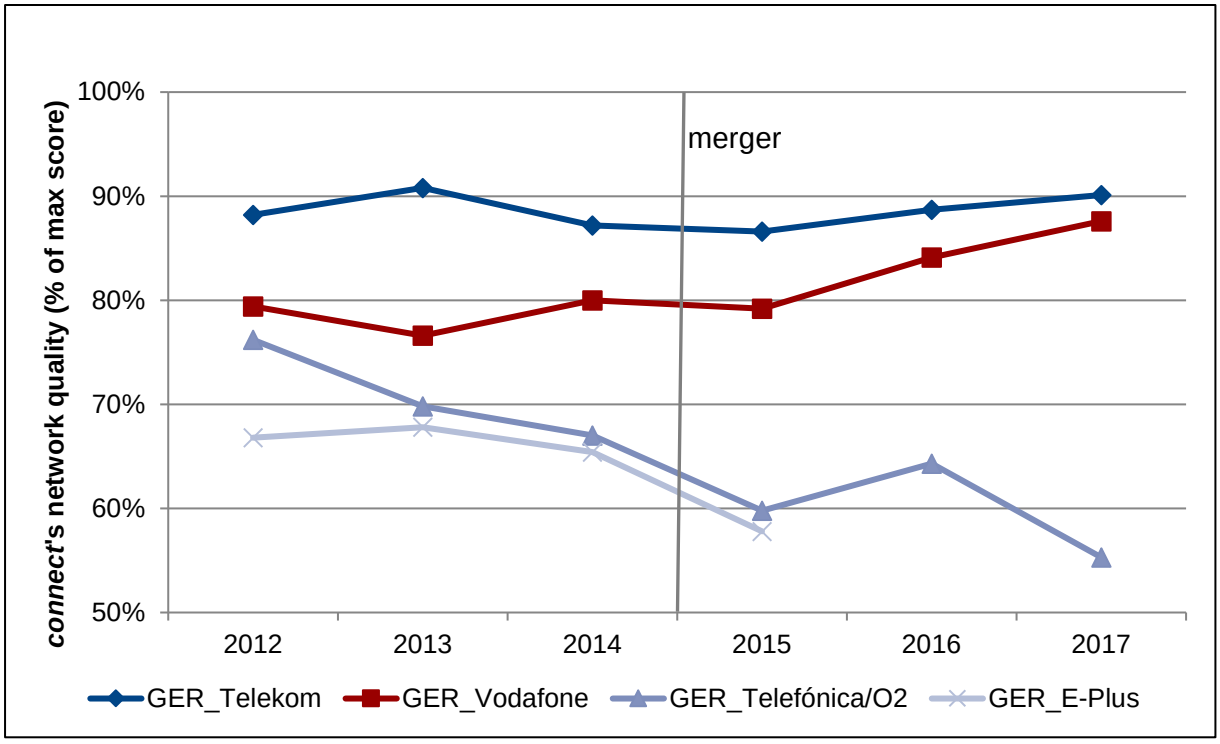


Figure 14: Overall results of *connect*'s network test, Germany 2012-2017

For this specific measure of network quality, in both cases there appears to be a short- to medium-run quality decrease compared to the pre-merger period and also compared to the non-merging operators.[53] As argued previously, this drop is most likely caused by the extensive effort necessary to integrate two separate networks. This would imply a negative effect on consumers, at least in the short to medium term.[54]

Regarding the long-term effects, the Austrian data seem to suggest that the network quality for the merged provider increased after a period of reduced quality, but did not fully reach the pre-merger level. Long-run improvements due to the merger therefore can only be observed for Orange customers, since Orange had a lower score pre-merger than the merged entity achieved three years after the merger.[55] For the other two providers (A1 Telekom and T-Mobile), no clear effect of the changed market structure on network quality is observable, at least until 2017.

For the German case (merger of Telefónica and O2), the integration process had not concluded as of 2017. Therefore, it is too early to predict how the merged provider's network quality will develop in the long run. This shows how long network integration and its potential

[53] It should be noted that for Telefónica and E-Plus the network quality seems to have slightly decreased even before the merger. This decline could be connected to the possible anticipation of the merger, but could also be unrelated to the merger.

[54] The results of the connect test for Austria are confirmed by a further network test of the Austrian magazine Futurezone (see e.g. https://futurezone.at/produkte/a1-gewinnt-futurezone-netztest-2017/300.746.959) where Hutchison falls behind the other operators in 2014 and 2015 compared to 2013 (the 2013 test was made in early 2013, at which time no merger effects can be expected).

[55] This is true in absolute terms but also relative to the non-merging parties.

effects on quality can take. For the other two providers (Deutsche Telekom and Vodafone), network quality seems to trend slightly upwards.

One study, which investigated quality effects of a mobile merger in detail, is GSMA (2017) (see Section 3). This study looks at the effects of the Hutchison/Orange merger in Austria and concludes that the merger had positive effects on 4G coverage and download speeds, in particular if the effect after two years is considered. The study uses a DiD approach – similar to this report's methodology for estimating price effects – based on data from (up to) 18 European countries and controls for supply and demand-related factors, such as spectrum holdings, GDP and population density. There are, however, some limitations regarding the method and data used in GSMA (2017):

- Firstly, for the analysis of the effects of the merger on Hutchison's 4G network quality (in terms of download speeds), there are no data available for the pre-merger period (see GSMA, 2017, p. 24). In BEREC's view, consistently estimating post-merger differences with a DiD approach and using that to make causal inference would also require pre-merger data.
- Secondly, with regard to the effects of the merger on download speeds for all Austrian operators, pre-merger data is available, but only for a short period of time (i.e. four quarters). Furthermore, the chart and the estimated coefficients suggest that the largest effect occurred immediately after the merger, namely in the next two quarters of the first year (see GSMA, 2017, p. 26-27). It is very unlikely, in BEREC's view, and inconsistent with data shown in our descriptive analysis, that positive quality effects, measured by download speeds, could be realised in such a short timeframe after the merger. This suggests that there might be other factors influencing network quality (or, in this case, average download speeds) which are not controlled for in the regression.
- Thirdly, regarding the effects on 4G coverage, the pre-merger levels were very low across Europe. It is inevitable therefore that the fixed effect for Hutchison Austria in the pre-merger period is quite small. In the post-merger period (in particular after 2014), coverage is more widespread, for instance from 50% to 100%. This might imply that the estimated post-merger differences might rather capture structural differences not captured in the pre-merger period rather than the true effect of the merger. It is debateable whether a pre-merger period with no 800MHz spectrum available in Austria (and 1800 MHz spectrum not allowed for 4G) can really result in a good counterfactual for rollout after the merger with 800 MHz / 1800MHz spectrum.

BEREC is therefore of the view that a number of challenges remain for estimating the effects of mergers on network quality.

In summary, the results of the analysis of one of the measures of network quality can give some insights as to how quality might be affected by a structural change in the market, namely a merger. Network quality, in this example a specific network test, is only one of the measures of quality. Specifically, the data from the *connect* network test seem to suggest that the mergers in Austria and Germany had negative effects on network quality in the short to medium run. The long-run effects are uncertain: in Germany, the network integration is still ongoing and in Austria there might have been positive effects for Orange customers but not necessarily for Hutchison customers. Of course, this analysis should be interpreted with caution, since it only looks at the development of a specific measure of network quality in the countries affected.

9 Conclusions

This report presents estimates of price effects of three mobile-to-mobile telecom mergers in the EU which took place in the years 2013 and 2014 in Austria, Germany and Ireland. Detailed tariff data from MNOs in 13 European countries, as well as other control variables (MTRs and GDP) are used to estimate the effects of the mergers on prices with the well-established DiD-framework and the synthetic control group approach.

In all of the three cases considered, there is at least some evidence that retail prices for new customers increased due to the merger compared to the situation without the merger (the counterfactual). However, the patterns differ across countries:

In Austria, for which data from two years prior to the merger and three years post-merger are available, there is evidence that the merger led to significant price increases in 2014 and 2015. In 2016 H1, the effect became considerably smaller and statistically insignificant in most specifications (although, for the medium usage basket, some effect in 2016 H1 cannot be ruled out completely). This is likely caused by competitive pressure from MVNOs, which gained significant market share since entry at the beginning of 2015. This suggests, however, that the MVNO remedy took more than three years to actually become effective for Austrian consumers.

For Ireland and Germany, data are available only for one and a half years after the merger and therefore only short- to medium-run effects can be estimated.

In the Irish case, the results of the estimations suggest that the merger led to a statistically significant price increase in all three baskets (low, medium and high usage), but that the magnitude and persistence of this effect varies across baskets. It is only for the high basket that the price effect is sustained across the entire period under study. Although the size of the coefficients and the statistical significance vary across specifications – especially for the high and medium baskets – most of the robustness checks do show at least one statistically significant price increase in at least one post-merger period for each of the three baskets. The effects of the MVNO remedy were small: two MVNOs entered the market in the second half of 2015 but their market share remained <1% each by mid-2017 and one of the MVNOs left the market in 2018.

In the German case, there is also evidence of price increases for all three baskets in the basic specification. However, the results are not very robust across specifications for the high and the medium basket. In case of the low basket, it should also be considered that no data is available for the MVNO and service provider segment, which is relatively large in Germany (approximately 20%) as well as sub-brands of MNOs. The possibility that pricing in this segment differs systematically from MNO pricing or that the merger affected pricing in different ways cannot be excluded, and consequently the conclusions of the results for the low basket may not be representative of the whole low price segment.

What lessons can be learned from these three cases? All three mergers considered in this report were 4-to-3 mergers and involved the smallest competitor, thereby increasing market symmetry considerably (in no case was a competitor with less than 20% market share left). Unilateral (as well as coordinated) effects may arise due to such a change in market structure. Precisely because of such expectations, the mergers were only approved with remedies.

These remedies were both structural and behavioural in nature. Structural remedies should have facilitated the entry of a new MNO, but these remedies had not become effective in any

of the cases considered by the time that this report is published. It is beyond the scope of this report to study the reasons for this.

The behavioural remedies consisted in granting access to MVNOs. The Austrian case shows that such a remedy might take considerable time (several years) to become effective, in particular if the MVNO segment pre-merger is small and MNOs already follow a multi-brand strategy. The Irish case also seems to provide some evidence in this regard, as the MVNOs that entered the market based on the merger commitments have not gained significant market shares so far. The German case is a bit different, as the MVNO segment pre-merger was significantly larger than in Austria or Ireland and an already established MVNO (Drillisch) benefitted from the merger remedies. It appears that the remedy became effective earlier compared to the Austrian or Irish case.

The wholesale billing scheme (per unit versus capacity based) might have also had some influence on the timing and competitive impact of MVNO entry. In Austria, the wholesale billing is per unit. Therefore, there was little pressure for the up-front MVNO to enter the market quickly. Once they entered the market, it appears that they were able to develop competitive pressure on MNOs (based on the per unit wholesale prices). In the Irish and German case, the access is capacity based. One would therefore assume that MVNOs have an incentive to enter the market and grow quickly in order to cover up-front costs for capacity. However, this seemed to have happened only in the German case. This suggests that similar remedies can lead to quite different results, depending on the national circumstances.[56]

This study also discusses some evidence of quality effects of the mergers in Austria and Germany. In BEREC's view, there are a number of difficulties with measuring quality in the first place and even more so for determining the effects of mergers on quality. The data from network tests that are analysed in this report suggest that there are some negative consequences for consumers of the merged entities, which may be due to (technical) issues with network integration in the short to medium run. The long-run effects are uncertain.

In conclusion, this study confirms that a careful approach should be taken with 4-to-3 mergers. Structural remedies might not be possible to implement at all and MVNO remedies may take considerable time to become effective or might not be sufficiently effective (or at least not in all parts of the market).[57] This report provides some evidence that, even with such remedies, the studied mergers led to price increases compared to a situation without the mergers in the short to medium run (even up to three years after the merger in the Austrian case).

[56] In Germany, Drillisch was already established as a competitive and low-price mobile brand, whereas the new MVNOs in Ireland entered the market without an established base of mobile customers.

[57] It might also be questioned how sustainable MVNO competition will be as the market evolves. For instance, it might be difficult for MVNOs to get full access to new technologies. Also, changes in regulation, such as the Roaming Regulation, might have a negative impact on MVNOs. Finally, the commitments are usually imposed for a certain period of time (e.g. ten years) and there is some uncertainty about what would happen afterwards.

Abbreviations

Country abbreviations:

AT: Austria	BE: Belgium	CZ: Czech Republic	DE: Germany
DK: Denmark	EL: Greece	ES: Spain	IR: Ireland
IT: Italy	NO: Norway	PL: Poland	PT: Portugal
SE: Sweden	UK: United Kingdom		

Other abbreviations:

ARPU	Average revenue per user
CAPEX	Capital expenditure
EBITDA	Earnings before interest, taxes, depreciation and amortization
EC	European Commission
EU	European Union
DiD	Differences in differences
GDP	Gross domestic product
M&A	Mergers and acquisitions
MNO	Mobile network operator
MTR	Mobile termination rates
MVNO	Mobile virtual network operator
RMSPE	Root mean squared prediction error

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Annex 1: Basket price calculation

Tariff data

Detailed Tariff data were provided by IDATE/Tarifica according to a format specified by BEREC. The tariff elements included in the database are:

- Activation charge/connection fee/yearly service fee
- Monthly rental/fixed fee
- Minimum rental per month
- Number of minutes/SMS included in the fixed fee by target network (i.e. on-net, off-net or fixed networks)
- Data included total and until throttling of speed
- Price per minute/SMS and one-time connection fee by target network
- Allowances/included units
- Minimum revenues

Information on handset subsidies was not available.

Altogether, we have more than 20,000 tariff observations from 48 operators on a semi-annual basis.

Usage data and price calculation

The usage data consists of the following elements:

- Number of minutes to (national) landlines
- (National) on-net minutes
- (National) off-net minutes to mobile
- (National) SMS
- Data

International calls, voicemail calls and MMS are not included because those services are rarely used and consistent tariff data over the entire period were not available for all countries. Neither is there any consistent information available about additional services, such as music or TV streaming. As such, those services are not considered in the calculations of the prices over time.

The usage data for the basket calculation is taken from BEREC (2016) – this data is based on information from national regulatory authorities for an average user of mobile services in 2013. The usage data include (dedicated) mobile broadband services, which are not considered in our analysis. As in RTR (2016), we only take half of the average usage to account for this. The usage data are depicted in Table 9.

Table 9: Average usage 2013 and 2014 per month

		AT	BE	CZ	DE	DK	ES	UK	EL	IR	IT	PL	PT	SE
2013	min to fixed	28	20	22	16	25	22	27	32	33	27	21	28	30
	min on-net	56	41	44	32	50	44	54	63	66	54	41	57	60
	min off-net	56	41	44	32	50	44	54	63	66	54	41	57	60
	SMS	37	176	54	27	98	6	130	34	144	65	71	172	84
	data in MB	361	68	69	99	366	114	151	32	326	151	88	39	832
2014	min to fixed	28	21	26	18	26	25	28	36	36	29	24	25	32
	min on-net	56	42	52	36	53	51	55	72	73	58	49	50	63
	min off-net	56	42	52	36	53	51	55	72	73	58	49	50	63
	SMS	29	166	54	18	88	4	110	30	118	41	76	123	77
	data in MB	559	80	91	163	616	168	241	69	560	224	191	152	1106

Source: BEREC (2016)

In our base specification, the 2013 usage is kept constant over the entire period in order to prevent changes in consumption patterns potentially impacting the observed prices.

In a robustness check, we calculate a chain index with the 2013 usage for the years before and including 2013, and the 2014 usage for the years 2014 and thereafter. We calculate the chain index as follows: first we calculate two price time series, one based on 2013 usage and one based on 2014 usage. Then we calculate the chain index as:

*p_chain_H1-14 = p_usage2013_H1-14 * p_usage2013_H2-13 / p_usage2013_H2-13*

for H1/2014 and thereafter as

*p_chain = p_usage2014_t * p_chain_t-1 / p_usage2014_t-1.*

In order to reflect different market segments and the highest possible number of tariffs, we use three different user types (low, medium, high).

We calculate the monthly expenditure on each tariff based the following assumptions:

- The average duration of a call is two minutes (similar to OECD (2006)). Billing intervals are not included in the calculations.
- Activation fees are divided equally over 24 months, which often corresponds to the minimum contract period. An annual service fee (which most Austrian operators charge) is divided over 12 months.
- With regard to tariffs for the use of data services, the only ones that are considered are those where the amount of data included in the monthly fixed fee is equal to or exceeds the data usage in the respective basket. Per-unit (excess) data charges are not available for all tariffs and therefore are not considered.

Once a price has been calculated for each tariff, the four (or in a robustness check two) cheapest tariffs per operator are selected.[58] The reason why we include four tariffs per operator in the basic specification rather than just one or two, is that consumers are rarely perfectly informed about their own consumption and the range of tariffs in the market.

[58] We eliminate the lowest 1% and the highest 5% of all tariffs to exclude implausibly low and high values (and to exclude very expensive tariffs which are unlikely to be chosen by a significant share of customers in practice).

Therefore, they cannot all be expected to select the optimal tariff. In this way we also cover a wider range (and larger share) of tariffs.

A maximum of 50% pre-paid plans are taken into account per operator and point of time. This is to ensure that not only cheaper pre-paid plans are included in the average price per operator, even though post-paid tariffs usually have larger market shares. Youth and social tariffs are not considered. Using the average of the four (or two) tariffs per operator, the mean per country and point of time is calculated, weighted by the operators' market shares, which shows the price development over time.

The price time series for the different countries based on the four cheapest tariffs per operator and constant 2013 usage are depicted in Figure 15 to 17

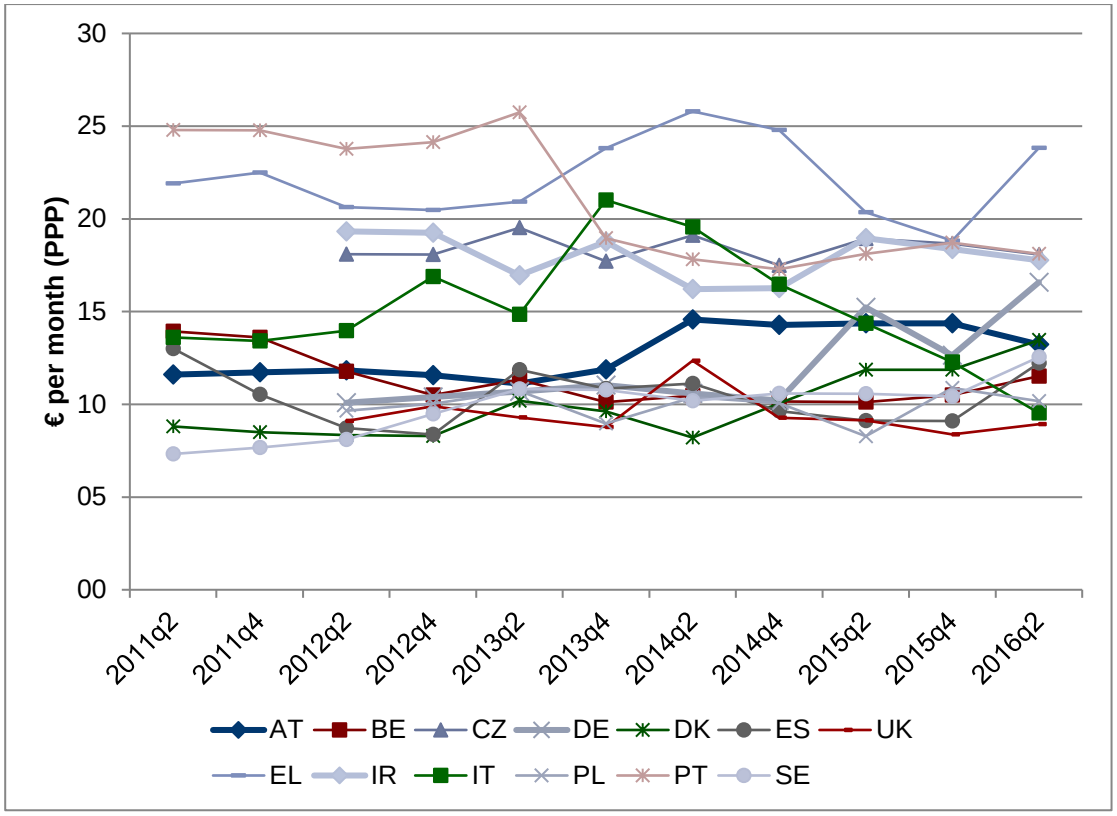

Figure 15: Price trends low usage basket (4 cheapest tariffs, constant 2013 usage)

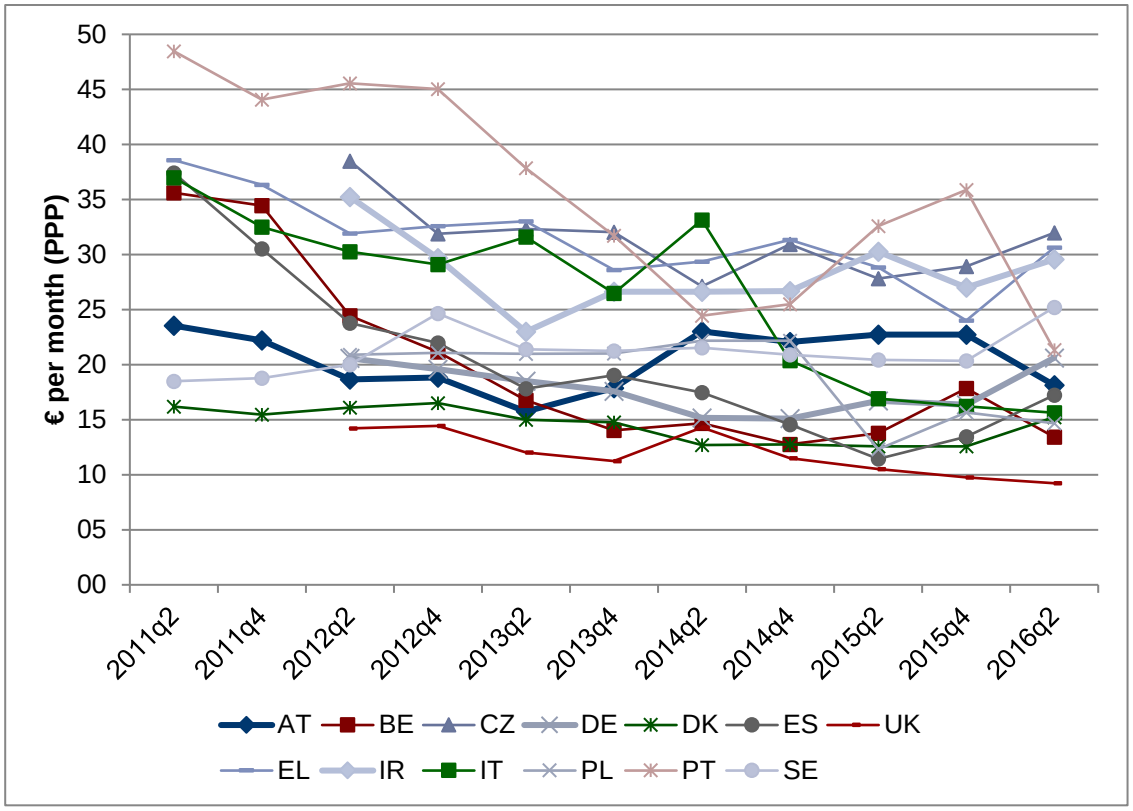

Figure 16: Price trends medium usage basket (4 cheapest tariffs, constant 2013 usage)

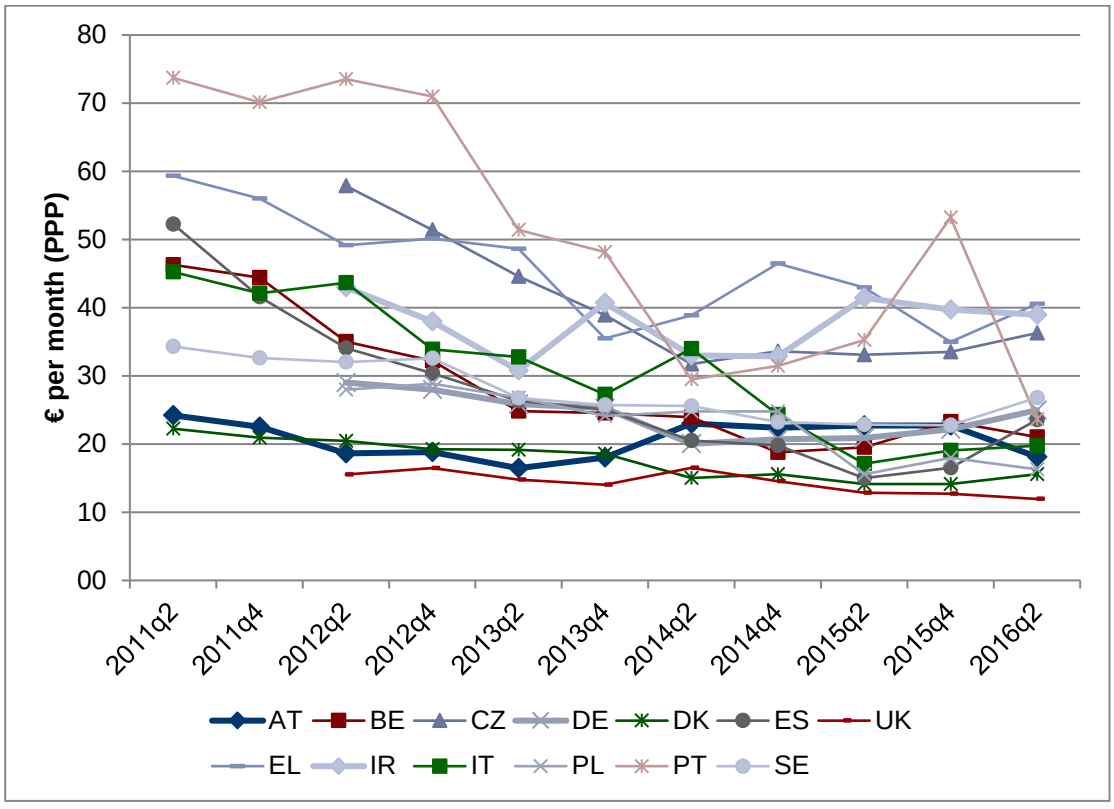

Figure 17: Price trends high usage basket (4 cheapest tariffs, constant 2013 usage)

Annex 2: Details on the estimation technique

The DiD approach

For the three usage baskets we estimate the following fixed effects[59] model at the operator level:

$$(1)\ \ln(p_{i,t}) = \gamma_t D_{i,t} + \delta_1 GDP\ growth_{i,t} + \delta_2 \ln(MTR_{i,t}) + \tau_t + c_{i,k} + \varepsilon_{i,t}$$

where $\ln(p_{i,t})$ is the natural logarithm of the real price of the respective basket in country i at time t, τ_t is a time fixed effect for period t, c_i is a fixed effect for country i, $D_{i,t}$ are dummies which take the value 1 for the merging country and each half year t after the merger and $\varepsilon_{i,t}$ is an idiosyncratic error term. The coefficient of interest is γ_t, which can be interpreted as the merger effect in period t following the merger.[60]

DiD estimators are unbiased if the average outcomes of the treated and control groups would follow the same parallel trend over time. We test whether the pre-merger trend of the affected countries is similar to the average trend of the control countries. A similar pre-merger trend may thus suggest that the estimated price effects are reliable (Angrist and Pischke, 2008).

We carry out a formal test of the common trend hypothesis. To perform this test we first estimate the deviation of the treated country's price from the average price of the control countries in each quarter. Then, the test assesses whether the deviations of the treated country's price in the pre-merger period follow a different trend than the average price of the control countries.[61]

When the test fails, country specific linear trends can be included in the DiD model. Under this model specification, the identification of the effect relies on the assumption that, absent the merger, the price in the treated country would have followed the same pre-existing (linear) trend that characterised the pre-merger period (after controlling for the other time-varying explanatory variables and for the common time effect). It is assumed that the diverging trends will continue in the post-intervention periods between the treatment and control groups

In the DiD specification with country-specific trends we follow an approach similar to Wolfers (2006). Formally, we estimate the following specification (trend specification):

$$(2)\ ln(p_{k,i,t}) = \gamma_t D_{i,t} + \partial_i t + \delta_1 GDP\ growth_{i,t} + \delta_2 ln(MTR_{i,t}) + \tau_t + c_{i,k} + \varepsilon_{k,i,t}$$

[59] Fixed effects are applied at the country level. That means that a dummy variable is included for each country to control for country-specific effects which are constant over time.

[60] In one of the robustness checks we estimate equation (1) at the operator level and include operator-specific fixed effects.

[61] Formally, we substitute the short-term and medium-term effect dummies in equation (1) with one dummy variable for each half year that assumes the value of 1 only for the treated country in the relevant half year. We then compute the slope of a linear trend of the coefficients of these dummies in the pre-merger period and test whether the estimated slope is statistically different from zero using the *lincom* command in Stata. Our test is similar to the one proposed by Ashenfelter et al (2013) and to the one discussed by Angrist, Pischke (2008). This test is "passed" when we are not able to reject the null-hypothesis (at the 10% level). This however only provides some indication that a common trend may exist pre-merger, in particular because there are only a few pre-merger observations.

where $\partial_i t$ represents the country-specific linear trends.

However, assuming that diverging trends will continue in the post-intervention periods may not be appropriate, as trends often converge in the long run. In that case, allowing for (linear) country specific trends may even result in more biased estimates than the standard DiD estimator (see O'Neill et al. (2016)). Testing the common trend hypothesis and including country specific trends is also sensitive to the number of pre-treatment periods, with results improving with the number of pre-treatment periods. As we only have four pre-merger observations, testing the common trend hypothesis or including a country-specific trend can be problematic. If the common trend assumption is not met pre-merger, we therefore present and discuss the results of both specifications (with and without trends).

Bertrand et al (2004) showed that not taking into account existing autocorrelation can lead to underestimated standard errors and therefore the erroneous finding of statistically significant results. Therefore, we account for autocorrelation and heteroscedasticity in the residuals by using a cluster-robust estimator with clustering at the country level. This allows the error terms to be correlated within a country and over time, but not across countries. However, the small sample of available countries (and, therefore, clusters) likely still results in a downward bias in the standard errors, and, in turn, somewhat spuriously increases the statistical significance of the merger effects estimated by the models (Wooldridge, 2003).

Annex 3: Descriptive statistics

Table 10: Summary statistics for the country-level analysis of the Austrian merger (half-yearly data from 2011 H1 to 2016 H1, merger period (2013 H1) excluded)

	count	mean	sd	min	max
Total					
p_low4_real	80	14.032	5.064	7.118	25.685
p_med4_real	80	23.493	9.008	11.271	50.218
p_high4_real	80	31.080	14.763	13.873	76.384
gdp_growth	80	-0.002	0.011	-0.029	0.028
mtr_real	80	2.187	1.679	0.722	7.276
AT					
p_low4_real	10	13.259	1.203	11.536	14.872
p_med4_real	10	21.180	1.959	17.953	23.667
p_high4_real	10	21.468	2.018	17.953	24.329
gdp_growth	10	0.001	0.005	-0.006	0.008
mtr_real	10	1.502	0.760	0.797	2.684
BE					
p_low4_real	10	11.539	1.632	10.058	14.586
p_med4_real	10	20.985	9.528	13.097	37.280
p_high4_real	10	29.992	11.271	19.410	48.468
gdp_growth	10	0.003	0.004	-0.003	0.010
mtr_real	10	2.172	1.396	1.152	4.502
DK					
p_low4_real	10	10.131	1.700	8.090	13.406
p_med4_real	10	14.537	1.732	12.537	16.721
p_high4_real	10	17.740	3.362	13.873	22.996
gdp_growth	10	0.006	0.006	-0.002	0.018
mtr_real	10	2.262	1.960	0.722	6.147
ES					
p_low4_real	10	10.622	1.383	8.981	13.345
p_med4_real	10	20.938	8.390	11.271	38.379
p_high4_real	10	28.581	12.028	14.864	53.631
gdp_growth	10	-0.003	0.011	-0.016	0.018
mtr_real	10	2.374	1.724	1.074	5.150

	count	mean	sd	min	max
EL					
p_low4_real	10	22.026	1.701	19.026	24.316
p_med4_real	10	31.740	3.987	24.016	37.433
p_high4_real	10	46.273	7.807	35.000	57.581
gdp_growth	10	-0.011	0.015	-0.029	0.023
mtr_real	10	2.667	1.823	1.090	4.803
IT					
p_low4_real	10	14.619	3.327	9.457	20.779
p_med4_real	10	24.382	8.091	15.504	38.595
p_high4_real	10	29.267	11.098	16.951	47.235
gdp_growth	10	-0.006	0.008	-0.017	0.006
mtr_real	10	2.831	2.714	0.950	7.276
PT					
p_low4_real	10	20.865	3.607	16.322	25.685
p_med4_real	10	35.102	9.923	21.008	50.218
p_high4_real	10	50.364	19.536	23.324	76.384
gdp_growth	10	-0.005	0.013	-0.027	0.015
mtr_real	10	2.225	1.509	0.818	5.180
SE					
p_low4_real	10	9.194	1.607	7.118	12.399
p_med4_real	10	19.077	2.708	15.385	24.906
p_high4_real	10	24.952	6.057	17.394	35.101
gdp_growth	10	0.000	0.017	-0.024	0.028
mtr_real	10	1.461	0.758	0.804	2.762

Table 11: Summary statistics for the country-level analysis of the Irish merger (half-yearly data from 2012 H1 to 2016 H1, merger period (2014 H2) excluded)

	count	mean	sd	min	max
Total					
p_low4_real	88	14.092	4.936	8.209	25.660
p_med4_real	88	22.729	8.284	9.172	45.955
p_high4_real	88	29.847	12.888	11.875	74.159
gdp_growth	88	0.002	0.018	-0.047	0.085
mtr_real	88	1.818	1.180	0.722	5.438
IR					
p_low4_real	8	18.205	1.192	16.145	19.481
p_med4_real	8	28.507	3.651	23.005	35.521
p_high4_real	8	38.206	4.275	30.806	43.337
gdp_growth	8	0.013	0.042	-0.047	0.085
mtr_real	8	2.828	1.062	1.043	4.446
BE					
p_low4_real	8	10.812	0.696	10.058	12.058
p_med4_real	8	17.087	4.226	13.097	25.045
p_high4_real	8	25.662	5.729	19.410	35.876
gdp_growth	8	0.004	0.004	-0.002	0.010
mtr_real	8	1.595	0.778	1.152	2.869
CZ					
p_low4_real	8	18.616	0.584	17.800	19.559
p_med4_real	8	31.493	3.792	27.164	39.159
p_high4_real	8	41.212	9.969	31.810	58.875
gdp_growth	8	0.001	0.012	-0.014	0.014
mtr_real	8	1.919	1.516	0.970	4.357
DK					
p_low4_real	8	10.257	1.942	8.215	13.406
p_med4_real	8	14.490	1.675	12.537	16.695
p_high4_real	8	17.114	2.670	14.098	20.703
gdp_growth	8	0.005	0.003	0.001	0.011
mtr_real	8	1.512	1.149	0.722	3.579
ES					
p_low4_real	8	10.083	1.470	8.280	12.149
p_med4_real	8	17.631	4.076	11.271	23.941
p_high4_real	8	23.754	6.574	14.789	34.339
gdp_growth	8	-0.003	0.008	-0.016	0.008
mtr_real	8	2.004	1.302	1.074	4.080

	count	mean	sd	min	max
UK					
p_low4_real	8	9.573	1.236	8.353	12.328
p_med4_real	8	12.108	2.302	9.172	14.891
p_high4_real	8	14.519	1.927	11.875	16.878
gdp_growth	8	0.010	0.024	-0.028	0.041
mtr_real	8	1.553	0.954	0.936	3.686
EL					
p_low4_real	8	21.331	2.326	18.828	25.223
p_med4_real	8	29.158	2.494	24.016	31.823
p_high4_real	8	41.570	5.466	34.756	48.174
gdp_growth	8	-0.010	0.014	-0.024	0.023
mtr_real	8	2.140	1.630	1.090	4.757
IT					
p_low4_real	8	15.244	3.734	9.457	20.909
p_med4_real	8	24.821	7.454	15.504	32.861
p_high4_real	8	28.357	9.397	16.951	43.959
gdp_growth	8	-0.005	0.007	-0.017	0.005
mtr_real	8	1.800	1.577	0.950	5.438
PL					
p_low4_real	8	9.848	0.899	8.238	10.924
p_med4_real	8	18.520	3.709	12.252	21.953
p_high4_real	8	22.704	5.339	15.492	28.821
gdp_growth	8	0.009	0.012	-0.003	0.030
mtr_real	8	1.731	1.081	1.005	3.665
PT					
p_low4_real	8	20.649	3.349	17.802	25.660
p_med4_real	8	34.289	8.888	21.008	45.955
p_high4_real	8	48.243	18.456	23.324	74.159
gdp_growth	8	-0.001	0.010	-0.018	0.015
mtr_real	8	1.621	0.874	0.818	3.530
SE					
p_low4_real	8	10.388	1.197	8.209	12.399
p_med4_real	8	21.909	1.922	20.232	24.906
p_high4_real	8	26.980	3.844	22.642	32.837
gdp_growth	8	0.002	0.018	-0.024	0.028
mtr_real	8	1.296	0.566	0.804	2.332

Table 12: Summary statistics for the country-level analysis of the German merger (half-yearly data from 2012 H1 to 2016 H1, merger period (2014 H2) excluded)

	count	mean	sd	min	max
Total					
p_low4_real	77	13.621	4.761	8.215	25.660
p_med4_real	77	21.162	7.745	9.172	45.167
p_high4_real	77	27.232	11.408	11.875	71.220
gdp_growth	77	0.002	0.012	-0.028	0.041
mtr_real	77	1.469	0.817	0.722	4.756
DE					
p_low4_real	7	12.478	2.453	10.547	16.532
p_med4_real	7	17.848	1.948	15.191	20.557
p_high4_real	7	23.961	3.023	20.058	28.380
gdp_growth	7	0.007	0.007	-0.007	0.016
mtr_real	7	2.003	0.629	1.655	3.418
BE					
p_low4_real	7	10.634	0.520	10.058	11.411
p_med4_real	7	15.950	2.962	13.097	21.467
p_high4_real	7	24.203	4.292	19.410	32.680
gdp_growth	7	0.004	0.004	-0.002	0.010
mtr_real	7	1.414	0.630	1.152	2.841
CZ					
p_low4_real	7	18.645	0.625	17.800	19.559
p_med4_real	7	30.398	2.362	27.164	32.534
p_high4_real	7	38.688	7.518	31.810	52.484
gdp_growth	7	0.003	0.011	-0.012	0.014
mtr_real	7	1.573	1.250	0.970	4.357
DK					
p_low4_real	7	10.517	1.942	8.215	13.406
p_med4_real	7	14.234	1.630	12.537	16.695
p_high4_real	7	16.601	2.421	14.098	19.448
gdp_growth	7	0.004	0.002	0.001	0.008
mtr_real	7	1.216	0.853	0.722	3.124
ES					
p_low4_real	7	10.267	1.485	8.280	12.149
p_med4_real	7	16.730	3.435	11.271	21.729
p_high4_real	7	22.242	5.392	14.789	30.040
gdp_growth	7	-0.002	0.007	-0.014	0.008
mtr_real	7	1.707	1.075	1.074	3.424

	count	mean	sd	min	max
UK					
p_low4_real	7	9.579	1.335	8.353	12.328
p_med4_real	7	11.711	2.169	9.172	14.792
p_high4_real	7	14.270	1.938	11.875	16.878
gdp_growth	7	0.007	0.024	-0.028	0.041
mtr_real	7	1.248	0.442	0.936	1.895
EL					
p_low4_real	7	21.547	2.424	18.828	25.223
p_med4_real	7	28.940	2.611	24.016	31.823
p_high4_real	7	40.759	5.360	34.756	48.174
gdp_growth	7	-0.007	0.013	-0.015	0.023
mtr_real	7	1.766	1.340	1.090	4.756
IT					
p_low4_real	7	15.412	4.000	9.457	20.909
p_med4_real	7	24.016	7.666	15.504	32.861
p_high4_real	7	26.128	7.527	16.951	33.927
gdp_growth	7	-0.003	0.006	-0.010	0.005
mtr_real	7	1.280	0.618	0.950	2.603
PL					
p_low4_real	7	9.881	0.965	8.238	10.924
p_med4_real	7	18.193	3.880	12.252	21.953
p_high4_real	7	21.967	5.309	15.492	28.821
gdp_growth	7	0.011	0.012	-0.001	0.030
mtr_real	7	1.455	0.806	1.005	3.087
PT					
p_low4_real	7	20.172	3.311	17.802	25.660
p_med4_real	7	32.622	8.138	21.008	45.167
p_high4_real	7	44.541	16.415	23.324	71.220
gdp_growth	7	0.001	0.008	-0.008	0.015
mtr_real	7	1.348	0.443	0.818	2.278
SE					
p_low4_real	7	10.700	0.875	9.562	12.399
p_med4_real	7	22.143	1.950	20.232	24.906
p_high4_real	7	26.196	3.391	22.642	32.837
gdp_growth	7	0.001	0.019	-0.024	0.028
mtr_real	7	1.148	0.412	0.804	1.755

Annex 4: Figures for the synthetic control group approach

These figures compare the price trends in the treated country to those of the synthetic control group. They show how good the pre-merger fit is, as well as the size and pattern of the post-merger effects. They are based on the basket price calculation with the four cheapest tariffs and with constant 2013 usage.

Figures for Austria

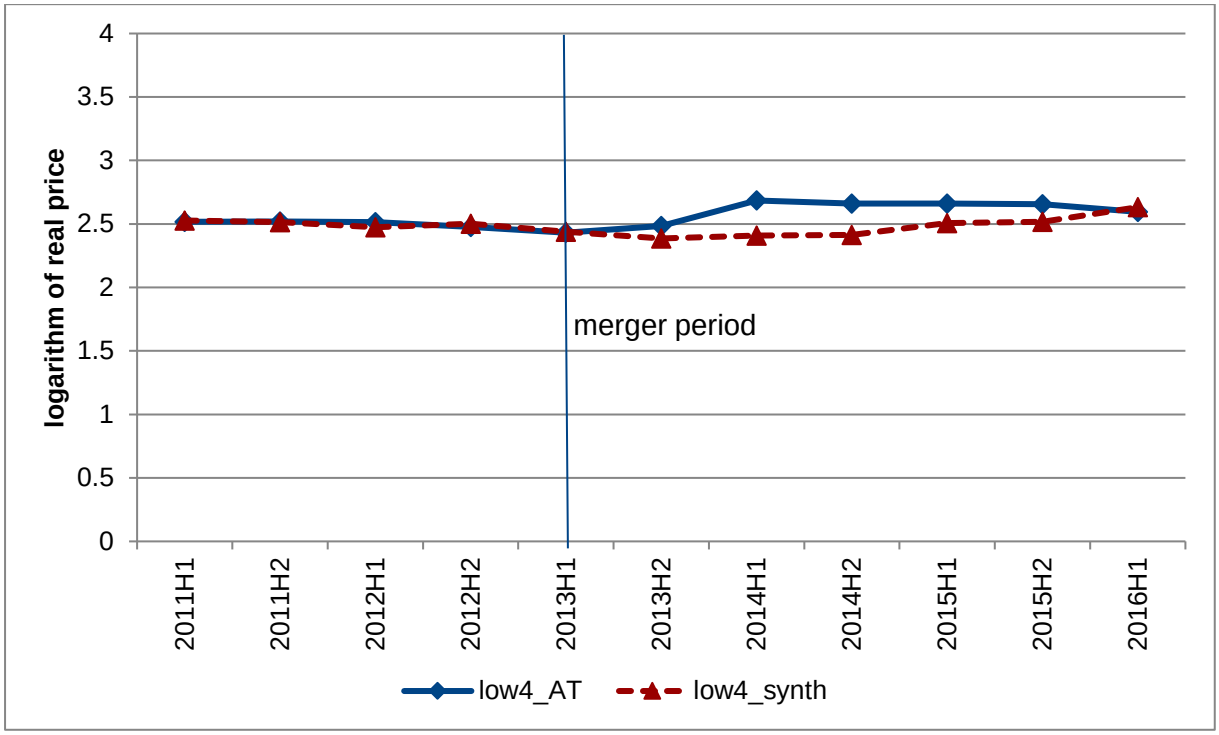

Figure 18: Austria vs. the synthetic control group for the low user

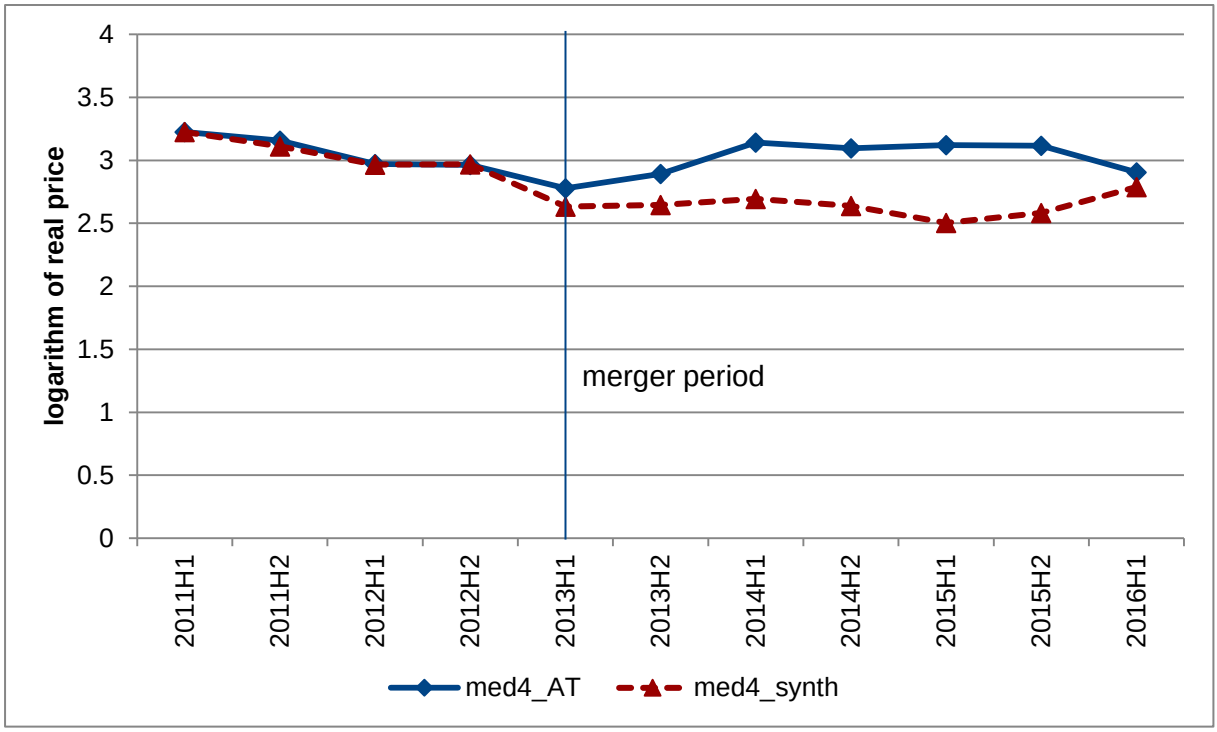

Figure 19: Austria vs. the synthetic control group for the medium user

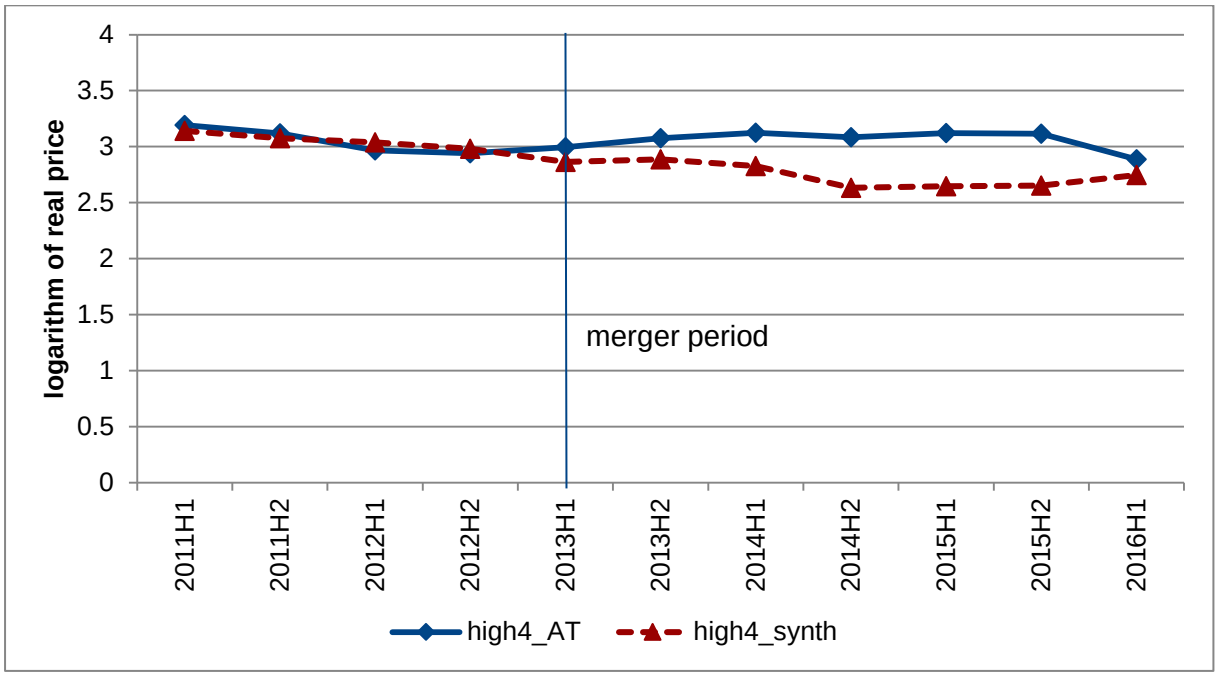

Figure 20: Austria vs. the synthetic control group for the high user

Figures for Ireland

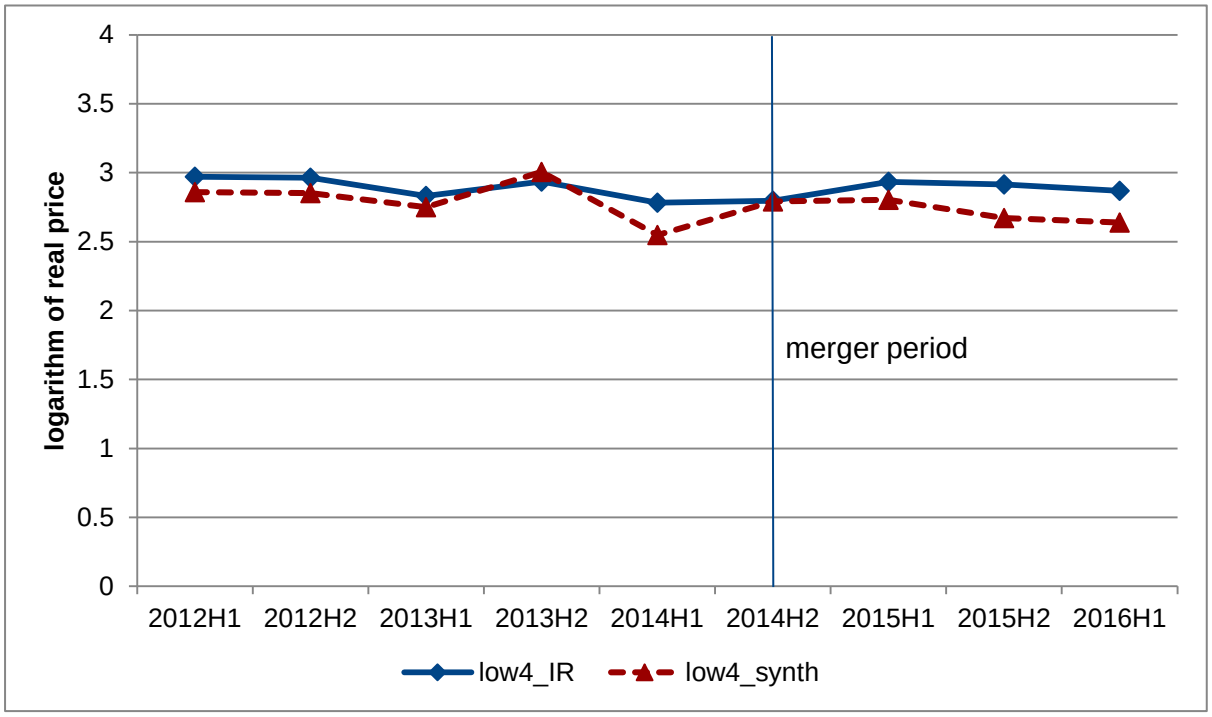

Figure 21: Ireland vs. the synthetic control group for the low user

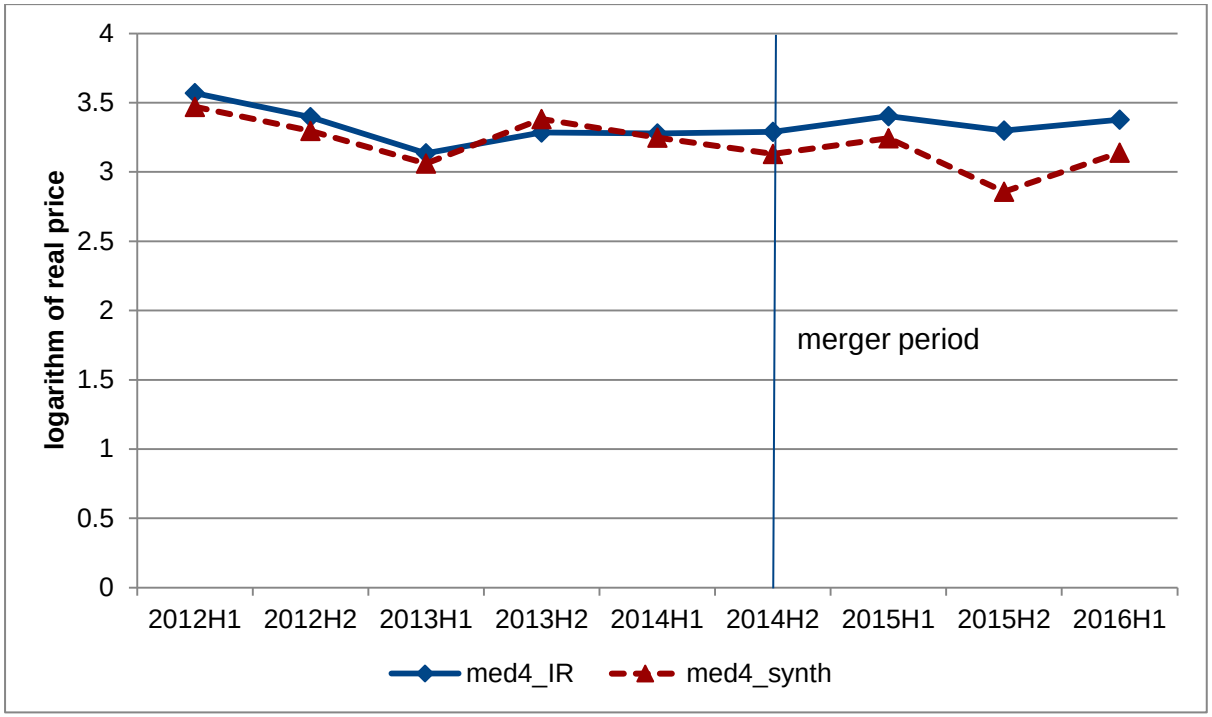

Figure 22: Ireland vs. the synthetic control group for the medium user

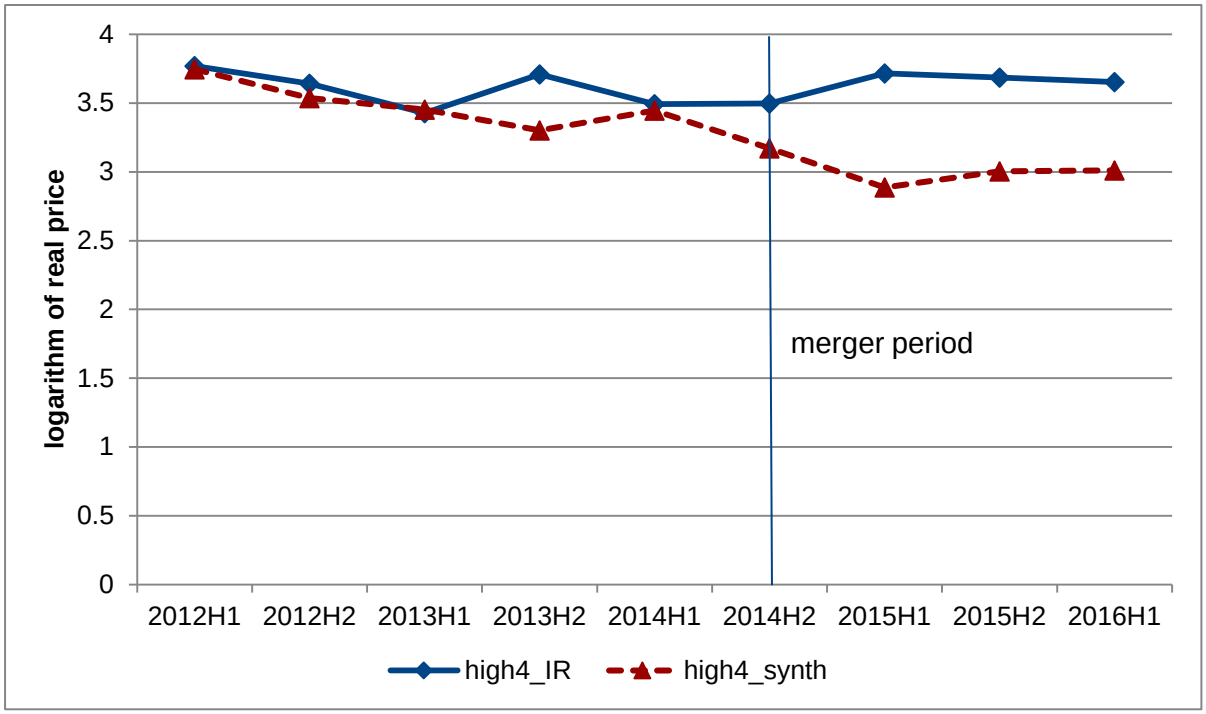

Figure 23: Ireland vs. the synthetic control group for the high user

Figures for Germany

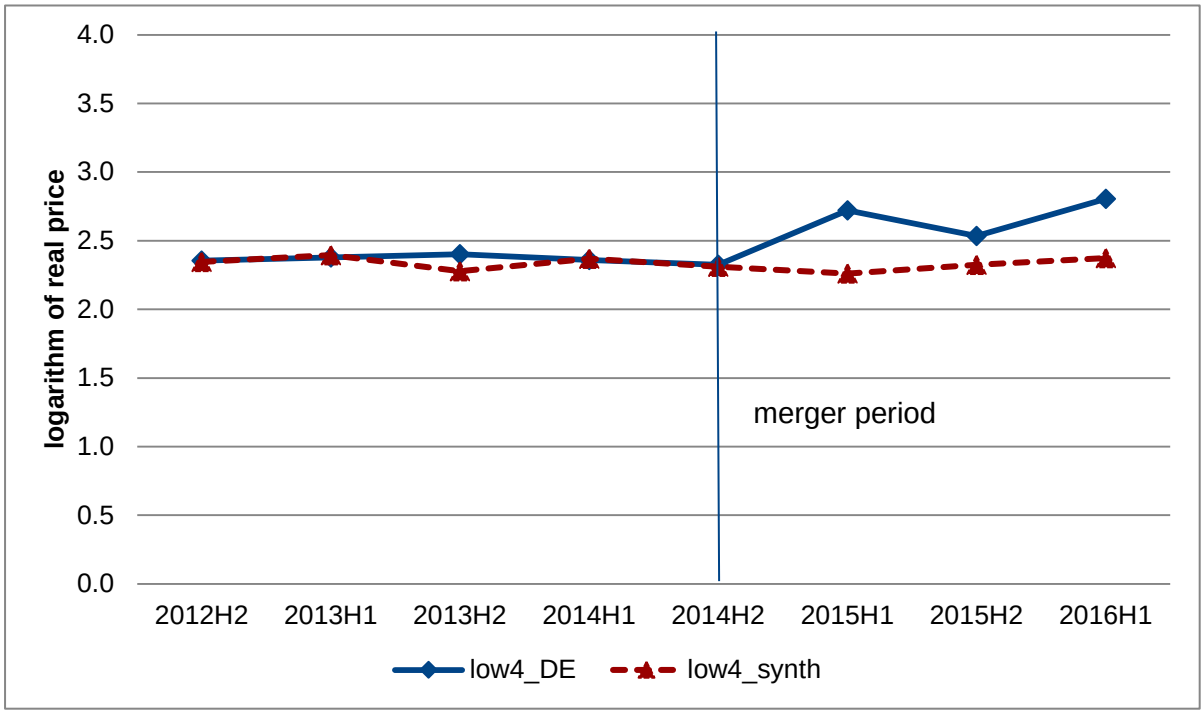

Figure 24: Germany vs. the synthetic control group for the low user

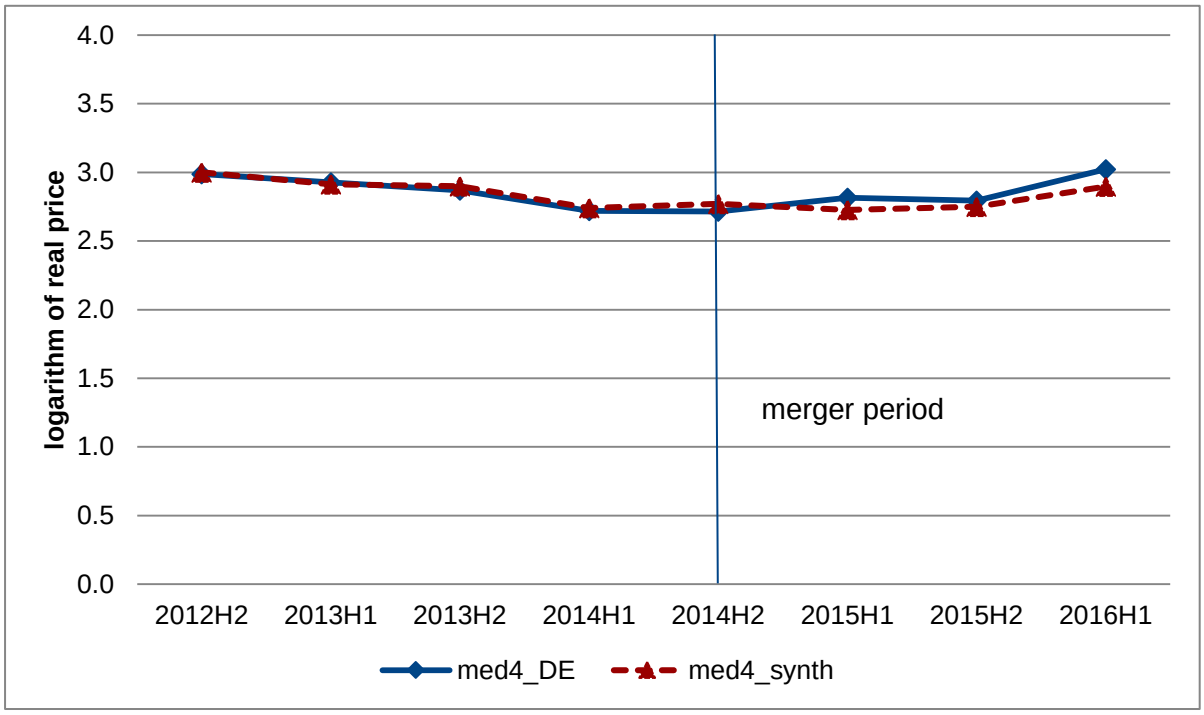

Figure 25: Germany vs. the synthetic control group for the medium user

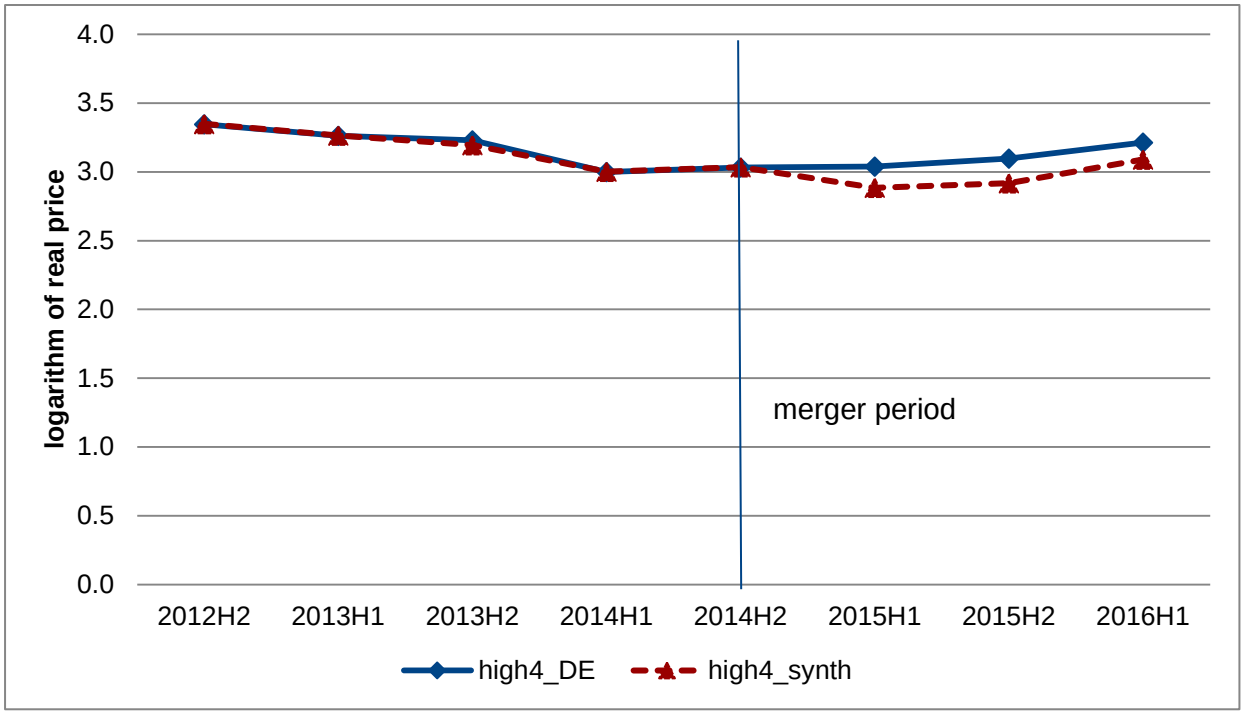

Figure 26: Germany vs. the synthetic control group for the high user

Annex 5: Robustness checks

In this section we present several robustness checks:

- Using only the two cheapest tariffs per operator per period.
- Using usage data from 2013 for the years up to 2013 and usage data from 2014 thereafter.
- Excluding the UK as a control for the analysis for Germany and Ireland.[62]
- Estimating the DiD-effects with operator-level (instead of country-level) data.

Robustness checks for Austria

1. With baskets based on the 2 cheapest tariffs instead of the 4 cheapest tariffs per operator and period.

[62] The merger between T-Mobile and Orange was in 2010. However, the rebranding to Everything Everywhere, or EE, only happened in 2014-2015. Our price baskets show some price effect in 2014, which could be interpreted as a late consequence of the 2010 merger.

Table 12: Results for Austria, 2 cheapest tariffs, country-level, 2013 usage

	Low (2 tariffs)			Medium (2 tariffs)			High (2 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2013 H2	0.163	0.216**	0.099†	0.307*	0.449***	0.200	0.477***	0.481***	0.078
	(0.268)	(0.048)	(0.000)	(0.093)	(0.002)	(0.571)	(0.001)	(0.007)	(0.714)
2014 H1	0.236**	0.174	0.390†	0.472***	0.592***	0.438	0.546***	0.462***	0.152
	(0.020)	(0.202)	(0.000)	(0.000)	(0.000)	(0.286)	(0.000)	(0.003)	(0.429)
2014 H2	0.214***	0.104	0.215†	0.617***	0.694***	0.473	0.745***	0.616***	0.418
	(0.002)	(0.445)	(0.000)	(0.000)	(0.000)	(0.286)	(0.000)	(0.001)	(0.143)
2015 H1	0.168**	0.059	0.062†	0.566***	0.709***	0.513	0.748***	0.612***	0.412
	(0.040)	(0.709)	(0.000)	(0.000)	(0.001)	(0.143)	(0.000)	(0.005)	(0.286)
2015 H2	0.175	0.008	0.049	0.607***	0.685***	0.468	0.736***	0.548**	0.402
	(0.128)	(0.967)	(0.143)	(0.000)	(0.004)	(0.286)	(0.000)	(0.033)	(0.429)
2016 H1	0.051	-0.108	-0.094	0.366***	0.531*	0.201	0.577***	0.388	0.180
	(0.641)	(0.607)	(0.143)	(0.005)	(0.051)	(0.741)	(0.000)	(0.189)	(0.741)
GDP growth	-1.357	-2.798		4.995	1.533		3.851	2.705	
	(0.663)	(0.178)		(0.108)	(0.489)		(0.115)	(0.336)	
MTRs	-0.181	-0.315**		0.099	-0.015		0.038	-0.056	
	(0.109)	(0.027)		(0.441)	(0.906)		(0.724)	(0.741)	
constant	2.342***	7.428***		2.374***	12.592***		2.155***	2.590	
	(0.000)	(0.005)		(0.000)	(0.001)		(0.000)	(0.512)	
Obs.	80	80		80	80		80	80	
R^2	0.853	0.936		0.834	0.942		0.920	0.945	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 15.5%, DK: 50.1, ES: 5.3%, PT: 29.1%

Weights synth. control group med: DK: 84.2%, ES: 15.8%; Weights synth. control group high: DK: 100.0%

The results for the low usage and high usage basket are comparable to those of the specification with 4 tariffs. The results for the medium usage basket are somewhat stronger, in terms of the magnitude of the effect, in the DiD basic specification. The magnitude of the synth estimates is comparable, but they are not statistically significant. However, in 2014 and 2015 there are only 1 or 2 control group countries with placebo effects larger than Austria.

2. With increasing usage (2013 usage for 2011-2013 and 2014 usage for 2014-2016)
    a. With the four cheapest tariffs per operator and period

Table 13: Results for Austria, 4 cheapest tariffs, country-level, 2013 and 2014 usage

	Low (4 tariffs)			Medium (4 tariffs)			High (4 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2013 H2	0.109	0.089	0.005	0.026	0.213	0.079	-0.017	0.148	-0.049
	(0.489)	(0.484)	(1.000)	(0.892)	(0.159)	(0.429)	(0.914)	(0.404)	(0.571)
2014 H1	0.201**	0.011	0.236	0.342***	0.484***	0.435†	0.058	0.243*	0.140
	(0.028)	(0.933)	(0.143)	(0.003)	(0.001)	(0.000)	(0.581)	(0.094)	(0.741)
2014 H2	0.197**	-0.070	0.212	0.392***	0.493***	0.446†	0.143*	0.351**	0.157
	(0.017)	(0.591)	(0.143)	(0.000)	(0.001)	(0.000)	(0.087)	(0.029)	(0.286)
2015 H1	0.250***	-0.046	0.217	0.475***	0.647***	0.623†	0.224**	0.482***	0.314
	(0.003)	(0.770)	(0.143)	(0.000)	(0.000)	(0.000)	(0.033)	(0.009)	(0.143)
2015 H2	0.269**	-0.115	0.206	0.468***	0.574***	0.533†	0.249***	0.525**	0.291
	(0.012)	(0.530)	(0.143)	(0.000)	(0.005)	(0.000)	(0.006)	(0.020)	(0.143)
2016 H1	0.097	-0.309	0.023	0.220*	0.419*	0.133	0.005	0.337	-0.031
	(0.436)	(0.137)	(0.714)	(0.056)	(0.054)	(0.286)	(0.959)	(0.198)	(0.857)
GDP growth	0.117	-1.311		1.299	-2.268		2.090	1.207	
	(0.964)	(0.486)		(0.606)	(0.388)		(0.275)	(0.661)	
MTRs	-0.167	-0.329**		0.075	-0.071		0.195	0.156	
	(0.165)	(0.016)		(0.592)	(0.653)		(0.102)	(0.438)	
constant	2.442***	3.897		2.670***	11.513***		2.532***	10.126***	
	(0.000)	(0.140)		(0.000)	(0.000)		(0.000)	(0.000)	
Obs.	80	80		80	80		80	80	
R^2	0.828	0.918		0.805	0.904		0.919	0.936	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth control group low: BE: 40.1%, PT: 21.5%, SE: 38.5%

Weights synth control group med: BE: 5.8%, DK: 47.0%, ES: 39.6%, SE: 7.5%

Weights synth control group high: DK: 92.1%, ES: 7.9%

The results of the DiD basic specification are comparable to those with constant 2013 usage for the low and the medium usage baskets. The magnitude of the synth results is also comparable. For the low usage basket, the synth results are insignificant. However, there is only one country with a higher placebo effect than Austria. The point estimates for the high usage basket are lower than in the specification with constant 2013 usage (but still statistically significant for 2014 and 2015 in the DiD specification).

b. With the two cheapest tariffs per operator and period

Table 14: Results for Austria, 2 cheapest tariffs, country-level, 2013 and 2014 usage

	Low (2 tariffs)			Medium (2 tariffs)			High (2 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2013 H2	0.123	0.075	-0.172	0.074	0.198	0.105	0.116	0.140	-0.097
	(0.409)	(0.492)	(0.286)	(0.709)	(0.200)	(0.714)	(0.446)	(0.454)	(0.57)
2014 H1	0.145*	-0.052	-0.005	0.418***	0.506***	0.411	0.212*	0.165	0.133
	(0.092)	(0.666)	(1.000)	(0.000)	(0.002)	(0.143)	(0.050)	(0.328)	(0.86)
2014 H2	0.097	-0.179	-0.105	0.396***	0.418**	0.335	0.305***	0.219	0.142
	(0.228)	(0.186)	(0.429)	(0.001)	(0.019)	(0.143)	(0.002)	(0.256)	(0.43)
2015 H1	0.164**	-0.140	-0.087	0.521***	0.611***	0.562	0.444***	0.360	0.336
	(0.040)	(0.370)	(0.571)	(0.000)	(0.004)	(0.143)	(0.000)	(0.110)	(0.43)
2015 H2	0.182*	-0.213	-0.082	0.515***	0.512**	0.508†	0.423***	0.291	0.326
	(0.097)	(0.253)	(0.714)	(0.000)	(0.040)	(0.000)	(0.000)	(0.275)	(0.43)
2016 H1	0.035	-0.381*	-0.234	0.329***	0.420	0.244	0.186*	0.064	0.007
	(0.741)	(0.066)	(0.143)	(0.005)	(0.139)	(0.286)	(0.055)	(0.833)	(1.00)
GDP growth	-0.834	-2.413		2.004	-2.258		2.393	1.093	
	(0.738)	(0.172)		(0.438)	(0.320)		(0.230)	(0.638)	
MTRs	-0.196*	-0.336***		0.156	0.020		0.176	0.088	
	(0.082)	(0.004)		(0.274)	(0.878)		(0.115)	(0.589)	
constant	2.365***	3.558		2.428***	10.608***		2.151***	4.363	
	(0.000)	(0.170)		(0.000)	(0.006)		(0.000)	(0.260)	
Obs.	80	80		80	80		80	80	
R^2	0.868	0.947		0.836	0.934		0.932	0.948	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth control group low: BE: 1.3%, DK: 51.9%, EL: 46.8%

Weights synth. control group med: DK: 80.4%, ES: 19.6%

Weights synth. control group high: DK: 100.0%

For the low usage basket, the results of the basic DiD are slightly weaker compared to the specification with constant 2013 usage. In the synth results, the effects become negative, although not significant (this might result from including EL in the synthetic control group, which is not the case in the other specifications). The results for the medium usage basket are largely in line with those of the other specifications. The synth results are insignificant in 2014 and for 2015 H1, but there is only one placebo test with a higher effect than Austria. The high usage basket continues to exhibit significant DiD estimates in the years 2014 and 2015 with somewhat lower (and insignificant) values than the synthetic control group approach.

3. Operator-level estimates (DiD)
    a. Constant 2013 usage

Table 15: Results for Austria, 4 cheapest tariffs, operator-level, 2013 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	**DiD trend**	**DiD basic**	**DiD trend**	**DiD basic**	**DiD trend**
2013 H2	0.147	0.144	0.095	0.184*	0.281**	0.271**
	(0.537)	(0.189)	(0.707)	(0.059)	(0.013)	(0.019)
2014 H1	0.280*	0.211	0.419**	0.511***	0.517***	0.505***
	(0.076)	(0.141)	(0.011)	(0.003)	(0.000)	(0.005)
2014 H2	0.340***	0.254	0.518***	0.593***	0.663***	0.651***
	(0.004)	(0.106)	(0.005)	(0.001)	(0.000)	(0.002)
2015 H1	0.281*	0.178	0.499**	0.616***	0.678***	0.663***
	(0.081)	(0.331)	(0.017)	(0.000)	(0.000)	(0.002)
2015 H2	0.290*	0.170	0.563***	0.652***	0.704***	0.692***
	(0.051)	(0.418)	(0.004)	(0.005)	(0.001)	(0.002)
2016 H1	0.130	-0.009	0.284	0.426*	0.458***	0.440
	(0.454)	(0.964)	(0.165)	(0.083)	(0.005)	(0.167)
GDP growth	-0.216	-0.146	4.135	2.303	3.963	4.178
	(0.955)	(0.876)	(0.243)	(0.345)	(0.226)	(0.182)
MTRs	-0.115	-0.168	0.061	0.009	-0.022	-0.017
	(0.556)	(0.362)	(0.768)	(0.948)	(0.845)	(0.917)
constant	2.892***	6.834**	3.386***	11.839***	3.495***	6.300**
	(0.000)	(0.023)	(0.000)	(0.000)	(0.000)	(0.035)
Obs.	290	290	290	290	289	289
R^2	0.778	0.834	0.761	0.839	0.818	0.841
Trend test passed?	No		Yes		Yes	

Operator and time fixed effects included in the regressions (but not shown in the table)
Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 16: Results for Austria, 2 cheapest tariffs, operator-level, 2013 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	**DiD trend**	**DiD basic**	**DiD trend**	**DiD basic**	**DiD trend**
2013 H2	0.133	0.154	0.135	0.222**	0.331***	0.264**
	(0.637)	(0.212)	(0.669)	(0.023)	(0.003)	(0.040)
2014 H1	0.268	0.192	0.484**	0.601***	0.558***	0.457***
	(0.140)	(0.205)	(0.011)	(0.000)	(0.000)	(0.009)
2014 H2	0.224*	0.117	0.601***	0.693***	0.741***	0.611***
	(0.058)	(0.523)	(0.005)	(0.000)	(0.000)	(0.003)
2015 H1	0.209	0.088	0.574**	0.724***	0.757***	0.608***
	(0.211)	(0.698)	(0.010)	(0.000)	(0.000)	(0.006)
2015 H2	0.203	0.048	0.624**	0.730***	0.771***	0.592***
	(0.224)	(0.857)	(0.010)	(0.001)	(0.000)	(0.005)
2016 H1	0.101	-0.066	0.408*	0.590**	0.625***	0.429
	(0.595)	(0.812)	(0.076)	(0.011)	(0.001)	(0.158)
GDP growth	-1.985	-2.442	4.495	1.769	3.609	3.297
	(0.638)	(0.213)	(0.218)	(0.301)	(0.199)	(0.160)
MTRs	-0.165	-0.259	0.056	0.012	-0.026	-0.044
	(0.453)	(0.159)	(0.809)	(0.920)	(0.766)	(0.768)
constant	2.788***	7.142**	3.017***	12.596***	3.130***	3.351
	(0.000)	(0.041)	(0.000)	(0.000)	(0.000)	(0.228)
Obs.	290	290	290	290	289	289
R^2	0.757	0.820	0.769	0.848	0.828	0.843
Trend test passed?	Yes		Yes		No	

Operator and time fixed effects included in the regressions (but not shown in the table)

Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The results for the medium usage and the high usage baskets are comparable to the country-level analysis. With regard to the low usage basket, the trend test is not passed for the specification with the four cheapest tariffs. With the country-specific trends, the coefficients become smaller and, although they are still economically significant, the statistical significance disappears. There is statistical significance, however, in the DiD basic specification. For the low usage basket with the two cheapest tariffs, the trend test is passed. The coefficients are slightly lower than in the country-level specification in 2014 and 2015 and only statistically significant in 2014 H2.

b. Increasing usage (2013 usage for 2011-2013 and 2014 usage for 2014-2016)

Table 17: Results for Austria, 4 cheapest tariffs, operator-level, 2013 and 2014 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	**DiD trend**	**DiD basic**	**DiD trend**	**DiD basic**	**DiD trend**
2013 H2	0.142	0.135	0.122	0.199**	0.219**	0.257**
	(0.542)	(0.200)	(0.607)	(0.029)	(0.014)	(0.034)
2014 H1	0.272*	0.204	0.444***	0.522***	0.324***	0.340*
	(0.075)	(0.140)	(0.005)	(0.002)	(0.009)	(0.055)
2014 H2	0.344***	0.265*	0.540***	0.603***	0.570***	0.579**
	(0.003)	(0.093)	(0.002)	(0.001)	(0.000)	(0.011)
2015 H1	0.296*	0.197	0.520**	0.619***	0.467***	0.485***
	(0.069)	(0.286)	(0.013)	(0.000)	(0.004)	(0.006)
2015 H2	0.303**	0.195	0.590***	0.664***	0.582***	0.590**
	(0.042)	(0.358)	(0.002)	(0.005)	(0.000)	(0.015)
2016 H1	0.141	0.009	0.320*	0.440*	0.254*	0.273
	(0.414)	(0.965)	(0.093)	(0.068)	(0.081)	(0.411)
GDP growth	-0.498	-0.147	3.680	2.039	5.292*	4.850
	(0.899)	(0.879)	(0.277)	(0.394)	(0.081)	(0.133)
MTRs	-0.114	-0.156	0.031	-0.015	0.049	0.013
	(0.559)	(0.383)	(0.869)	(0.893)	(0.522)	(0.940)
constant	2.892***	6.903**	3.416***	11.082***	3.446***	7.378**
	(0.000)	(0.021)	(0.000)	(0.001)	(0.000)	(0.029)
Obs.	290	290	290	290	289	289
R^2	0.776	0.833	0.769	0.836	0.816	0.833
Trend test passed?	No		Yes		Yes	

Operator and time fixed effects included in the regressions (but not shown in the table)

Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 18: Results for Austria, 2 cheapest tariffs, operator-level, 2013 and 2014 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	**DiD trend**	**DiD basic**	**DiD trend**	**DiD basic**	**DiD trend**
2013 H2	0.143	0.149	0.143	0.221**	0.285***	0.265*
	(0.612)	(0.219)	(0.622)	(0.022)	(0.007)	(0.052)
2014 H1	0.267	0.186	0.506***	0.620***	0.408***	0.327*
	(0.138)	(0.202)	(0.004)	(0.000)	(0.004)	(0.073)
2014 H2	0.246**	0.142	0.621***	0.709***	0.634***	0.511**
	(0.040)	(0.434)	(0.003)	(0.000)	(0.000)	(0.016)
2015 H1	0.240	0.117	0.579***	0.725***	0.643***	0.514**
	(0.164)	(0.606)	(0.007)	(0.000)	(0.000)	(0.014)
2015 H2	0.225	0.078	0.649***	0.751***	0.702***	0.524**
	(0.166)	(0.766)	(0.006)	(0.001)	(0.000)	(0.016)
2016 H1	0.121	-0.046	0.427**	0.605***	0.430***	0.252
	(0.528)	(0.866)	(0.042)	(0.008)	(0.009)	(0.413)
GDP growth	-2.409	-2.461	4.270	1.526	4.933*	3.815
	(0.573)	(0.207)	(0.205)	(0.373)	(0.074)	(0.120)
MTRs	-0.178	-0.254	0.045	0.009	0.029	-0.037
	(0.426)	(0.146)	(0.824)	(0.938)	(0.609)	(0.806)
constant	2.801***	7.130**	3.027***	11.656***	3.160***	4.475
	(0.000)	(0.040)	(0.000)	(0.000)	(0.000)	(0.152)
Obs.	290	290	290	290	289	289
R^2	0.753	0.818	0.777	0.840	0.823	0.835
Trend test passed?	Yes		Yes		No	

Operator and time fixed effects included in the regressions (but not shown in the table)

Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The results with increasing usage are quite similar to those with constant 2013 usage for the operator-level analysis

All in all, it can be concluded that the results are fairly robust to changes in the specification. While the effects for the medium usage basket are high, with a range of 0.33-0.65 in 2014-2015 and remain significant (or close to significant in the synth approach) for almost all specifications, the effects for the low usage basket are lower (0.05-0.39 in 2014 and 2015) and in some specifications become insignificant (and, for the synth approach with two tariffs and changing usage, the results even become negative, but not statistically significant). The DiD results for the high usage basket are usually even stronger than for the medium usage basket, but these effects are likely to be overestimated (see discussion in section 5.2).

Robustness checks for Ireland

1. With baskets based on the 2 cheapest tariffs instead of the 4 cheapest tariffs per operator and period.

Table 19: Results for Ireland, p_low2, p_med2, p_high2 country-level, 2013 usage

	Low (2 tariffs)			Medium (2 tariffs)			High (2 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2015 H1	0.216*** (0.002)	0.284*** (0.003)	0.228 (0.200)	0.301*** (0.002)	0.335** (0.018)	.634 (0.300)	0.373*** (0.000)	0.342** (0.016)	0.670 (0.300)
2015 H2	0.218*** (0.001)	0.337** (0.010)	0.215 (0.500)	0.024 (0.819)	0.153 (0.441)	0.486† 0.000	0.265** (0.028)	0.222 (0.248)	0.599 (0.500)
2016 H1	0.031 (0.763)	0.135 (0.305)	-0.008 (1.000)	0.249* (0.052)	0.267 (0.181)	0.691 (0.100)	0.336** (0.016)	0.283 (0.170)	0.728 (0.300)
GDP Growth	-0.051 (0.956)	-0.382 (0.691)		0.763 (0.492)	-0.269 (0.793)		-0.517 (0.718)	-0.501 (0.682)	
MTRs	-0.145** (0.038)	-0.097 (0.185)		0.043 (0.631)	0.044 (0.530)		0.085 (0.355)	0.053 (0.553)	
Constant	2.289*** (0.000)	7.042*** (0.000)		2.474*** (0.000)	11.966*** (0.000)		2.882*** (0.000)	6.334*** (0.000)	
Obs.	88	88		88	88		88	88	
R^2	0.901	0.944		0.903	0.941		0.910	0.937	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 23.5%, CZ: 67.0%, PL: 4.0%, PT: 5.5%

Weights synth. control group med: BE: 7.1%, UK: 2.2%, IT: 90.8%

Weights synth. control group high: CZ: 17.8%, EL:11.3%, IT: 64.8%, PL: 6.1%

For each of the three baskets, the results for the first period after the merger are quantitatively comparable to those of the specification with four tariffs (Table 5). However, in the low usage basket, the basic DiD specification gains significance for the second post-merger period when only two tariffs are used. In the medium basket, the synth results are significant for the second period after the merger. However, neither of the DiD specifications using either two or four tariffs are significant for this period.

2. With increasing usage (2013 usage for 2011-2013 and 2014 usage for 2014-2016)
    a. With the four cheapest tariffs per operator and period

Table 20: Results for Ireland, p_low4, p_med4 and p_high4, country-level, 2013 and 2014 usage

	Low (4 tariffs)			Medium (4 tariffs)			High (4 tariffs)		
	DiD basic	DiD trend	Synth	DiD basic	DiD trend	Synth	DiD basic	DiD trend	Synth
2015 H1	0.165* (0.053)	0.350*** (0.001)	0.291 (0.400)	0.137 (0.159)	0.238* (0.082)	0.206 (0.500)	0.347*** (0.003)	0.164 (0.294)	0.824 (0.300)
2015 H2	0.118 (0.236)	0.410*** (0.004)	0.298 (0.300)	-0.034 (0.748)	0.169 (0.408)	0.043 1.000	0.334*** (0.005)	0.113 (0.580)	0.904 (0.400)
2016 H1	0.115 (0.373)	0.387*** (0.008)	0.442 (0.200)	0.195 (0.147)	0.318* (0.100)	-0.017 (1.000)	0.158 (0.295)	-0.133 (0.557)	0.598 (0.600)
GDP growth	0.459 (0.657)	-0.181 (0.865)		0.837 (0.436)	-0.075 (0.951)		-0.559 (0.694)	-0.708 (0.548)	
MTRs	-0.060 (0.498)	-0.004 (0.958)		-0.048 (0.595)	-0.045 (0.623)		0.084 (0.386)	0.042 (0.699)	
constant	2.326*** (0.000)	7.563*** (0.000)		2.600*** (0.000)	6.994** (0.028)		2.973*** (0.000)	6.136*** (0.000)	
Obs.	88	88		88	88		88	88	
R^2	0.860	0.928		0.862	0.905		0.881	0.917	
Trend test passed?	No			Yes			No		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: CZ: 0.5%, UK: 31.6%, PT: 67.9%

Weights synth. control group med: BE: 1.5%, CZ: 58.2%, ES: 40.3%

Weights synth. control group high: IT: 90.9%, PL: 9.1%

The results from the three specifications for the low usage basket are very similar to those with constant 2013 usage (Table 5). However, the results differ in the medium usage basket, with significance lost in the first and third periods post-merger in the base specification. Similarly, significance is lost in the third period post-merger in the base specification for their high usage basket. For each of the three baskets, the synth results remain insignificant. The trend test was not passed for the low or high usage baskets.

b. With the two cheapest tariffs per operator and period

Table 21: Results for Ireland, p_low2 and p_med2, country-level, 2013 and 2014 usage

	Low (2 tariffs)			Medium (2 tariffs)			High (2 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2015 H1	0.220*** (0.007)	0.313** (0.017)	0.269 (0.100)	0.074 (0.447)	0.181 (0.187)	0.432 (0.300)	0.207** (0.046)	0.151 (0.319)	0.517 (0.200)
2015 H2	0.193** (0.038)	0.358** (0.038)	0.257 (0.200)	-0.108 (0.317)	0.114 (0.549)	0.440 (0.100)	0.149 (0.234)	0.102 (0.633)	0.512 (0.400)
2016 H1	0.132 (0.281)	0.267 (0.161)	0.228 (0.700)	0.103 (0.472)	0.231 (0.257)	0.637 (0.400)	0.124 (0.447)	0.025 (0.912)	0.541 (0.800)
GDP growth	0.424 (0.689)	-0.082 (0.942)		0.603 (0.609)	-0.440 (0.696)		-0.477 (0.775)	-0.780 (0.533)	
MTRs	-0.072 (0.397)	-0.028 (0.725)		0.078 (0.434)	0.081 (0.322)		0.102 (0.335)	0.079 (0.436)	
constant	2.193*** (0.000)	8.501*** (0.000)		2.409*** (0.000)	10.091*** (0.001)		2.801*** (0.000)	6.800*** (0.000)	
Obs.	88	88		88	88		88	88	
R^2	0.881	0.936		0.890	0.932		0.874	0.927	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 21.0%, CZ: 57.9%, PL: 7.9%, PT: 13.3%

Weights synth. control group med: BE: 11.4%, IT: 88.6%

Weights synth. control group high: CZ: 28.3%, IT: 58.0%, PL: 13.6%

For the low usage basket, the results are qualitatively similar to those obtained with constant 2013 usage using two tariffs. In the medium usage basket, none of the results are statistically significant, but the second period post-merger synth result shows that only one control group country out of ten had a merger effect higher than Ireland, putting it at the edge of significance. Significance is lost in periods two and three of the high usage basket compared to the specification with constant 2013 usage.

3. Operator-level estimates (DiD)
    c. Constant 2013 usage

Table 22: Results for Ireland, p_low4, p_med4 and p_high4, operator-level, 2013 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	DiD trend	DiD basic	DiD trend	DiD basic	DiD trend
2015 H1	0.134*	0.304***	0.348***	0.307**	0.338***	0.150
	(0.099)	(0.004)	(0.001)	(0.014)	(0.000)	(0.135)
2015 H2	0.076	0.333**	0.139*	0.152	0.297**	0.038
	(0.243)	(0.045)	(0.092)	(0.398)	(0.018)	(0.846)
2016 H1	0.024	0.277*	0.275**	0.185	0.150	-0.133
	(0.873)	(0.061)	(0.018)	(0.127)	(0.198)	(0.252)
GDP growth	0.260	-0.201	0.880	0.098	-0.630	-0.386
	(0.801)	(0.854)	(0.181)	(0.933)	(0.608)	(0.768)
MTRs	-0.118	-0.062	-0.040	-0.050	0.066	0.024
	(0.205)	(0.497)	(0.381)	(0.278)	(0.135)	(0.705)
constant	2.349***	6.115***	3.039***	9.353***	3.308***	5.959***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	304	304	304	304	304	304
R^2	0.743	0.782	0.771	0.796	0.775	0.794
Trend test passed?	No		No		Yes	

Operator and time fixed effects included in the regressions (but not shown in the table)

Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 23: Results for Ireland, p_low2, p_med2 and p_high2, operator-level, 2013 usage

	Low (2 tariffs)		Medium (2 tariffs)		High (2 tariffs)	
	DiD basic	DiD trend	DiD basic	DiD trend	DiD basic	DiD trend
2015 H1	0.169**	0.226***	0.291***	0.290***	0.285***	0.218**
	(0.029)	(0.009)	(0.001)	(0.006)	(0.001)	(0.035)
2015 H2	0.153**	0.243	0.014	0.091	0.216*	0.105
	(0.034)	(0.133)	(0.873)	(0.606)	(0.061)	(0.594)
2016 H1	0.010	0.101	0.191*	0.160	0.207**	0.106
	(0.937)	(0.389)	(0.063)	(0.215)	(0.035)	(0.382)
GDP growth	-0.131	-0.301	0.789	-0.144	-0.621	-0.356
	(0.907)	(0.801)	(0.263)	(0.894)	(0.570)	(0.786)
MTRs	-0.136	-0.091	0.025	0.024	0.089	0.052
	(0.106)	(0.261)	(0.686)	(0.494)	(0.202)	(0.513)
constant	2.221***	6.431***	2.769***	11.678***	3.098***	5.670***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	304	304	304	304	304	304
R^2	0.744	0.778	0.789	0.814	0.769	0.787
Trend test passed?	No		No		No	

Operator and time fixed effects included in the regressions (but not shown in the table)

Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The trend test is not passed for five of the six specifications in Tables 22 and 23. The results are broadly comparable to the country-level analysis, though the magnitudes are smaller.

d. Increasing usage (2013 usage for 2011-2013 and 2014 usage for 2014-2016)

Table 24: Results for Ireland, p_low4, p_med4 and p_high4, operator-level, 2013 and 2014 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	DiD trend	DiD basic	DiD trend	DiD basic	DiD trend
2015 H1	0.127	0.319***	0.133	0.211*	0.430***	0.183
	(0.134)	(0.003)	(0.256)	(0.089)	(0.000)	(0.172)
2015 H2	0.094	0.323*	-0.029	0.129	0.393***	0.018
	(0.429)	(0.062)	(0.754)	(0.540)	(0.006)	(0.933)
2016 H1	0.083	0.385***	0.168	0.247*	0.159	-0.219*
	(0.581)	(0.008)	(0.285)	(0.075)	(0.223)	(0.083)
GDP growth	0.005	0.187	0.871	0.077	-0.501	0.135
	(0.996)	(0.860)	(0.261)	(0.960)	(0.666)	(0.911)
MTRs	-0.047	-0.017	0.010	-0.041	0.081	-0.029
	(0.728)	(0.848)	(0.941)	(0.649)	(0.157)	(0.711)
constant	2.323***	9.705***	3.192***	12.500***	3.525***	7.960***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	354	354	354	354	354	354
R^2	0.708	0.778	0.726	0.775	0.780	0.803
Trend test passed?	No		No		No	

Operator and time fixed effects included in the regressions (but not shown in the table)

Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 25: Results for Ireland, p_low2, p_med2 and p_high2, operator-level, 2013 and 2014 usage

	Low (2 tariffs)		Medium (2 tariffs)		High (2 tariffs)	
	DiD basic	DiD trend	DiD basic	DiD trend	DiD basic	DiD trend
2015 H1	0.151*	0.255***	0.133	0.216*	0.308***	0.241*
	(0.067)	(0.005)	(0.247)	(0.067)	(0.002)	(0.064)
2015 H2	0.156	0.262	-0.073	0.099	0.254*	0.109
	(0.247)	(0.116)	(0.521)	(0.626)	(0.066)	(0.669)
2016 H1	0.074	0.247**	0.152	0.232	0.149	0.042
	(0.554)	(0.040)	(0.356)	(0.152)	(0.332)	(0.752)
GDP growth	-0.356	-0.041	1.028	0.123	-0.513	0.087
	(0.720)	(0.969)	(0.259)	(0.933)	(0.683)	(0.951)
MTRs	-0.043	-0.014	0.090	0.027	0.098**	-0.008
	(0.765)	(0.850)	(0.517)	(0.760)	(0.037)	(0.921)
constant	2.160***	10.530***	2.927***	14.650***	3.389***	8.174***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	354	354	354	354	354	354
R^2	0.718	0.785	0.720	0.774	0.744	0.778
Trend test passed?	No		No		No	

Operator and time fixed effects included in the regressions (but not shown in the table)

Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The trend test is not met for any of the specifications above. The results differ somewhat from those with constant usage for the operator-level analysis, especially for the medium usage basket, with changes in significance across each of the post-merger periods. By contrast, the results are quite similar for the low and high usage baskets.

Robustness checks for Germany

1. With baskets based on the 2 cheapest tariffs instead of the 4 cheapest tariffs per operator and period.

Table 26: Results for Germany, p_low2, p_med2 and p_high2, country-level, 2013 usage

	Low (2 tariffs)			Medium (2 tariffs)			High (2 tariffs)		
	DiD basic	DiD trend	Synth	DiD basic	DiD trend	Synth	DiD basic	DiD trend	Synth
2015 H1	0.276***	0.324**	0.112	0.053	0.225	0.201	0.056	0.302	0.194
	(0.000)	(0.014)	0.400	(0.401)	(0.133)	0.200	(0.474)	(0.132)	0.400
2015 H2	0.248***	0.311*	0.083	-0.006	0.207	0.024	-0.025	0.285	0.001
	(0.000)	(0.053)	0.300	(0.929)	(0.258)	0.700	(0.776)	(0.250)	1000
2016 H1	0.272***	0.363*	0.104	0.310***	0.595***	0.333	0.237***	0.633**	0.263
	(0.000)	(0.058)	0.200	(0.000)	(0.008)	0.100	(0.005)	(0.038)	0.500
GDP growth	0.882	0.190		2.785**	0.783		2.614*	1.167	
	(0.521)	(0.899)		(0.034)	(0.628)		(0.072)	(0.512)	
MTRs	-0.147*	-0.051		0.004	0.053		0.061	0.078	
	(0.054)	(0.466)		(0.962)	(0.499)		(0.509)	(0.434)	
constant	2.268***	4.628***		2.436***	8.510***		2.867***	6.034**	
	(0.000)	(0.009)		(0.000)	(0.003)		(0.000)	(0.023)	
Obs.	77	77		77	77		77	77	
R^2	0.894	0.939		0.918	0.940		0.912	0.929	
Trend test passed?	Yes			Yes			No		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 49.8%, DK: 45.0%, PT: 5.1%

Weights synth. control group med: BE: 23.2%, ES: 72.9%, PL: 3.3%, PT: 0.6%

Weights synth. control group high: DK: 33.6%, ES: 49.9%, PT: 16.5%

The estimated results for the low usage basket are qualitatively comparable to those of the specification with four tariffs. However, the estimated coefficients for the medium and high usage baskets are smaller in magnitude. For these two usage profiles, statistically significant effects can only be found for the third half-year after the merger. With regard to the high usage basket, the trend test is not passed. Including country-specific trends into the specification, the estimated coefficients become larger in magnitude. The estimate coefficient in the third half-year after the merger remains statistically significant at the 5% level.

The synth estimates are smaller in magnitude for the low usage basket. For the medium and high usage basket, no clear pattern can be identified compared to the results of the specification with the four cheapest tariffs. All estimated coefficients are statistically insignificant.

2. With increasing usage (2013 usage for 2011-2013 and 2014 usage for 2014-2016)
    a. With the four cheapest tariffs per operator and period

Table 27: Results for Germany, p_low4, p_med4 and p_high4, country-level, 2013 and 2014 usage

	Low (4 tariffs)			Medium (4 tariffs)			High (4 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2015 H1	0.451***	0.461***	0.546	0.094	0.206	-0.003	0.062	-0.018	0.263
	(0.000)	(0.000)	0.100	(0.186)	(0.224)	0.900	(0.380)	(0.897)	0.200
2015 H2	0.268***	0.279**	0.202	0.044	0.181	-0.037	0.234***	0.124	0.348
	(0.000)	(0.030)	0.200	(0.533)	(0.378)	0.500	(0.000)	(0.454)	0.100
2016 H1	0.468***	0.499***	0.515 †	0.256***	0.442*	0.117	0.094	-0.022	0.096
	(0.000)	(0.002)	0.000	(0.001)	(0.082)	0.200	(0.190)	(0.921)	0.400
GDP growth	1.075	0.011		1.741	0.247		2.062	0.386	
	(0.443)	(0.995)		(0.208)	(0.891)		(0.163)	(0.832)	
MTRs	-0.089	-0.009		-0.069	-0.035		0.093	0.107	
	(0.316)	(0.909)		(0.408)	(0.672)		(0.360)	(0.420)	
constant	2.364***	4.531***		2.628***	3.161		2.974***	5.096**	
	(0.000)	(0.006)		(0.000)	(0.347)		(0.000)	(0.030)	
Obs.	77	77		77	77		77	77	
R^2	0.862	0.922		0.891	0.923		0.896	0.912	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: UK: 7.8%, IT: 8.9%, PL: 65.7%, SE: 17.6%

Weights synth. control group med: CZ: 6.1%, DK: 78.3%, PT: 15.6%

Weights synth. control group high: DK: 12.7%, ES: 30.8%, GR: 4.8%, PL: 51.6%

The results of the DiD basic specification are qualitatively comparable in the case of the low usage basket to those with constant usage. For the medium and high usage baskets, we only find positive and significant effects in one of the three half-year periods after the merger took place. This is in contrast to the regressions with constant 2013 usage, where all estimate coefficients were at least significant at the 10% level.

The synth results are comparable to those with constant 2013 usage. Only for the low usage basket in the third half-year after the merger can a statistically significant coefficient be found.

b. With the two cheapest tariffs per operator and period

Table 28: Results for Germany, country-level, 2013 and 2014 usage

	Low (2 tariffs)			Medium (2 tariffs)			High (2 tariffs)		
	DiD basic	DiD trend	Synth	DiD basic	DiD trend	Synth	DiD basic	DiD trend	Synth
2015 H1	0.291***	0.330***	0.125	-0.010	0.195	0.151	-0.005	-0.002	0.128†
	(0.000)	(0.010)	0.200	(0.878)	(0.219)	0.200	(0.919)	(0.991)	0.000
2015 H2	0.261***	0.311**	0.095	-0.078	0.180	-0.051	0.007	0.003	0.026†
	(0.000)	(0.045)	0.400	(0.257)	(0.350)	0.400	(0.899)	(0.988)	0.000
2016 H1	0.283***	0.357*	0.115	0.235***	0.569**	0.243	0.051	0.066	0.031
	(0.000)	(0.054)	0.200	(0.001)	(0.016)	0.100	(0.378)	(0.746)	0.200
GDP growth	0.921	0.244		1.893	0.335		2.588	0.730	
	(0.481)	(0.864)		(0.111)	(0.828)		(0.111)	(0.676)	
MTRs	-0.140*	-0.059		0.021	0.055		0.080	0.086	
	(0.070)	(0.401)		(0.782)	(0.446)		(0.407)	(0.426)	
constant	2.259***	4.438**		2.418***	5.951**		2.816***	6.513***	
	(0.000)	(0.012)		(0.000)	(0.034)		(0.000)	(0.010)	
Obs.	77	77		77	77		77	77	
R^2	0.900	0.942		0.929	0.947		0.909	0.929	
Trend test passed?	Yes			No			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 52.3%, DK: 43.0%, PT: 4.6%

Weights synth. control group med: BE: 22.7%, ES: 74.7%, PL: 2.0%, PT: 0.6%

Weights synth. control group high: BE: 24.4%, CZ: 3.6%, ES: 52.3%, PL: 19.8%

The results of the DiD basic specification are qualitatively comparable for the low usage basket to those with constant 2013 usage. In the case of the medium usage basket, the trend test is not passed. Including country-specific trends into the specification, the estimated coefficients become larger in magnitude. The estimate coefficient in the third half-year after the merger remains statistically significant at the 5% level. For the high usage basket, we do not find significant effects in one of the three half-year periods after the merger took place. This is in contrast to the regressions with constant 2013 usage, where at least the estimated coefficient for the third half-year was significant.

In magnitude the synth results are mostly comparable to those with constant 2013 usage for the low usage basket. For the high usage basket we even find two significant estimates in the first and second half-year periods after the merger. This is in contrast to the specification with constant 2013 usage, where no significant effects have been found.

3. Excluding the UK
    a. With the four cheapest tariffs per operator and period

Table 29: Results for Germany, country-level, 2013 usage

	Low (4 tariffs)			Medium (4 tariffs)			High (4 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2015 H1	0.428***	0.449***	0.521†	0.197***	0.264*	0.079	0.140**	0.169	0.148
	(0.000)	(0.000)	0.000	(0.007)	(0.082)	0.333	(0.042)	(0.331)	0.333
2015 H2	0.227***	0.236*	0.154	0.127*	0.172	0.039	0.135*	0.144	0.163
	(0.000)	(0.053)	0.444	(0.099)	(0.354)	0.444	(0.077)	(0.499)	0.111
2016 H1	0.442***	0.483***	0.450	0.334***	0.438*	0.126	0.253***	0.297	0.169
	(0.000)	(0.002)	0.111	(0.000)	(0.066)	0.222	(0.002)	(0.271)	0.333
GDP growth	0.090	-1.900		1.952	-1.940		2.332	-0.391	
	(0.961)	(0.274)		(0.341)	(0.421)		(0.220)	(0.875)	
MTRs	-0.079	0.012		-0.047	-0.020		0.048	0.066	
	(0.392)	(0.882)		(0.623)	(0.854)		(0.651)	(0.597)	
constant	2.384***	5.801***		2.657***	7.595**		3.022***	5.804**	
	(0.000)	(0.001)		(0.000)	(0.025)		(0.000)	(0.018)	
Obs.	70	70		70	70		70	70	
R^2	0.858	0.925		0.843	0.894		0.874	0.900	
Trend test passed?	Yes			Yes			Yes		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 20.5%, IT: 0.5%, PL: 64.9%, SE: 9.6%

Weights synth. control group med: CZ: 22.7%, DK: 73.8%, ES: 0.5%, PT: 3.0%

Weights synth. control group high: CZ: 25.9%, DK: 47.9%, ES: 18.7%, PL: 6.4%, PT: 1.1%

The specification without the UK (that leaves nine instead of ten control countries) generates similar results to the specification with the UK. The estimated coefficients are slightly smaller in magnitude for the low and medium usage baskets. In the case of the high usage basket, the magnitude is marginally larger than with the UK. All estimated coefficients show statistically significant results.

The synth estimates are comparable in magnitude to the results with the UK. However, we find no statistically significant effects, except for the first half-year period after the merger for the low usage basket. This is different to the case with the UK, where we found a statistically significant effect in the third half-year period after the merger.

b. With the two cheapest tariffs per operator and period

Table 30: Results for Germany, country-level, 2013 usage

	Low (2 tariffs)			Medium (2 tariffs)			High (2 tariffs)		
	DiD basic	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**	**DiD basic**	**DiD trend**	**Synth**
2015 H1	0.274***	0.312***	0.104	0.047	0.213	0.201	0.072	0.290	0.198
	(0.000)	(0.007)	0.111	(0.463)	(0.129)	0.333	(0.352)	(0.149)	0.333
2015 H2	0.228***	0.266*	0.073	-0.015	0.159	0.024	-0.011	0.242	0.005
	(0.000)	(0.058)	0.556	(0.827)	(0.354)	0.778	(0.905)	(0.331)	1.000
2016 H1	0.264***	0.334*	0.095	0.300***	0.560**	0.332	0.255***	0.597*	0.261
	(0.000)	(0.051)	0.222	(0.000)	(0.010)	0.222	(0.003)	(0.055)	0.333
GDP growth	-0.364	-1.824		2.301	-1.450		1.930	-0.812	
	(0.827)	(0.204)		(0.191)	(0.464)		(0.270)	(0.742)	
MTRs	-0.139*	-0.041		0.020	0.058		0.051	0.073	
	(0.091)	(0.576)		(0.813)	(0.484)		(0.608)	(0.520)	
constant	2.279***	5.928***		2.443***	9.930***		2.862***	7.250***	
	(0.000)	(0.001)		(0.000)	(0.001)		(0.000)	(0.007)	
Obs.	70	70		70	70		70	70	
R^2	0.896	0.946		0.902	0.934		0.899	0.916	
Trend test passed?	Yes			Yes			No		

Country and time fixed effects included in the regressions (but not shown in the table)

DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Synth: Standardised p-values (Galiani and Quistorff, 2016): † treated county has highest RMSP-ratio

Weights synth. control group low: BE: 47.6%, DK: 46.6%, PT: 5.8%

Weights synth. control group med: BE: 23.0%, ES: 73.3%, PL: 3.1%, SE: 0.6%

Weights synth. control group high: DK: 32.3%, ES: 51.9%, PT: 15.8%

A comparison between the estimated results for the two cheapest tariffs between the specification with and without UK shows that excluding the UK from the sample does not change the results strongly. The estimated coefficients are closely comparable to the results with the UK. Also the levels of significance for the estimated coefficients show the same pattern as for the specification with the UK.

The same is true for the estimated coefficients with the synthetic control approach. For all usage profiles we find comparable results in magnitude, but the statistical significance is negated.

4. Operator-level estimates (DiD)
    a. Constant 2013 usage
        i. With the four cheapest tariffs per operator and period

Table 31: Results for Germany, operator-level, 2013 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	**DiD trend**	**DiD basic**	**DiD trend**	**DiD basic**	**DiD trend**
2015 H1	0.358***	0.372***	0.112	0.177	0.102	0.153
	(0.000)	(0.009)	(0.120)	(0.111)	(0.111)	(0.165)
2015 H2	0.206***	0.222	0.039	0.113	0.101	0.161
	(0.009)	(0.183)	(0.571)	(0.401)	(0.109)	(0.261)
2016 H1	0.342***	0.377*	0.146*	0.260**	0.173**	0.260**
	(0.002)	(0.064)	(0.050)	(0.042)	(0.016)	(0.027)
GDP growth	1.118	0.264	2.325	0.409	2.516	1.221
	(0.523)	(0.873)	(0.183)	(0.852)	(0.176)	(0.580)
MTRs	-0.102	-0.009	-0.057	-0.028	0.075	0.084
	(0.300)	(0.917)	(0.342)	(0.602)	(0.185)	(0.241)
constant	2.301***	4.001***	3.017***	6.572***	3.277***	4.644***
	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.002)
Observations	266	266	266	266	266	266
R^2	0.715	0.752	0.758	0.777	0.770	0.783
Trend test passed?	Yes		Yes		Yes	

Operator and time fixed effects included in the regressions (but not shown in the table)
DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Comparing the country-level estimates for the four cheapest tariffs with the operator-level results, we find qualitatively comparable results for the low usage basket. The estimated coefficients show highly statistically significant effects for the first three half-year periods after the merger. In the cases of the medium and high usage baskets, the results are smaller in magnitude than for the country-level specification. For these, we only find statistically significant effects in the third half-year period after the merger.

ii. With the two cheapest tariffs per operator and period

Table 32: Results for Germany, operator-level, 2013 usage

	Low (2 tariffs)		Medium (2 tariffs)		High (2 tariffs)	
	DiD basic	**DiD trend**	**DiD basic**	**DiD trend**	**DiD basic**	**DiD trend**
2015 H1	0.224***	0.262**	-0.011	0.192*	0.027	0.276**
	(0.001)	(0.031)	(0.816)	(0.067)	(0.620)	(0.022)
2015 H2	0.205**	0.255	-0.071	0.180	-0.033	0.280*
	(0.010)	(0.110)	(0.173)	(0.203)	(0.598)	(0.076)
2016 H1	0.235***	0.308	0.119*	0.452***	0.161**	0.560***
	(0.007)	(0.109)	(0.061)	(0.005)	(0.012)	(0.001)
GDP growth	0.985	0.461	2.525	0.452	2.273	0.933
	(0.550)	(0.759)	(0.150)	(0.829)	(0.177)	(0.670)
MTRs	-0.153*	-0.057	0.009	0.053*	0.098	0.111
	(0.088)	(0.496)	(0.876)	(0.099)	(0.133)	(0.122)
constant	2.219***	4.047***	2.750***	8.846***	3.088***	5.774***
	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.001)
Observations	266	266	266	266	266	266
R^2	0.724	0.756	0.783	0.799	0.776	0.790
Trend test passed?	Yes		Yes		Yes	

Operator and time fixed effects included in the regressions (but not shown in the table)
DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Comparing the country-level estimates and the operator-level estimates for the two cheapest tariffs results in smaller estimates in magnitude in the case of the operator-level results. However, they are statistically significant only for all half-year periods after the merger for the low usage basket and for the third half-year period after the merger in the case of the medium and high usage baskets.

b. Increasing usage (2013 usage for 2011-2013 and 2014 usage for 2014-2016)
   i. With the four cheapest tariffs per operator and period

Table 33: Results for Germany, operator-level, 2013 and 2014 usage

	Low (4 tariffs)		Medium (4 tariffs)		High (4 tariffs)	
	DiD basic	DiD trend	**DiD basic**	DiD trend	**DiD basic**	DiD trend
2015 H1	0.372***	0.376***	0.025	0.137	-0.045	0.019
	(0.000)	(0.010)	(0.707)	(0.200)	(0.455)	(0.872)
2015 H2	0.224***	0.227	-0.034	0.102	0.074	0.149
	(0.007)	(0.173)	(0.591)	(0.429)	(0.231)	(0.214)
2016 H1	0.356***	0.374*	0.080	0.263**	-0.035	0.075
	(0.002)	(0.067)	(0.202)	(0.037)	(0.622)	(0.456)
GDP growth	1.156	0.248	1.442	0.106	1.923	0.359
	(0.508)	(0.876)	(0.310)	(0.960)	(0.277)	(0.853)
MTRs	-0.098	-0.016	-0.063	-0.038	0.102	0.121
	(0.334)	(0.851)	(0.240)	(0.325)	(0.166)	(0.241)
constant	2.307***	3.978***	3.032***	3.508**	3.267***	4.944***
	(0.000)	(0.004)	(0.000)	(0.017)	(0.000)	(0.001)
Observations	266	266	266	266	266	266
R^2	0.712	0.751	0.777	0.793	0.784	0.795
Trend test passed?	Yes		Yes		Yes	

Operator and time fixed effects included in the regressions (but not shown in the table)
Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Comparing the country-level estimates with increasing usage for the four cheapest tariffs with the operator-level results above, we find qualitatively comparable results for the low usage basket. The estimated coefficients show highly statistically significant effects for the first three half-year periods after the merger. For the medium and high usage baskets, the results are smaller in magnitude and, in some cases, even negative compared to the country-level specification. However, the estimated coefficients are not statistically significant for the medium and high usage baskets.

ii. With the two cheapest tariffs per operator and period

Table 34: Results for Germany, operator-level, 2013 and 2014 usage

	Low (2 tariffs)		Medium (2 tariffs)		High (2 tariffs)	
	DiD basic	**DiD trend**	**DiD basic**	**DiD trend**	**DiD basic**	**DiD trend**
2015 H1	0.236***	0.266**	-0.067	0.170	-0.105**	0.050
	(0.000)	(0.025)	(0.202)	(0.113)	(0.021)	(0.658)
2015 H2	0.217***	0.255*	-0.132***	0.165	-0.090	0.100
	(0.006)	(0.093)	(0.009)	(0.235)	(0.194)	(0.515)
2016 H1	0.246***	0.303	0.058	0.441***	-0.073	0.182
	(0.005)	(0.105)	(0.266)	(0.007)	(0.275)	(0.213)
GDP growth	1.001	0.518	1.530	-0.063	2.429	0.624
	(0.527)	(0.716)	(0.246)	(0.975)	(0.238)	(0.783)
MTRs	-0.149	-0.067	0.021	0.054*	0.101	0.115
	(0.112)	(0.433)	(0.711)	(0.079)	(0.120)	(0.109)
constant	2.220***	3.858***	2.744***	6.192***	3.116***	6.649***
	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	266	266	266	266	266	266
R^2	0.729	0.759	0.800	0.812	0.782	0.800
Trend test passed?	Yes		Yes		Yes	

Operator and time fixed effects included in the regressions (but not shown in the table)
DiD: Robust p-values in parentheses, *** p<0.01, ** p<0.05, * p<0.1

A comparison between the country-level estimates with increasing usage and the operator-level results for the two cheapest tariffs show a similar pattern in case of the low us age basket. For the medium and high usage baskets, the estimated coefficients in the third half-year period after the merger even show negative and significant effects for one of the three half-years after the merger. This is in contrast to all the other results.

Annex 6: Data and methodology of the *connect* network test

This Annex provides disaggregated data of the *connect* network test, namely results differentiated by data connectivity and voice telephony, as well as further explanation on the methodological approach that *connect* and *P3 Communications* use when testing mobile networks.

Disaggregated results for data usage and voice calls

In the test results presented in the main text, the overall results were shown, which are produced by combining the results for data connectivity (with 60% weight) and the results for voice telephony (with 40% weight). In the following illustrations, the disaggregated results are shown for Austria and Germany.

Firstly, the results for data usage are shown in Figures 27 and 28. The relative and absolute changes over time seem to resemble those of the overall results.

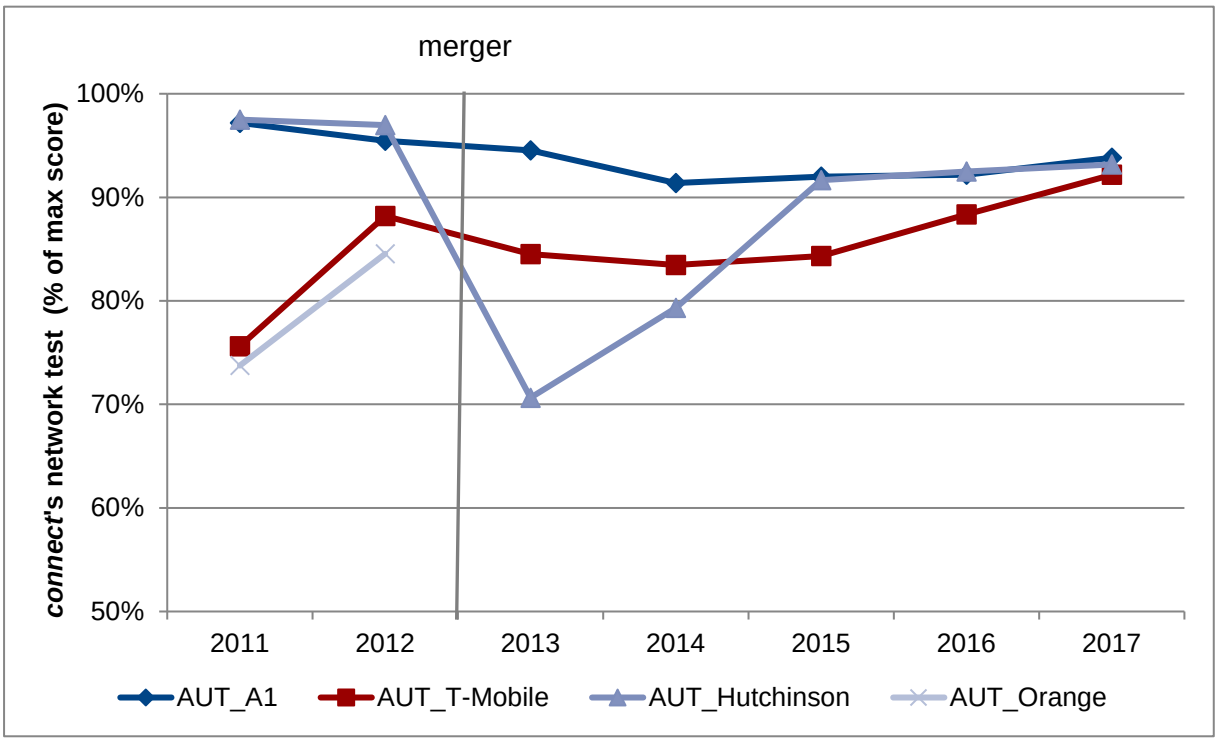

Figure 27: Results of *connect*'s network test for data connectivity, Austria 2011-2017

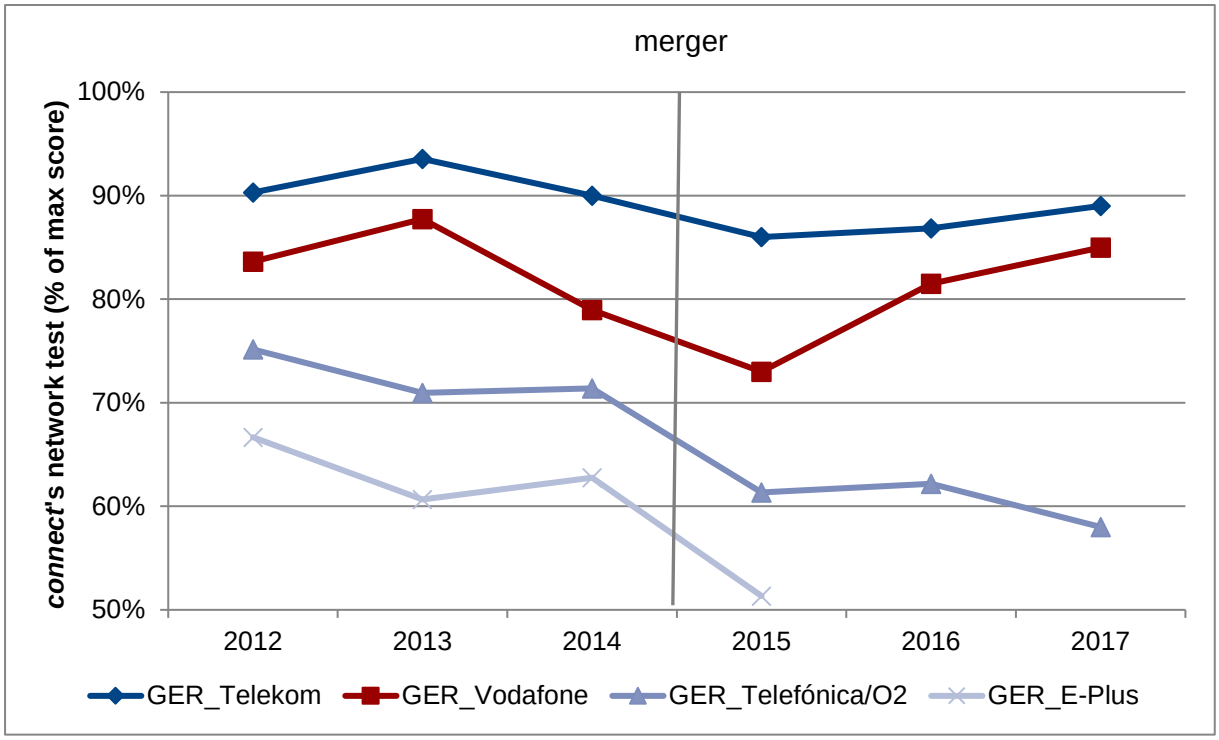

Figure 28: Results of *connect*'s network test for data connectivity, Germany 2012-2017

Figures 29 and 30 show the results for voice telephony. In this case, the quality of network providers seems to be very close in the Austrian case, such that most of the overall differences in quality seem to be driven by differences in the quality of data usage. For the German case, voice quality seems to follow a more similar pattern compared to data usage. Only in the case of Vodafone, quality in regards to data usage and voice calls differs a lot for the year of 2013.

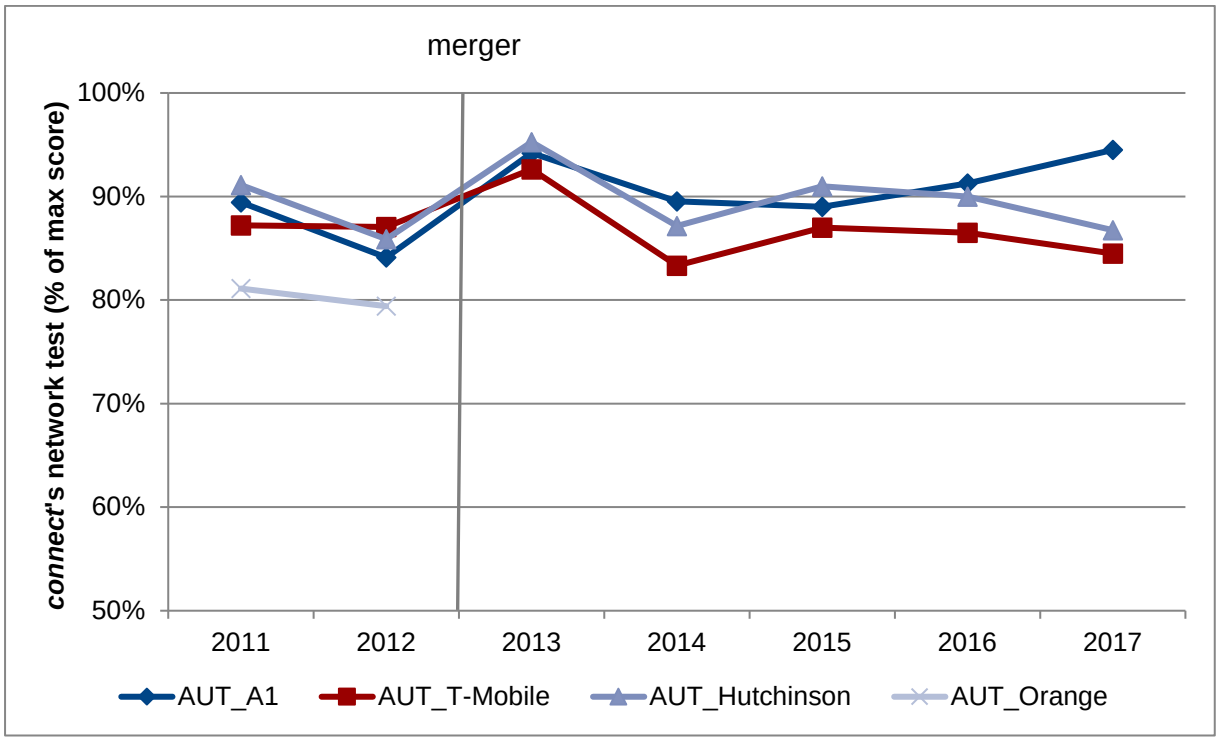

Figure 29: Results of *connect*'s network test for voice calls, Austria 2011-2017

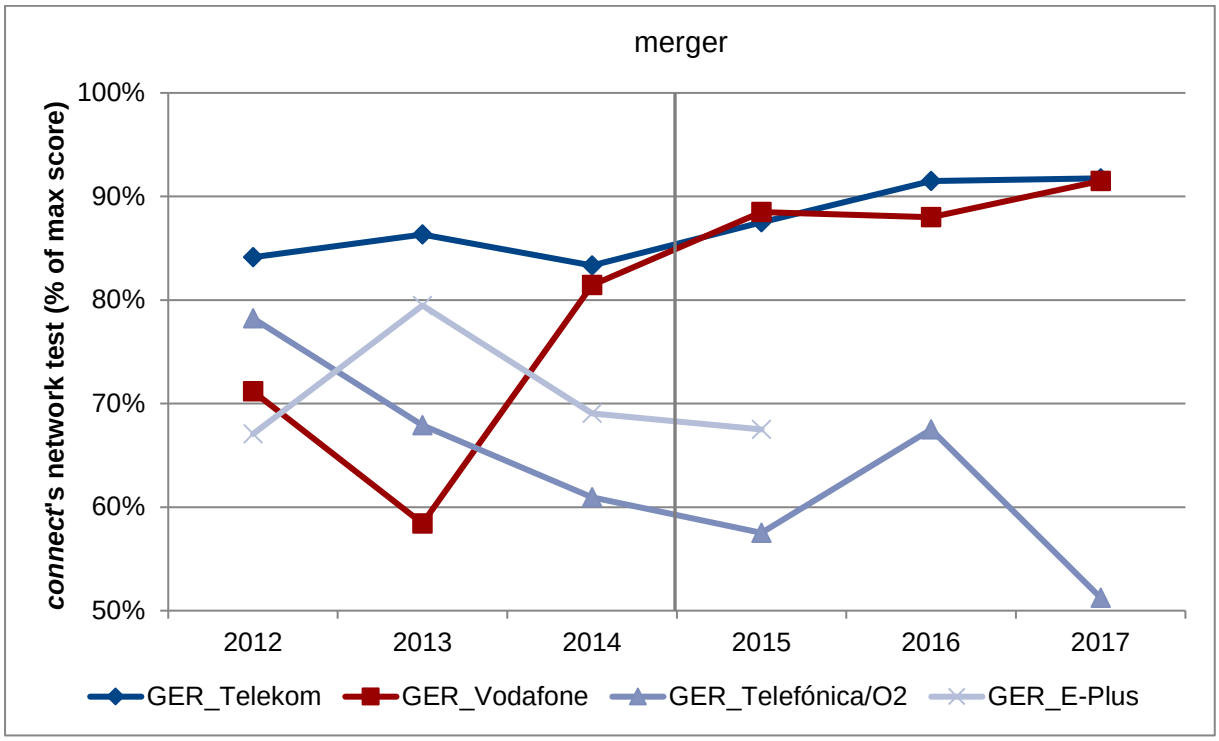

Figure 30: Results of *connect*'s network test for voice calls, Germany 2012-2017

Further details on the methodology

For each of the above mentioned categories (data and voice), *connect* gathers data on multiple dimensions of quality that might cause differences in user perception. As mentioned in the main text already, in each category network tests are performed in larger cities, towns and on roads connecting cities or towns. The method makes use of drive tests, walk tests and tests on public transport. Within each category *connect* defines relevant dimensions and scoring criteria, as well as the requirements for achieving a score of 100% in a given sub-category.

It should be noted that the performance that is required to reach 100% in specific parts of the tests is designed to change from year to year. The reason for the changes over time is that *connect* aims to reflect user perception of quality with the network test. As the perception of a given result (e.g. 4.5 seconds needed to start a YouTube video) might change over time, the scale aims to account for this as well. For this reason, inferences about relative test scores (rankings between network operators) and changes in test scores for a given operator can be made. However, because of the scale changes, one should be more cautious when interpreting the results.

To give an example of the details of the methodology, tests that were performed for the network test in 2018 are described in more detail.[63] Each of the following sub-categories were performed in the above mentioned test locations (drive test big cities, walk test big cities, drive test towns, walk test towns and walk test train). For data connectivity, several tests are taken

[63] A more comprehensive overview of the methodology used can be found here: https://www.connect-testlab.com/germany-2018methodology.

into consideration. Firstly, the countries' most commonly used websites (ranked by Alexa), as well as a static web site ("Kepler reference page"), were downloaded and scoring was based on success rate, reaction time and speed. Secondly, HTTP downloads and uploads of small files (1 and 3 MB) were performed, again measuring the success rate and the speed. Thirdly, to cover peak performance, a seven second download and upload of a very large file was conducted, with success rate, average speed and top speed as variables of interest. Lastly, to measure the perception of quality of YouTube content, *connect* measured the success when buffering a video, the time until the video starts, the percentage of video playouts with no interruptions and the average resolution of the video.[64]

For voice telephony, the quality of mobile-to-mobile calls is measured by the success rate, the time to setup the call and by recording relatively short speech samples. The samples are assessed by POLQA (Perceptual Objective Listening Quality Assessment) wideband scoring.

[64] As YouTube has a feature that adapts the resolution of a video to the available bandwidth, the resolution itself is a measure of network quality.