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Norbert Maier, Julie Runge Jørgensen, Asger Lunde and Otto Toivanen

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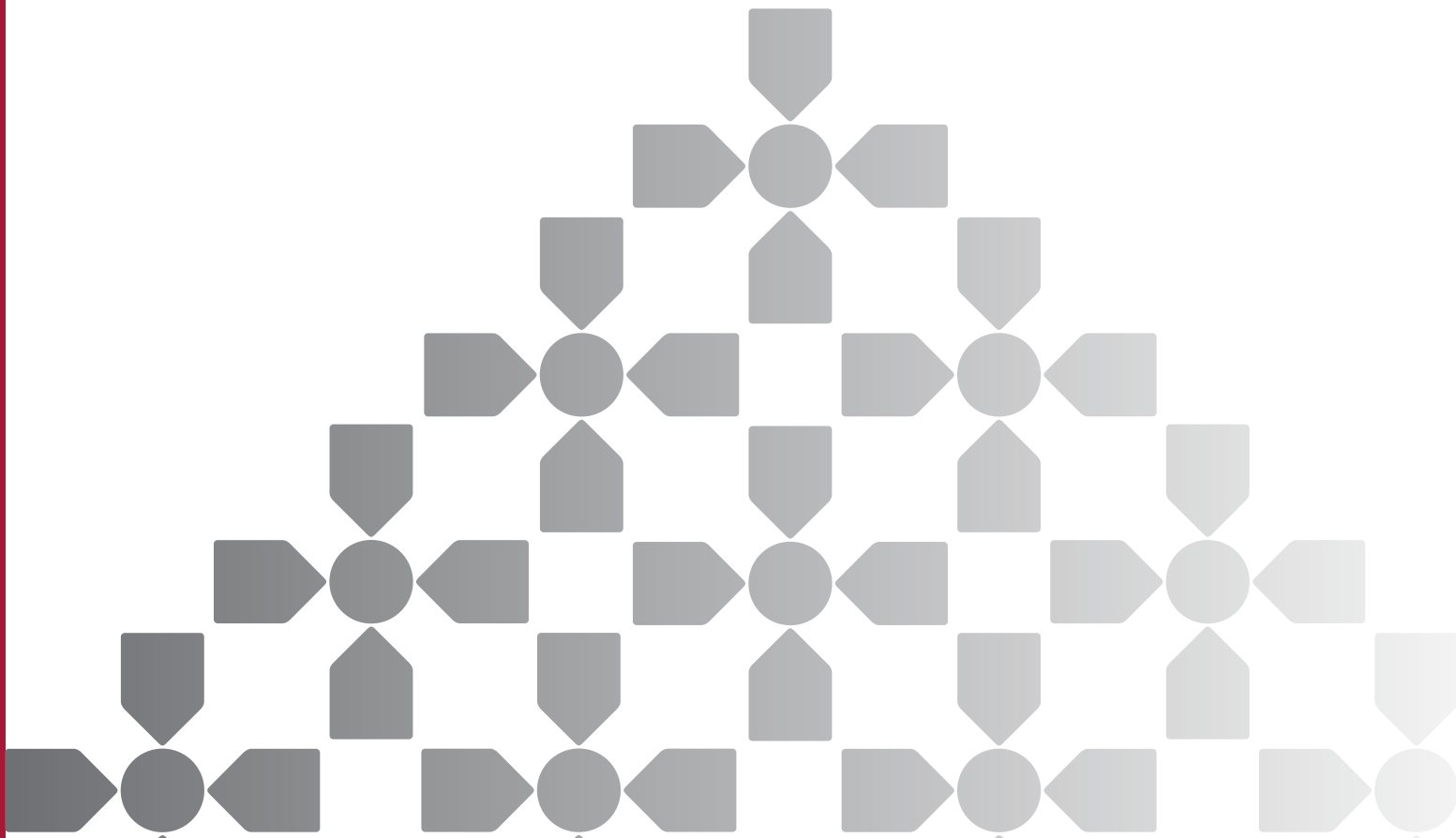

EX-POST ANALYSIS OF THE TELIASONERA-CHESS 2005 MERGER

Norbert Maier, Julie Runge Jørgensen, Asger Lunde and Otto Toivanen

ABSTRACT

We provide an ex-post analysis of the 2005 TeliaSonera-Chess merger in the Norwegian mobile telecommunication market. Applying a difference-in-difference approach and a synthetic control group method we find little evidence of price increase in the Norwegian mobile telecom market after the merger. Possible explanations for these findings include that Chess was a small player in the market, with a market share of 8% at the time of the merger and no spectrum license, and that by taking Chess on board, TeliaSonera could better exploit potential economies of scale related to the operation of its physical network and spectrum.

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1 INTRODUCTION

The European mobile telecom market has experienced a large wave of mergers over the past two decades. Many of these mergers was cleared unconditionally by the competition authorities in charge, some of them were cleared with commitments by the merging parties and a few were blocked or withdrawn before a likely prohibition decision.[1] These merger decisions were based on an ex-ante analysis of the possible future impact of the proposed transaction on the market. Ex-post analyses can complement such ex-ante analyses by identifying the actual impact of merger transactions. While ex-post analyses cannot be used to change the decision of competition authorities, ex-post analyses of merger decisions have the potential to single out competition authority decisions that turned out to be incorrect ex-post and identify market conditions that lead to such ex-post incorrect decisions. In this paper, we undertake an ex-post analysis of the impact of the TeliaSonera-Chess merger that was approved unconditionally by the Norwegian Competition Authority (NCA) on 31 October 2005.

We contribute to the growing body of ex-post analyses of mergers in various industries, including the telecom industry.[2] What is particular about our set-up is that the merger we study took place between two firms both of which had a significant market share, but only one of which (TeliaSonera) owned its (physical) network and had a spectrum license, the other (Chess) being a so-called virtual operator. Such "asymmetric" telecom mergers warrant study as the virtual operators are thought to be a key structural remedy for the otherwise high entry costs into mobile telephony, and thereby an important source of potential as well as actual competition in the industry. To the best of our knowledge, this is the first ex-post analysis of a mobile network operator and a mobile virtual network operator.

The mobile telecom industry has a number of particular features that make an ex-post merger assessment particularly challenging. For example, the industry is characterised by complex tariff offers and non-linear prices. Furthermore, when the merger involves service providers with individual spectrum licenses, the impact of a merger may be longer-lasting than in other industries. The analysis is further complicated by the fact that consumers typically do not purchase individual mobile services. Instead, they purchase a bundle of such services including mobile calls, both to other mobiles (on-net and off-net) and to landline phones, SMS messages and data transfer. We follow the relevant literature to address this complexity and compute a unique one-dimensional compound price index for mobile services consumed by consumers with a certain usage profile. Such a price index aggregates prices of various types of calls and SMSs – the price of data transfer is left out because of the low volume of such services in the examined time period.

[1] The European Commission blocked the H3G/Telefónica merger in the UK and the TeliaSonera-Telenor merger in Denmark was withdrawn in the expectation of a prohibition decision by the European Commission.

[2] See Mariuzzo et al. (2016), Ashenfelter and Hosken (2008) and Kwoka (2013) for an ex-post assessment of mergers, both in Europe and in the US.

We focus on the impact on mobile telecom prices of the TeliaSonera-Chess merger in Norway. This requires comparing the prices that emerged after the merger with the counterfactual prices that would have developed in Norway if there was no merger. We resort to a difference-in-difference (DiD) analysis using, in line with the existing literature, constructed compound price indices. Besides the standard DiD analysis, we also use the synthetic control method which aggregates price evolutions in individual countries in order to construct one single benchmark price evolution pattern.

We find little evidence of a price increase in Norway following the approval of the merger: In individual specifications, the treatment effect estimates vary but were mostly negative in absolute value. When significant, the point estimates were negative in all but one non-robust case. This finding is not in line with the recent work of Genakos, Valletti and Verboven (2018) who found that consolidation leads to higher prices, but also higher investment. Our findings could be explained by the fact that the acquired firm - Chess - was a mobile virtual network operator (MVNO), i.e., it did not own a spectrum license and bought wholesale network access services to develop its own retail mobile services. In other words, the concentration did not lead to the removal of a separate wholesale network from the market (total number of wholesale players remained the same). Instead, it led to a significant set of retail contracts (400,000 subscribers) to become provisioned via a different wholesale network (the TeliaSonera's NetCom network instead of Telenor's network), while the Chess brand remained active.[3]

In terms of existing literature, Aguzzoni et al. (2018), is particularly important for the present analysis as it develops an ex-post assessment of two mobile mergers (Austria and the Netherlands) that were very close in time to the TeliaSonera-Chess merger. In contrast to the TeliaSonera-Chess merger, these mergers were between firms that owned their physical networks and had spectrum licenses.[4] Another important recent paper is Genakos, Valletti and Verboven (2018) who study the effects of consolidation in the telecommunications industry using OECD level data. Both papers use the same data as the present study. Furthermore, Affeldt and Nitsche (2014), BEREC (2018), Frontier Economics (2015) and RTR (2016) provide ex-post assessments of mergers in the mobile communication industry. See also Csorba and Papai (2013) for a joint ex-post assessment of telecom mergers in 27 European countries in the period of 2003-2010.

The remaining sections of the paper are structured as follows. Section 2 provides background to the study. Sections 3 and 4 introduce the data and the empirical approach. Section 5 presents the results of the econometric analysis and section 6 concludes. Supporting material and a number of robustness checks are relegated into the Appendix.

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[3] See https://www.teliacompany.com/en/news/press-releases/2005/11/teliasonera-closes-deal-and-acquires-chesssense/. In 2018, the Chess brand was discontinued and fully absorbed into Telia, see https://www.dn.no/telekom/telia/idar-vollvik/kjersti-jamne/-folelsesmessig-leit/2-1-307580

[4] Aguzzoni et al. (2018) is based on a comprehensive ex-post merger assessment developed by the same authors for the European Commission. See European Commission (2016).

2 INSTITUTIONAL BACKGROUND

2.1 Merger control

Merger control is a key instrument of competition policy to assure a level playing field for competing companies and help maximizing consumer welfare. In particular, merger control deals with the identification of the expected impact on competition of merger transactions by parties with a turnover reaching a certain threshold.

In case of horizontal mergers, defined as mergers between two direct competitors active in the same market – the TeliaSonera/Chess merger falls into this category – merger control focuses on identifying the following effects of a proposed merger transaction:[5]

- non-coordinated, or unilateral effects, arising from the loss of competition between the merging firms[6],
- coordinated effects, arising from the creation or the strengthening of a collective dominant position[7],
- efficiency gains realised through lower costs and higher quality.

Merger control evaluates the balance between the first two possible effects of the merger, viewed as anti-competitive effects, with the last one, viewed as a competitive effect. If the anti-competitive effects dominate, the merger is considered being anti-competitive. Merger transactions viewed as anti-competitive in the approval process can only be cleared if the merging parties submit commitments that remedy the identified anti-competitive concerns. In the absence of such commitments, the merger will be prohibited by the competition authority in charge.

The importance of merger control is illustrated by the large number of merger investigations by competition authorities. For example, about 8000 proposed mergers were notified to the European Commission since 2000. In turn, almost 5000 mergers were notified to the Norwegian Competition Authority over the past 15 years.

2.2 The Norwegian mobile communication market

The TeliaSonera/Chess merger in the mobile communication industry was investigated by the NCA in the Summer and Autumn of 2005. At that time, the largest player in the market was Telenor, accounting for 56% of subscribers, followed by NetCom (TeliaSonera) with 27%, Sense (Chess) with 8% and Tele2 with 5% of subscribers.[8]

Only Telenor and NetCom had their own national-level physical mobile network, the former serving approximately 70% of subscribers and the latter 30%.[9,10] Furthermore, only these two players had their own spectrum licenses at

[5] See the European Commission's Horizontal Merger Guidelines (HMG, 2004) for further details.
[6] See for example Ivaldi et al. (2003a)
[7] See for example Ivaldi et al. (2003b)
[8] The remaining 4% included some small local players such as Teletopia in the Oslo area. See Norwegian Competition Authority (2005) Konkurransetilsynet 2005.1115 Clearence decision TeliaSonera-Vollvik Gruppen.
[9] Teletopia had an own network in the Oslo area but accounted for only a small share of the market.
[10] See Norwegian Communication Authority (2005), p. 19-23.

least since 2001, in the 900MHz range. This range was the only relevant range for the period, before the appearance of smartphones and the explosion of mobile data traffic.[11]

Another feature of the mobile communication market is the significant market power enjoyed by some players in the market of mobile call termination. This triggered the regulation of mobile termination rates (MTRs) for physical network owner Telenor and NetCom as they were found to have significant market power on mobile call termination. These regulated MTRs reflected individual service operators' costs and could therefore be set at different levels for operators from the same country. In case of Norway, Netcom was allowed to charge higher MTRs than Telenor up till July 2008.[12]

3 THE DATA

Our analysis is based on mobile communication service price (tariff) and usage data from Norway and a number of benchmark countries. In case of mobile telecom services, consumers can pay for services either in advance (pre-paid services) or in a subscription system at the end of the month (post-paid services). Pre-paid services typically include an upfront fixed payment, which can then be used to consume various services, each of them with a separate price. Post-paid services typically have a monthly fee component that includes a pre-defined quantity bundle (monthly quota) of various types of calls and SMSs, as well as individual service prices for usage exceeding the monthly quota. We use all these service pricing and usage features to develop three different compound price indices for each country, i.e. one index for each of the three different usage profiles.

Our main data source for mobile tariff data in a dataset by Teligen ("Teligen data"), a provider of telecom market data covering the OECD countries. In addition, we collected usage and mobile termination rates data from national regulators and obtained data on various control variables (GDP per capita), exchange rates and consumer prices from Eurostat.

3.1 Tariff data

Tariff data was obtained from Teligen, the only data provider to have quarterly tariff data for the time period around the merger; such data was not available from national regulators for a time period in such a distant past.

The Teligen data includes quarterly data on retail mobile service tariffs offered by the two largest mobile service operators to their customers in each OECD country – the two largest operators do not need to stay the same over the examined period. For Norway, the Teligen data includes prices for Telenor and TeliaSonera but not Chess. However, this is not an effective limitation for our analysis because the impact on prices of the merger can be identified from the evolution of TeliaSonera's prices. Ultimately, as per the prior literature, the focus is on the

[11] Spectrum became scarce only in the 1800MHz range after the take-off of the smartphones.
[12] See Norwegian Communication Authority (2005) and (2007).

evolution of main pricing reference points affecting the Norwegian market and for this the Teligen data is a very close proxy.

Each service provider offers multiple tariff bundles. The data covers the period from 2003Q4 to 2007Q3, i.e., covering two full years before and after the date of the merger clearing decision by the Norwegian Competition Authority on 31 October 2005.[13] In our estimation, 2005Q4 is part of the post-merger period. As a robustness test, we leave this quarter out of the sample and find that this does not change the conclusion of our results.

For each tariff bundle, the Teligen tariff data includes data on:

- connection fee,
- monthly fixed fee,
- monthly allowance of national landline, on-net and off-net calls and SMSs included in the monthly fixed fee,
- fees for national landline, on-net and off-net calls and SMSs made in addition to the monthly allowance (out-of-bundle call fees),
- monthly national landline, on-net and off-net calls and SMSs usage – this is the same across countries.

The connection fee is a one-off fee paid by a customer when joining a bundle offered by an operator. As operators often ask for a loyalty period of two years (and this was even more true during the observation period), i.e., 24 months, the connection fee is divided by 24 to obtain its monthly value. Fees for out-of-bundle national landline, on-net and off-net calls are often split into peak time, off-peak time and weekend fees.[14] Fees are expressed both in national currencies as well as in USD, with the conversion being made by the same period's exchange rate. The data for each country includes both pre-paid and post-paid tariffs. Handset subsidies, offered as part of a tariff bundle, are not separately identified in the dataset.

In our analysis we exclude packages that can be identified as targeting business users because such users typically receive large discounts and, therefore, such tariffs are less representative.[15,16]

3.2 Usage data

Usage data were collected from national regulators. For Belgium and the UK where usage data were not available from the national regulator we relied on usage data presented in Aguzzoni et al. (2018), a study covering the same countries over the same period, but looking at two other mergers.[17] These usage data include monthly average usage of calls made by mobile phone number owners, broken up into minutes to national fixed line, on-net and off-net,

[13] Technically, the data covers 25 months prior to the merger approval decision and 23 months following the merger approval decision. Our robustness analysis indicates that this is not a true problem.

[14] The earlier periods also split the allowance on peak, off-peak and weekend. But the allowance in the earlier periods only refers to calls, while it can also refer to SMSs in the later periods. Also, the call setup charge is one variable in the earlier period and can depend on national line, on-net and off-net (though they're often the same) in the later periods

[15] Such data accounts for less than 10% of all observations.

[16] These choices are consistent with the choices made, for example, in Aguzzoni et al. (2018).

[17] See Table 2 in Aguzzoni et al. (2018).

and monthly average number of SMSs sent. The usage data do not include international calls, calls to voicemail, MMS and data transfer services – data services usage was very low in the examined period. The usage data used in our analysis are presented in the table below.

Table 1

Usage data

TYPE OF USAGE	BE	CH	DE	FR	HU	IT	NO	PT	UK
min to fixed	12.00	22.66	13.96	34.80	7.22	14.22	30.41	5.65	31.00
min on-net	51.00	21.93	15.85	70.38	47.62	48.37	41.83	54.00	30.00
min off-net	22.00	13.02	9.88	32.80	27.65	18.41	27.88	15.77	25.00
SMS	60.00	42.04	21.34	31.71	16.00	32.56	67.20	31.71	55.00

Notes: Data from national regulators and Aguzzoni et al. (2018)

Furthermore, in order to cover a wider range of tariffs and usage patterns, we follow the approach used by Aguzzoni et al. (2018) and define a low and a high usage pattern in addition to the base usage numbers - to construct the low (high) usage basket we multiply the numbers above with a factor that is less (greater) than 1.[18,19]

Table 2

Weighting of usage bundles

BASKET	MINUTES FACTOR	SMS FACTOR
Low	0.46	0.66
Medium	1	1
High	2.15	1.1

Notes: Data from Aguzzoni et al. (2018)

[18] See Table 3 in Aguzzoni et al. (2018).

[19] These factors are taken from the OECD's study on mobile tariffs – See OECD (2006), p. 6.

3.3 The mobile service compound price index

We follow the literature and compress the various types of price information associated to each bundle into a one-dimensional price index. In particular, for each bundle, we calculate the monthly expenditure associated with the three pre-defined (low, medium and high) country-specific usage patterns.

The incorporation of usage data into the compound price index is needed to get a cleaner estimate of actual prices that users face in the mobile telecom industry as they often consume more than what is covered by the monthly allowances determined by their chosen tariff package.[20]

As a certain bundle typically involves a monthly fixed fee, including allowances for a certain number of call minutes and SMSs, the price index assigned to a particular bundle and usage pattern is defined as the sum of:

- the connection fee broken down to monthly level,
- the monthly fixed fee, and
- the value of calls and SMSs initiated in excess of what is included in the monthly allowance covered by the monthly fixed fee.

In order to make the price indices and their evolution in time across the various countries directly comparable, and to take into account the potential incentives of mobile operators to raise their prices following the merger, we introduce the following adjustments for the calculated price indices:[21]

- deduct value-added taxes (VAT) as they changed in some countries over the examined time window,
- convert figures expressed in national currency into EUR-figures by using the average nominal exchange rate over the period investigated. This choice limits the impact of fluctuations of the exchange rate on the countries' price time series,
- control for inflation by using harmonised indices of consumer prices (HICP) to construct real prices.

To account for the fact that a certain usage pattern cannot be associated exclusively to individual tariffs, we take the four cheapest tariffs per operator for each usage pattern, i.e., we calculate four price indices for each operator corresponding to the four lowest expenditure levels for each usage pattern (low, medium, high) for each operator's available tariffs. This choice takes into account heterogeneity across the users for each average usage basket and it also reflects that users may not know their behaviour in advance exactly and may not always be fully rational. Finally, this choice also averages out potential measurement errors of tariffs.[22]

[20] It is important to note, however, that this risks in part to make price information endogenous with demand/consumption – a challenge not solved in this field of literature and thus a limitation also in our research.

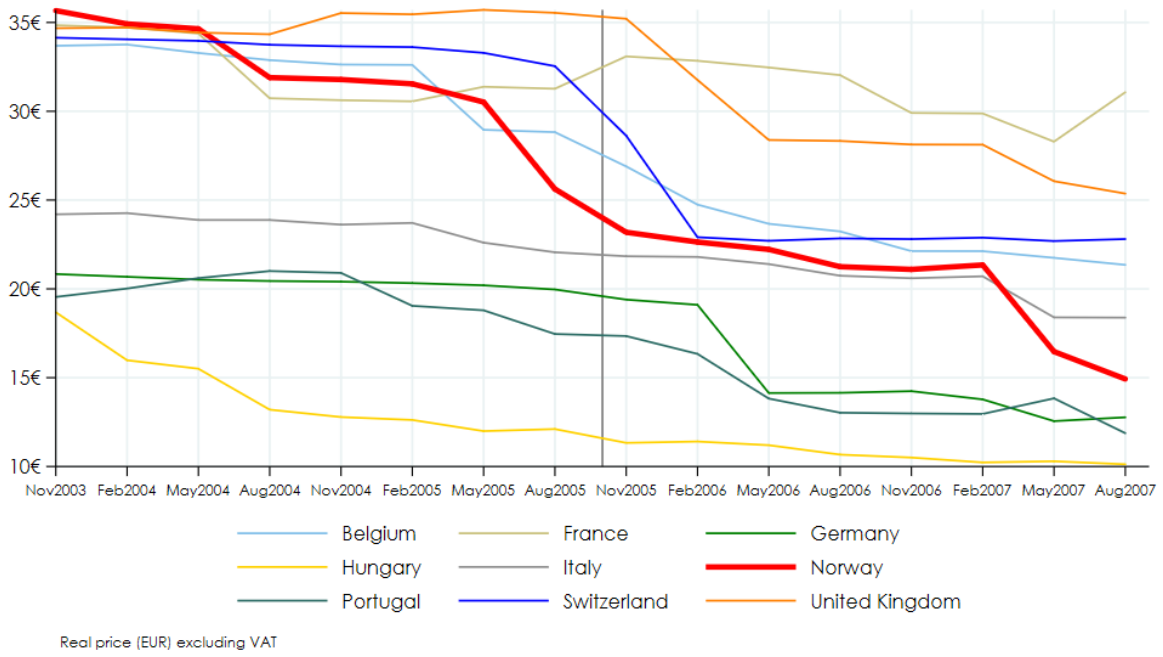
[21] These adjustments are in line with the methodology presented in Aguzzoni et al. (2018).

[22] The same choice was made, for example, in Aguzzoni et al. (2018). We carry out a robustness check of this in the appendix, where we construct the price index using only the two cheapest tariffs for each provider.

As a next step, for each usage pattern (low, medium and high) we calculate the average price index for each operator in each country by taking the average of the individual euro-level prices computed for each of the four cheapest tariffs. We then calculate the country level price index for each usage pattern by taking the average of the two price indices computed for the operators for which tariff data is available in the Teligen data[23]. The following figure illustrates the price index for medium usage pattern for Norway and for the selected set of benchmark countries for the period of 2003Q4-2007Q3, the vertical line indicating the time of the merger clearance decision by the NCA.

Figure 1

Price index for medium usage



Note: Real price excluding VAT. Data from Teligen.

The evolution of price indices in this figure is very similar to the price indices for the same period in Aguzzoni (2018) and Genakos, Valletti and Verboven (2018).[24] The figure provides a few interesting insights on the evolution of telecom "prices" in a selection of EEA countries. In particular, most countries experience a decline in prices during the investigated 4-years long period. Furthermore, a few countries, notably Norway, Switzerland, the UK and, to a smaller extent, Germany, experience a sharp drop in their prices around the time of the merger approval.

[23] For a more detailed description of how we construct the price index, please refer to section 8.1 (in the Appendix).
[24] See Figure 1 in Aguzzoni (2018).

Furthermore, the curves in the figure seem to suggest that Norwegian prices do not show an upward turn after the merger – not even when compared to the price evolution in other countries, e.g. Switzerland or the United Kingdom. In fact, the Norwegian prices show the biggest decline (both in absolute and relative terms) between the two end-points of the examined time period.

3.4 Mobile termination rates data

Mobile termination rates (MTR) data were collected from national regulators. It is important to point out that these MTRs were typically set by the regulator as part of finding some individual operators to have significant market power in their call termination services offered to other operators and the national landline service provider. As these call termination rates were also linked to individual operators' costs they often differ across operators from the same country. Furthermore, they can also change in time, depending on the operator's position in the call termination segment and its costs. Finally, these MTRs can be viewed as mostly exogenously set by the regulator even if they are linked to costs.

3.5 Other data

As one could think of MTRs as factors influencing the supply of services, we add the growth rate of GDP per capita as a proxy for changes in demand. We use the growth rate of the GDP per capita as it is a stationary economic measure, whereas the GDP per capita is a non-stationary measure.

3.6 Descriptive analysis

Table 3 below shows the summary statistics for price indices for the three chosen usage patterns for Norway and our benchmark countries before and after the merger. For each period we have 64 observations for Norway: 8 quarters (2 years) and 4 prices per quarter for each of the 2 largest mobile operators. For each period we have 512 observation for our control group: 64 observations per country (as for Norway), with 8 control countries.

The pre-merger prices are higher in Norway than in the control countries for all baskets (low, medium and high usage), but the MTR is lower. Prices post-merger are essentially identical between Norway and the control group. These observations, in line with Figure 1, suggest that the merger may have decreased prices in Norway. MTRs are similarly essentially identical post-merger, suggesting that the merger may have led to an increase in MTRs in Norway: the raw DiD estimate is (0.112 – 0.122) – (0.117 – 0.158) = 0.031.

Table 3

Descriptive analysis

	Norway			CONTROL		
	N	**Mean**	**Standard dev**	**N**	**Mean**	**Standard dev**
Pre-merger						
Price, low basket	64	19.286	2.691	512	16.043	6.810
Price, medium basket	64	32.074	4.511	512	26.350	8.029
Price, high basket	64	54.531	10.528	512	43.075	11.283
MTR	64	0.122	0.004	512	0.158	0.037
GDP per capita growth	64	0.031	0.046	512	0.012	0.058
Post-merger						
Price, low basket	64	12.636	4.030	512	12.809	6.207
Price, medium basket	64	20.392	5.538	512	20.892	7.649
Price, high basket	64	34.265	7.202	512	34.292	11.180
MTR	64	0.112	0.004	512	0.117	0.027
GDP per capita growth	64	0.016	0.035	512	0.012	0.055

Note: Weights of the synthetic control for the base investigation of Norway

4 THE EMPIRICAL METHODOLOGY

4.1 Setup of methodology

In order to identify the economic impact of the merger between TeliaSonera and Chess one would need to compare the observed prices of mobile services ("prices") after the merger with the prices that one could have observed over the same period if there was no merger, i.e. one would need to compare post-merger observed prices with the counterfactual prices of the period following the completion of the merger.

However, due to the inherent difficulty of reproducing counterfactual prices of mobile services with sufficient precision, the economic impact of the merger can be assessed by comparing prices in Norway with prices in a number of benchmark countries in a time window that includes the merger.

To minimize the distortions from such a cross-country comparison, these benchmark countries should be chosen in such a way that the structure and dynamics of their mobile services industry is sufficiently similar to the structure of the mobile services industry in Norway, absent the merger. For example, these benchmark countries cannot have mergers or large-scale entry and exit events in the chosen time window.[25] We identified Belgium, France, Germany, Hungary, Italy, Portugal, Switzerland and the UK as suitable benchmark countries for our exercise.[26]

Looking at the prices in benchmark countries helps to control for cross-country changes in the evolution of prices. Therefore, the evolution pattern of prices in these countries after the time of the merger in Norway can be considered a good proxy for the Norwegian counterfactual prices, i.e., the prices that would have evolved in Norway absent the merger. When focusing on the evolution of prices in the chosen countries we use a compound price index for three usage groups rather than individual service prices (see Section 3.3).

4.2 The econometric approach

We developed our DiD analysis for a time window encompassing two years before and two years after the date of the merger clearance decision, 2005 October 31. This choice of the time window has two motivations. First, in a fast-changing industry such as the telecom industry, a longer time window would risk including market environments that are too dissimilar to the one at the time of the merger approval. Second, this choice is in line with many previous studies.

[25] Any of these events would lead to a price change in the benchmark country that would make the comparison less valid. For example, a large-scale exit from the market in one of the benchmark countries would fail to reveal any post-merger price increase in Norway if there was no control for that exit. It is safer not to include such markets in the set of benchmark countries.

[26] While Aguzzoni et al. (2018) also included Denmark, Finland and Sweden in its set of benchmark countries, we did not include them in our investigation because we identified mergers in these countries falling in our examined time period. Furthermore, the Czech Republic was left out because of the lack of mobile termination rate data.

Besides the standard DiD,[27] we apply the synthetic control method version, where price evolutions in individual countries are aggregated to construct one single price evolution pattern.

The DiD specification

The DiD approach compares the difference in prices after and before the merger in the treated country, Norway, with the difference in prices after and before the merger in the benchmark countries (the control group). This relies on the assumption that the prices in the control group countries post-merger will be good indicators of the counterfactual price evolving in Norway if there was no merger.

However, as the examined countries are somewhat heterogenous from the point of view of their price evolution, one would need to include some additional variables in the regression, e.g. growth of GDP per capita and marginal termination rates (MTRs), to control for some of the observed differences.[28]

The DiD model that we take as our starting point takes the following form:

$$(1) \qquad log(p_{i,j,t}) = \alpha + \gamma_s D^s_{i.t} + \gamma_m D^m_{i.t} + \Sigma_t \tau_t + \Sigma_i S_i + \delta_1 GDPgrowth_{it} + \delta_2 \log(MTR_{it}) + \varepsilon_{ijt}$$

where subscript i denotes country, j a usage bundle (low, medium, high) and t a specific quarter. The dummy variables $D^s_{i.t}$ and $D^m_{i.t}$ take the value of one for Norway for quarters in the first and second year after the merger respectively and zero otherwise, and thus their coefficients measure the short-term (1st year) and medium-term (2nd year) impact of the merger. Finally, $\Sigma_t \tau_t$ is a series of time fixed effects. These take account of market changes that affect countries in the same way (e.g. technological change) over time. Similarly, $\Sigma_i S_i$ is a series of country-fixed effects. ε_{ijt} is an independently and identically distributed random term. We label this model as the "*Base specification*" model.

To control for the possibility of a first-order autoregressive (AR(1)) error term, we estimate the parameters of the above regression using two different assumptions about the standard errors. First, we use a cluster-robust estimator with clustering at the country level but assume that there is no autocorrelation.[29] Second, we allow for first order autocorrelation, but at the cost of not being able to cluster the standard errors.[30]

We test for the common trends hypothesis by following the method in Abramitzky and Lavy (2014). We investigate the period before the merger (2003Q4 – 2005Q3) using both a linear time trend and individual time dummies for each quarter. We add an interaction term between the time variable (either the time trend or time dummies) and the treated country (Norway). This interaction term is our variable of interest: if the coefficient is statistically

[27] See e.g. Ashenfelter and Hosken (2008).

[28] GDP growth is used as a proxy for demand side factors, whereas MTR is used as a proxy for supply side factors affecting price evolution.

[29] Brewer, Crossley and Joyce (2018) show that tests of the correct size can be obtained with, for example, Stata's cluster-robust estimates in many DiD settings. However, the small number of clusters (available countries) is likely to result in a downward bias of standard errors, overstating the statistical significance of the results, see Wooldridge (2003).

[30] Not accounting for autocorrelation can lead to underestimating the standard errors, overestimating the statistical significance of the results. See Bertrand, Duflo and Mullainaithan (2004).

insignificant, our common trend hypothesis cannot be rejected. A statistically significant coefficient means that our common trend hypothesis fails. For each investigation we carry out the analysis using, first, a dummy for the treated country (Norway) and, second, country-fixed effects.

Some, but not all, specifications of the Abramitzky-Lavy tests indicate that the Norwegian price index follows a different pre-merger trend than the price indices of control countries. As an auxiliary analysis, we therefore control for such potential trend differences with the introduction of country-specific time trends as follows:[31]

$$(2) \qquad log(p_{ijt}) = \alpha + \Sigma_{t>T}\gamma_t D_{i,t} + \Sigma_t \partial_i t + \Sigma_t \tau_t + \Sigma_i S_i + \delta_1 GDPgrowth_{it} + \delta_2 log(MTR_{it}) + \varepsilon_{ijt}$$

where $\partial_i t$ denote the country-specific linear time trend. We use the dummies $D_{i,t}$ taking the value of one for each quarter after the merger for Norway (where T is the time of the merger) to estimate the effect of the merger. The short-term effect is the average of the first four quarters after the merger, where the medium-term effect is the average of the following four quarters after the merger.

We label this model the "*Trend specification*" model. This is not technically a new specification, but rather a (restricted) test of the common trend hypothesis. Such a specification is sometimes used to compare these results with the results from the model without group (country)-specific trends: if the treatment effect is consistent across models our result is more credible and robust.[32] We use a joint F-test to compute the statistical significance of the short-term and medium-term effects. As with our first specification, we carry out the above regression using both a normal fixed-effects regression with clustered error terms and a general random-effects regression that is able to handle AR(1) error terms.

Finally, to address the issue that Norway has experienced a price drop just before the approval of the merger, whereas some other countries (Switzerland, the UK and Germany) experience a similar drop just after the merger, we re-run our estimations on the same two models but by leaving out the three quarters (2005Q3-2006Q1) when these price decreases happened in the various countries.

The synthetic control method

The synthetic control method uses prices in the countries in the control group to build a single unique counterfactual price.[33] It is a weighted average of the prices in the control group countries, where the weights are chosen in such a way that the constructed weighted average prices pre-merger best approximate the treated country's (Norway's) prices pre-merger. These weights are computed by an algorithm that minimises the distance between the realisations of pre-merger prices in the treated country (Norway) and the (weighted) average of pre-merger prices

[31] In Wolfers (2006) it is shown that the simple inclusion of country-specific trends may lead to biased estimates in the DiD framework since the effect of the merger may be confounded with the estimated trend. Therefore, we identify the effect of the merger by assuming that the country-specific pre-merger time trend in the treated country (Norway) remains unchanged post-merger.

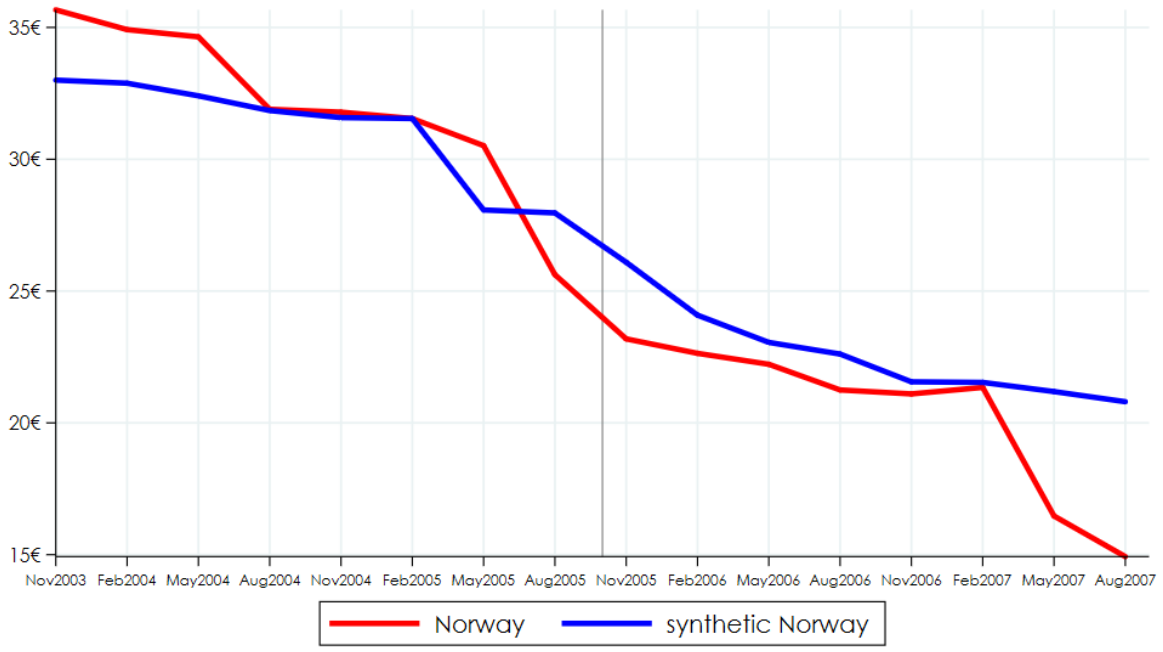
[32] Wing, Simon and Bello-Gomez (2018) Designing Difference in Difference Studies: Best Practices for Public Health Policy Research, page 459

[33] See Abadie and Gardeazabal (2003)

in the control group countries. This difference is formally called the root mean squared prediction error (RMSPE). Subsequently, the counterfactual price is constructed such that the same weighted average of the prices in the control group is extended to cover the post-merger period. The impact of the merger is then identified by comparing the constructed post-merger counterfactual price with the post-merger prices in the treated country (Norway). The figure below illustrates the price index for Norway along the price index for the constructed synthetic control for the medium usage bundle.

Figure 2

Synthetic price index for medium usage



Note: VAT excluded. Teligen data.

Visually, there seems there seems to be little evidence for the merger in Norway having affected prices adversely. If anything, prices in Norway seem to have dropped faster than the synthetic Norway from February 2007 and onwards.

To investigate the statistical significance of the estimated impact of the merger, we carry out a so-called "in-space" placebo test where we substitute the treated country, Norway, with each of the eight other benchmark countries, as if they had experienced a merger (leaving out Norway from the sample of benchmark countries).[34] For each test we store the RMSPE for both the pre-merger and post-merger period. We then compute the ratio of post-merger to

[34] This method has been proposed by, for example, Abadie et al. (2010) and Abadie et al. (2015).

pre-merger RMSPE. If Norway's prices have changed significantly following the merger, we would expect Norway's RMSPE ratio to be higher than all the placebo RMSPE ratios.[35]

As for the DiD estimation, the price drop in Norway just before the merger followed by similar price drops in Switzerland, the UK and Germany after the merger, can be an issue in correctly identifying the impact of the merger. The elimination of price points from the period 2005Q3-2006Q1 can help address the issue. In this case the synthetic control group price will be constructed by relying on control group countries' price point up until 2005Q2 (inclusive). Accordingly, the comparison of the counterfactual price and the Norwegian post-merger price will be done for the period of 2006Q2-2007Q3.

5 RESULTS

Our results section is split into four subsections: First, we go through our initial findings for the DiD regressions. We report both the Base and Trend specifications. We discuss the results both for the standard fixed effects model and for our specification with an AR(1) error term. Second, we go through our initial findings for our synthetic control. Third, we carry out sensitivity analysis of our DiD regressions and the synthetic control group approach by excluding the period just around the merger from the analysis. We do this to make sure we correctly identify the impact of the merger. The descriptive statistics of Norway and the control group countries and some further robustness checks can be found in the Appendix.

5.1 DiD estimation

The standard fixed effects method

Table 4 presents our main results for the Base and Trend specifications using the standard fixed effects method. Columns (1) - (3) present the results for the Base specification for the low, medium and high usage bundles respectively. Similarly, columns (4)-(6) present the results for the Trend specification for the low, medium and high usage bundles respectively.

As shown in the table, the Base specification indicates a significant price drop after the merger. This effect is present both in the short and the medium term. The estimated short-term impact varies between -14% (low usage bundle) and -18% (high usage bundle). For the estimated medium-term impacts, the ordering of the estimated effects is reversed, with the largest effect in absolute value (-24%) obtained for the low usage bundle and the smallest (-16%) for the high usage bundle. These results suggest that the merger had a large negative effect on prices. However, we reject at least at 5% level the Null hypothesis of common pre-trends both when using a linear trend specification

[35] This follows the method proposed by Abadie, Diamond, Hainmueller (2015) "Comparative Politics and the Synthetic Control Method", American Journal of Political Science, 59(2), pp. 495-510.

and when using quarter dummies, with one exception: for the low usage bundle and using a linear trend, we reject only at the 6% level. For this reason, we also report results from the Trend specification.

The results from the Trend specification are much smaller in absolute value at between 1 - 8%, but also negative in all but one case: According to these results, the high usage bundle prices increase in the medium run by almost 14%. Our results from the standard fixed effects model thus suggest that the merger between TeliaSonera and Chess lead to lower prices in Norway, but the magnitude of the effect is sensitive to the specification used.

Table 4

Standard fixed effects model

Specification	Base Specification			Trend Specification		
	(1)	(2)	(3)	(4)	(5)	(6)
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.137**	-0.159***	-0.180***	-0.041***	-0.038***	-0.011***
	(0.050)	(0.042)	(0.040)	**0.003**	**0.000**	**0.000**
Medium-term effect	-0.244***	-0.233***	-0.157**	-0.082***	-0.034***	0.119***
	(0.071)	(0.061)	(0.057)	**0.000**	**0.000**	**0.000**
GDP growth	-0.075	-0.122	-0.224	0.047	0.014	0.005
	(0.122)	(0.145)	(0.179)	(0.114)	(0.091)	(0.082)
Log MTR	-0.016	-0.078	-0.226	1.4	-0.046	-0.181
	(0.203)	(0.271)	(0.311)	(1.509)	(0.940)	(0.487)
Constant	2.366***	2.713***	2.870***	2.424***	3.124***	3.950***
	(0.485)	(0.611)	(0.692)	(0.583)	(0.318)	(0.550)
Observations	144	144	144	144	144	144
R-squared	0.775	0.814	0.775	0.865	0.909	0.914
Country-specific trend	No	No	No	Yes	Yes	Yes
Common trends hypothesis						
Conclusion of test	Pass	Fail	Fail	Fail	Fail	Fail
P-value of test	0.058	0.026	0.007	0.000	0.000	0.000

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%. For the linear trend, we "pass" the common trend test if we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

The AR(1) specification

Table 5 presents our main results for the Base and Trend specifications with an AR(1) error term. Columns (1) through (3) present the results for the Base specification for the low, medium and high usage bundles respectively. Similarly, columns (4) through (6) present the results for the Trend specification for the low, medium and high usage bundles respectively.

Table 5

Autoregressive model

Specification	Base Specification			Trend Specification		
	(1)	(2)	(3)	(4)	(5)	(6)
Usage bundle	Low	Medium	High	Low	Medium	High
Short-term effect	-0.083	-0.088	-0.097	0.102	0.109	0.107*
	(0.065)	(0.060)	(0.064)	**0.490**	**0.197**	**0.094**
Medium-term effect	-0.132	-0.115	-0.096	0.197***	0.239***	0.333
	(0.086)	(0.080)	(0.086)	**0.009**	**0.004**	**0.120**
GDP growth	0.039	0.029	0.017	0.086	0.053	0.036
	(0.084)	(0.076)	(0.078)	(0.081)	(0.071)	(0.083)
Log MTR	0.036	0.028	0.015	1.784**	0.874	0.394
	(0.097)	(0.089)	(0.093)	(0.773)	(0.673)	(0.773)
Constant	2.427***	2.875***	3.256***	1.754***	3.019	3.850***
	(0.062)	(0.052)	(0.049)	(0.477)	(1216.848)	(0.437)
Observations	135	135	135	135	135	135
R-squared	N/A	N/A	N/A	N/A	N/A	N/A
Country-specific trend	No	No	No	Yes	Yes	Yes
Coefficient of AR(1) error term p-value	0.745	0.770	0.798	0.672	0.633	0.542
	0.000	0.000	0.001	0.004	0.001	0.004

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; The AR(1) error term is statistically significant if the test that the correlation between past error terms is rejected at 5 % level.

We see that including an autoregressive error term of order one renders the post-merger price decreases statistically insignificant for the Base specification. This is both because the point estimates decrease somewhat in absolute value, and because the estimated standard errors increase. As in Table 4, all but the high usage bundle – medium term – treatment effect estimates are negative. The results from the Trend specification differ more from those in Table 4 According to the model, the merger resulted in statistically significantly (at the 95% level) *higher* prices in the mid-term for low and medium usage (and at the 90% level for short-term and high usage).

The synthetic control method

To complement our DiD analysis, we also use the synthetic control method. The table below shows that prices in Norway have dropped following the merger in all but one (short-term for high usage bundle) case, and even there the point estimate is low at 0.01. As the rankings show, these findings do not appear to have any statistical significance – in fact, Norway is consistently one of the countries with the smallest post- to pre-merger RMSPE ratios compared to the control countries.

Table 6

Synthetic control estimation

USAGE BUNDLE	PERIOD	EFFECT	RANK	CONTROL COUNTRIES
Low	Short	-0.104	5/9	Belgium, France, Hungary
	Medium	-0.191	3/9	
Medium	Short	-0.070	7/9	Belgium, Hungary
	Medium	-0.154	5/9	
High	Short	0.011	9/9	Switzerland, Hungary
	Medium	-0.063	8/9	

Note: A rank of 1/9 implies that Norway has seen the largest difference between the post- and pre-merger RMSPE, thus indicating that the effect is statistically significant. The control countries are the countries chosen by Stata to construct the synthetic Norway which estimates how the prices in Norway would have evolved in the absence of the merger

5.2 Robustness analysis

In this section, we report in detail the results of one robustness test where we drop the quarters close to the merger. We then report more briefly on other robustness analyses, the detailed results of which can be found in the Appendix.

Dropping quarters close to merger

To investigate the robustness of our results, especially to the price drops by four countries around the time of the merger approval and Norway being the first one experiencing this price drop right before the merger approval, we exclude the period from 2005Q3-2006Q1 and re-run our regressions and synthetic controls.

The standard fixed effects method

Excluding the middle three quarters from the regression does not significantly change the conclusion of the Base specification. The treatment effect estimates in Table 7 are somewhat weaker statistically than those in Table 4, and smaller in absolute value, but point to the same direction: the merger at the very least did not increase prices. In contrast to the earlier results, we now do not reject the Null of a common linear pre-trend, but still reject the Null of a common pre-trend when we use time (quarter) dummies.

Again, the absolute values of the coefficients decrease compared to the Base specification when we use the Trend specification, but the conclusions remain intact. It is also noteworthy that the absolute values of the coefficients increase compared to the specification where we used all quarters. Taken together, these results support the earlier findings that at the very least, the merger did not increase prices, and likely decreased at least some of them.

Table 7

The standard fixed effects model with 3 missing quarters

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.122	-0.148*	-0.159**	-0.038	-0.037	-0.005
	(0.059)	(0.046)	(0.045)	**0.576**	**0.598**	**0.319**
Medium-term effect	-0.252*	-0.260**	-0.186*	-0.194***	-0.164***	0.003***
	(0.076)	(0.066)	(0.066)	**0.000**	**0.000**	**0.001**
Observations	117	117	117	117	117	117
R-squared	0.833	0.842	0.805	0.921	0.937	0.945
Country-specific trend	No	No	No	Yes	Yes	Yes
Common trends hypothesis						
Conclusion of test	Pass	Pass	Pass	Fail	Pass	Fail
P-value of test	0.434	0.337	0.076	0.000	0.073	0.000

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; 2005Q3-2006Q1 excluded from regression. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

The AR(1) specification

Excluding the middle three quarters likewise does not change the conclusion for our Base specification with an AR(1) error term: the effect of the merger remains statistically insignificant, see Table 8 (and compare with Table 5). For our Trend specification, however the conclusion changes significantly. Instead of implying statistically significant higher prices, the Trend specification now implies statistically insignificant changes or statistically

significantly *lower* prices (in the medium-term for low and medium usage bundles) in Norway following the merger. In contrast to the earlier results, we now find little evidence of autocorrelation in the error terms.

Table 8

Robustness of AR(1) error term

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.08	-0.096	-0.091	0.042	0.011	0.064
	(0.099)	(0.095)	(0.100)	**0.744**	**0.729**	**0.705**
Medium-term effect	-0.128	-0.097	-0.081	-0.092**	-0.117***	0.055
	(0.109)	(0.107)	(0.113)	**0.011**	**0.000**	**0.121**
Observations	108	108	108	108	108	108
R-squared	N/A	N/A	N/A	N/A	N/A	N/A
Country-specific trend	No	No	No	Yes	Yes	Yes
Coefficient of AR(1) error term (with p-value)	0.762	0.854	0.867	0.630	0.763	0.587
	0.001	0.009	0.145	0.029	0.085	0.527

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; The AR(1) error term is statistically significant if the test that the correlation between past error terms is rejected at 5 % level; 2005Q3-2006Q1 excluded from regression

We thus find that controlling for the quarters immediately around the merger yields more robust results: the effect of the merger is consistent across the Base and Trend specifications for both our standard fixed effects model and for our model with AR(1) error term.

The synthetic control method

The sensitivity analysis for the synthetic control tell a similar story to those from the DiD regressions. As can be seen from Table 9, excluding the middle three quarters from the analysis puts Norway with the highest medium-

term rank for both the low and medium usage bundles, where the effect of the merger in both cases is a fall in prices. This finding supports the view that we should treat the quarter just before the merger as an outlier for Norway - it would bias our results if we did not do so. The sensitivity analysis for the synthetic control thus implies that the merger caused statistically significant lower prices in Norway.

Table 9

The synthetic control estimation with missing 3 quarters

USAGE BUNDLE	PERIOD	EFFECT	RANK	CONTROL COUNTRIES
Low	Short	-0.136	2/9	Belgium, France, Hungary, United Kingdom
	Medium	-0.255	1/9	
Medium	Short	-0.270	2/9	Belgium, France, United Kingdom
	Medium	-0.371	1/9	
High	Short	0.015	9/9	Switzerland, Hungary
	Medium	-0.096	8/9	

Note: A rank of 1/9 implies that Norway has seen the largest difference between the post- and pre-merger RMSPE, thus indicating that the effect is statistically significant; 2005Q3-2006Q1 excluded from the synthetic control estimation (treatment time is assumed to be *starting at* 2006Q2)

Further robustness analyses

A question that is relevant not only regarding our analyses but pertains also to the existing literature on telecom mergers is whether the results are biased due to the construction of price indices. As a robustness test, we therefore also used pre-paid tariffs as our dependent variable. We do not reject the Null of a common linear pre-trend but reject the Null hypothesis of a common pre-trend when we allow for quarter-specific effects. This time we find larger (in absolute value) and statistically more significant results when we allow for a common trend and for autocorrelation. All the point estimates are negative. With the synthetic control method, we again find negative effects, with Norway ranking first or second for the low and medium usage pre-paid tariffs, but eighth or ninth for the high usage, suggesting that the negative treatment effect is significant for the first two, but not the last usage group.

As a further robustness test, we use only the two cheapest tariffs of each provider when calculating the price indices. We again reject the Null of common pre-trends, now also for the linear case. All the results suggest a negative impact of the merger on prices but those where we allow for country-specific trends. In that case we find a large (0.07 when no autocorrelation assumed; 0.4 when allowing for AR(1)) and statistically significant positive impact on prices. With the synthetic control method, all point estimates are negative, but the ranks point to statistical insignificance.

6 CONCLUSIONS

We studied the impact of the TeliaSonera-Chess merger on mobile prices in Norway. Compared to the existing literature, this merger stands out in that only one of the parties has a physical network and a spectrum license; such mergers are however quite frequent in the mobile phone market and therefore relevant from a competition policy point of view. We find little evidence of the merger increasing prices. Indeed, most of our treatment effect estimates suggest that if the merger had any effect on prices, it decreased them.

The standard DiD specification systematically fails the common pre-trends test. For this reason, we also report results from specifications that include country-specific time-trends, and specifications where the error term is allowed to be serially correlated. Those results, with some exceptions, also point to either no price effects, or significant negative effects of the merger on prices. The results of the analyses where we use the synthetic control group method give further support for the conclusion that the merger did not raise prices.

Possible explanations of these findings include that Chess only had 8% of the market at the time of the merger - the 8% increment of TeliaSonera because of the merger could be viewed as of moderate size, and by taking Chess on board, TeliaSonera could better exploit potential economies of scale related to the operation of its physical network and spectrum.

Our results suggest that the removal of a virtual mobile phone operator did not impede competition in the case of Norway, suggesting that the impact of such firms on competition may rely as much on the threat of entry as it relies on their impact on actual competition. One context-specific reason for this could be that in the case we study, the customers of Chess changed physical networks, and this could have intensified the competition between the network owners compared to the counterfactual case where Chess would have operated in TeliaSonera's network already before the merger.

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8 APPENDIX

In this Appendix, we provide a detailed description of how construct the price index, the country weights for the synthetic control estimation, as well as the results from the following refinements and robustness checks:

- Leaving out the quarter of the merger from the regression analysis;
- Only looking at pre-paid tariffs. Handset subsidies are not included in the Teligen data, but they may affect the prices we observe. Pre-paid tariffs are less affected by these subsidies, and only looking at this subsample thus controls for this potential issue;
- Only looking at the two cheapest tariffs.

8.1 Constructing the price index

We use the Teligen data to construct our price index. For each country, we match our usage data with the Teligen data. Then, we multiply these usage numbers with the weighting of the usage bundles from the OECD's study on mobile tariffs (see Table 2), such that the usage varies between the different bundles.[36] To calculate the monthly tariff, we need to know the monthly fixed fee and the cost of any out-of-bundle usage as indicated in the box below.

Box 1 Total monthly tariff

The total price paid per month equals the fixed monthly fee plus any out-of-bundle usage:

$$price_{i,t} = fixed\ fee_{i,t} + (usage_i - included\ in\ bundle_{i,t}) * (cost_{i,t})$$

Where

- $price_{i,t}$ is the total cost of bundle i at time t
- $fixed\ fee_{i,t}$ is the total fixed fee paid for bundle i at time t
- $usage_i$ is our usage vector (calls min to fix, on-net, off-net, SMSs) figure for bundle i
- $included\ in\ bundle_{i,t}$ is the usage vector included in bundle i at time t
- $cost_{i,t}$ is the cost of out-of-bundle usage vector for bundle i at time t

Note: Illustration, Source: Copenhagen Economics

For the **fixed fee**, we assume that the consumer pays the connection fee once every two years (the typical duration the package binds the consumer, especially around that time).[37] Thus, we calculate the monthly fixed fee as the sum of the monthly fixed fees and 1/24 of the connection fee.

To calculate the **cost of out-of-bundle usage** we use the Teligen data's information on how many minutes of national fixed line, on-net and off-net calls are included in each bundle and whether the bundle includes calls during peak-time, evenings or weekends. For each type of call, we thus know the minutes of peak, evening and weekend

[36] OECD (2006), p. 6

[37] This follows the method of Aguzzoni et al. (2018)

out-of-bundle usage. We assume that calls last for two minutes on average and that they are split 50/50 between peak and off-peak (evenings and weekends) time, as also done by Aguzzoni et al. (2018).[38] This is relevant when we calculate the out-of-bundle usage, as the price of a call depends on (i) it's length of the call and (ii) any one-off charges associated with setting up the call. Furthermore, we use the Teligen data's information on how many SMSs are included in the bundle. We use this and the respective call and SMS prices to calculate the total out-of-bundle cost.[39]

Then, for the monthly tariffs to be comparable across countries, we

- convert non-euro currencies to euro, using the average nominal exchange rate over the period (2003Q4 to 2007Q3). We use the average nominal exchange rate to limit exchange-rate fluctuations affecting the relative prices;
- convert nominal prices to real prices, using the HICP with base year 2005 – This enables us to investigate the real development of prices rather than the development of inflation;
- exclude VAT from the price – VAT did not remain constant for all countries across the period investigated[40], which would lead to comparisons not being made across a constant basis.

Once we have real monthly tariffs that are comparable across countries, we can construct the price index. We do this through the following three steps:

First, we exclude all packages that we managed to identify as business packages. This follows the method of Aguzzoni et al. (2018), as such consumers are more likely to obtain large discounts on their packages, which makes the prices less representative of the average consumers. In our data this accounts for less than 10% of all observations.

Second, since a certain usage pattern cannot be explained exclusively by one individual tariff, we take the four cheapest real prices per operator for each basket (low, medium and high) each quarter. This choice both mimics heterogeneity across the consumers for each basket and reflects that consumers may not be fully rational or know their exact behaviour in advance. Finally, this choice also averages out potential measurement errors of tariffs.[41]

Third, for each basket and quarter we calculate the price index for each provider by taking the average of the four cheapest prices for that provider. To calculate the country level price index, we take the average of the two providers' price indexes for each country, basket and quarter. This leaves us with a price index consisting of one price per basket per country per quarter.

[38] Aguzzoni et al. (2018) p. 70

[39] In some cases, there is also a minimum monthly usage fee. If the calculated out-of-bundle usage cost is smaller than the minimum fee, we replace the calculated cost with the minimum fee

[40] In Germany, for example, VAT increased from 16% to 19% in 2007Q1

[41] The same choice was made by Aguzzoni et al. (2018)

8.2 Country weights for synthetic control estimation

Table 10

Country weights for the base synthetic control

Low basket		Medium basket		High BASKET	
Country	**Weight**	**Country**	**Weight**	**Country**	**Weight**
Belgium	0.567	**Belgium**	0.965	**Hungary**	0.12
France	0.358	**Hungary**	0.035	**Switzerland**	0.88
Hungary	0.075				

Note: Weights of the synthetic control for the base investigation of Norway

Table 11

Country weights for the robustness of the synthetic control

Low basket		Medium basket		High basket	
Country	**Weight**	**Country**	**Weight**	**Country**	**Weight**
Belgium	0.446	**Belgium**	0.356	**Hungary**	0.074
France	0.463	**France**	0.557	**Switzerland**	0.926
Hungary	0.072	**United Kingdom**	0.087		
United Kingdom	0.018				

Note: Weights of the synthetic control for the robustness investigation of Norway

8.3 Some further robustness checks

In this section we report our findings from the further robustness checks. For the sake of the overview we only report these results for the medium usage bundle. Briefly summarised, our further robustness checks show conclusions that resemble our original findings. The only specification where the conclusion changes is the Trend

specification using only the two cheapest tariffs (see Table 20 and Table 21). Here, prices are now implied to increase in Norway following the merger. However, this result is not very robust – in the robustness checks where we exclude the middle three quarters coefficients are either statistically significant or imply a price decrease. This specification's conclusion seems to be vulnerable to the period just before the merger, as our original specification is. As our initial findings only change for one specification (that does not seem robust) we therefore remain confident with our original results.

Excluding the quarter of the merger from the regression

Table 12

The standard fixed effects model, excluding the quarter of the merger

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.123*	-0.137**	-0.150**	-0.015	-0.004	0.025
	(0.055)	(0.047)	(0.046)	**0.132**	**0.190**	**0.161**
Medium-term effect	-0.240**	-0.229***	-0.152**	-0.080***	-0.029***	0.123***
	(0.073)	(0.064)	(0.063)	**0.000**	**0.000**	**0.001**
Observations	135	135	135	135	135	135
R-squared	0.792	0.819	0.781	0.883	0.915	0.922
Country-specific trend	No	No	No	Yes	Yes	Yes
Common trends hypothesis						
Conclusion of test	Pass	Pass	Pass	Fail	Pass	Fail
P-value of test	0.434	0.337	0.076	0.000	0.073	0.000

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; 2005Q4 is excluded from the regression. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 13

AR(1) regression, excluding the quarter of the merger

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.075	-0.051	-0.05	0.153	0.189	0.173
	(0.082)	(0.079)	(0.084)	**0.537**	**0.217**	**0.265**
Medium-term effect	-0.12	-0.066	-0.047	0.208***	0.320***	0.352*
	(0.096)	(0.094)	(0.101)	**0.009**	**0.002**	**0.098**
Observations	126	126	126	126	126	126
R-squared	N/A	N/A	N/A	N/A	N/A	N/A
Country-specific trend	No	No	No	Yes	Yes	Yes
Coefficient of AR(1) error term	0.759	0.809	0.819	0.673	0.701	0.565
(with p-value)	0.000	0.001	0.002	0.006	0.001	0.017

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; The AR(1) error term is statistically significant if the test that the correlation between past error terms is rejected at 5 % level; 2005Q4 is excluded from the regression. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Excluding the quarter of the merger changes the results a bit but not significantly, see Table 12 and Table 13: the conclusion of the Base specification remains the same, but less statistically significant. As our common trend hypothesis is carried out for the period before the merger, that remains the same, and there is some evidence of Norway possibly following a different pre-merger trend than the other countries. For the Trend specification, the short-term effect for the no AR(1) error term becomes statistically insignificant. No statistically significant coefficients change sign, however, and thus our conclusions do not change.

Only prepaid tariffs

Table 14

The standard fixed effects model, only prepaid tariffs

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	0.038	0.037	0.032	-0.016***	-0.035***	-0.033***
	(0.036)	(0.039)	(0.047)	**0.006**	**0.002**	**0.003**
Medium-term effect	-0.201**	-0.157*	-0.171*	-0.299***	-0.285***	-0.285***
	(0.069)	(0.076)	(0.089)	**0.000**	**0.000**	**0.000**
Observations	144	144	144	144	144	144
R-squared	0.596	0.576	0.572	0.830	0.826	0.839
Country-specific trend	No	No	No	Yes	Yes	Yes
Common trends hypothesis						
Conclusion of test	Pass	Pass	Pass	Fail	Fail	Fail
P-value of test	0.995	0.545	0.419	0.000	0.000	0.000

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; using only prepaid tariffs. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 15

AR(1) regression, only prepaid tariffs

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.029	-0.023	-0.022	-0.067	-0.065	-0.051
	(0.075)	(0.086)	(0.096)	**0.467**	**0.541**	**0.539**
Medium-term effect	-0.149	-0.08	-0.069	-0.401***	-0.355***	-0.325***
	(0.096)	(0.116)	(0.128)	**0.000**	**0.000**	**0.000**
Observations	135	135	135	135	135	135
R-squared	N/A	N/A	N/A	N/A	N/A	N/A
Country-specific trend	No	No	No	Yes	Yes	Yes
Coefficient of AR(1) error term (with p-value)	0.705	0.793	0.795	0.467	0.611	0.591
	0.004	0.010	0.025	0.020	0.016	0.044

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; The AR(1) error term is statistically significant if the test that the correlation between past error terms is rejected at 5 % level; using only prepaid tariffs. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 14 and Table 15 show our results when running our specifications on a price index constructed with only prepaid tariffs. We see that the conclusion is similar to our initial findings: the specification without AR(1) error term implies lower prices after the merger, however, this is less statistically significant. The AR(1) error term specification remains statistically insignificant. It is worth noting that we are less likely to reject the common trend hypothesis when only looking at prepaid tariffs. The conclusion for the specification without AR(1) error term remains the same for the Trend specification, implying lower prices after the merger. The AR(1) Trend specification gives a different conclusion from our Base results – rather than implying higher prices after the merger, this specification now also implies lower prices after the merger. Note that only the medium-term effects are statistically significant in this specification.

Table 16 reports our prepaid only synthetic control group findings. The implied effect of the merger is still a fall in prices. However, as with our Base result, the effect does not seem to be statistically significant when comparing to the placebo tests on the benchmark countries.

Table 16

Only prepaid tariffs: synthetic control

USAGE BUNDLE	PERIOD	EFFECT	RANK	CONTROL COUNTRIES
Low	Short	-0.116	2/9	France, Hungary, United Kingdom
	Medium	-0.381	1/9	
Medium	Short	-0.115	2/9	France, United Kingdom
	Medium	-0.364	1/9	
High	Short	-0.142	9/9	France, United Kingdom
	Medium	-0.424	8/9	

Note: A rank of 1/9 implies that Norway has seen the largest difference between the post- and pre-merger RMSPE, thus indicating that the effect is statistically significant; 2005Q3-2006Q1; only prepaid packages

Table 17 and Table 18 show the robustness of our prepaid only estimation. We see that the Base specification statistically insignificant both with and without the AR(1) error term. The Trend specification remains statistically significant and implies lower prices in Norway following the merger. The robustness of the synthetic control group using only prepaid tariffs remains the same as our initial findings (see Table 19): it implies lower prices in Norway after the merger, but these results do not seem statistically significant when comparing to the placebo tests on the benchmark countries.

Table 17

The standard fixed effects model, robustness of prepaid only

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	0.041	0.051	0.05	-0.005***	-0.015***	-0.011**
	(0.051)	(0.048)	(0.055)	**0.006**	**0.005**	**0.011**
Medium-term effect	-0.176	-0.139	-0.157	-0.267***	-0.272***	-0.274***
	(0.080)	(0.093)	(0.106)	**0.000**	**0.000**	**0.000**
Observations	117	117	117	117	117	117
R-squared	0.628	0.595	0.59	0.859	0.849	0.867
Country-specific trend	No	No	No	Yes	Yes	Yes
Common trends hypothesis						
Conclusion of test	Pass	Pass	Pass	Fail	Fail	Fail
P-value of test	0.812	0.663	0.547	0.000	0.000	0.000

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; using only prepaid tariffs; 2005Q3-2006Q1 excluded from the synthetic control estimation. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 18

AR(1) regression, robustness of prepaid only

Specification	Base Specification			Trend Specification		
	(1)	(2)	(3)	(4)	(5)	(6)
Usage bundle	Low	Medium	High	Low	Medium	High
Short-term effect	0.022	0.043	0.05	-0.047	-0.072	-0.035
	(0.124)	(0.155)	(0.171)	**0.133**	**0.189**	**0.226**
Medium-term effect	-0.074	0.016	0.033	-0.448***	-0.483***	-0.409***
	(0.136)	(0.174)	(0.192)	**0.000**	**0.000**	**0.000**
Observations	108	108	108	108	108	108
R-squared	N/A	N/A	N/A	N/A	N/A	N/A
Country-specific trend	No	No	No	Yes	Yes	Yes
Coefficient of AR(1) error term (with p-value)	0.746	0.846	0.846	0.500	0.701	0.653
	0.019	0.051	0.193	0.157	0.346	0.653

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; The AR(1) error term is statistically significant if the test that the correlation between past error terms is rejected at 5 % level; using only prepaid tariffs; 2005Q3-2006Q1 excluded from the synthetic control estimation. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 19

Robustness of only prepaid tariffs: synthetic control estimation

USAGE BUNDLE	PERIOD	EFFECT	RANK	CONTROL COUNTRIES
Low	Short	-0.153	5/9	Belgium, France, Hungary, United Kingdom
	Medium	-0.400	3/9	
Medium	Short	-0.030	7/9	Belgium, France, United Kingdom
	Medium	-0.305	3/9	
High	Short	-0.071	4/9	Belgium, France, Switzerland, United Kingdom
	Medium	-0.356	2/9	

Note: A rank of 1/9 implies that Norway has seen the largest difference between the post- and pre-merger RMSPE, thus indicating that the effect is statistically significant; 2005Q3-2006Q1 excluded from the synthetic control estimation (treatment time is assumed to be *starting at* 2006Q2); only prepaid packages

Only two cheapest tariffs

Table 20 and Table 21 report our results when using only the two cheapest tariffs for each provider when calculating the price index. Our conclusion for the Base no AR(1) error term remains the same but becomes more statistically significant, and the short-term effect is now a statistically significant price decrease rather than being statistically insignificant. Our Base AR(1) error term specification now also displays a statistically significant decrease in prices following the merger, compared to being statistically insignificant in our initial version. For the Trend specification the results change a bit: half our coefficients for our no AR(1) error term specification now imply a price increase following the merger. Our AR(1) coefficients also imply a price increase after the merger. Thus, both our results seem to change significantly (and in two different directions) when only looking at the two cheapest prices.

Table 20

The standard fixed effects model, two cheapest tariffs

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.267***	-0.249***	-0.209***	-0.115***	-0.043***	0.001***
	(0.040)	(0.044)	(0.039)	**0.000**	**0.000**	**0.000**
Medium-term effect	-0.266***	-0.271***	-0.202**	-0.015***	0.071***	0.144***
	(0.064)	(0.063)	(0.061)	**0.000**	**0.000**	**0.000**
Observations	144	144	144	144	144	144
R-squared	0.798	0.819	0.74	0.863	0.905	0.9
Country-specific trend	No	No	No	Yes	Yes	Yes
Common trends hypothesis						
Conclusion of test	Fail	Fail	Fail	Fail	Fail	Fail
P-value of test	0.005	0.001	0.002	0.000	0.000	0.000

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; using only the two cheapest tariffs. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 21

AR(1) regression, two cheapest tariffs

Specification	**Base Specification**			**Trend Specification**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.152**	-0.122*	-0.1	0.068	0.156	0.097
	(0.072)	(0.073)	(0.079)	**0.101**	**0.104**	**0.194**
Medium-term effect	-0.186**	-0.162*	-0.116	0.309*	0.421**	0.303*
	(0.091)	(0.094)	(0.104)	**0.073**	**0.023**	**0.084**
Observations	135	135	135	135	135	135
R-squared	N/A	N/A	N/A	N/A	N/A	N/A
Country-specific trend	No	No	No	Yes	Yes	Yes
Coefficient of AR(1) error term (with p-value)	0.688	0.720	0.752	0.616	0.554	0.439
	0.000	0.001	0.025	0.001	0.001	0.069

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; The AR(1) error term is statistically significant if the test that the correlation between past error terms is rejected at 5 % level; using only the two cheapest tariffs. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 22 shows our synthetic control using only the two cheapest tariffs. Here, the conclusion matches our initial findings: the implied effect of the merger is lower prices in Norway, however, this does not seem statistically significant when comparing with the placebo tests for the benchmark countries.

Table 22

Two cheapest tariffs: synthetic control

USAGE BUNDLE	PERIOD	EFFECT	RANK	CONTROL COUNTRIES
Low	Short	-0.39	4/9	France, Hungary, Portugal
	Medium	-0.42	4/9	
Medium	Short	-0.18	7/9	Belgium, Hungary
	Medium	-0.24	6/9	
High	Short	-0.03	9/9	Switzerland, Hungary
	Medium	-0.13	7/9	

Note: A rank of 1/9 implies that Norway has seen the largest difference between the post- and pre-merger RMSPE, thus indicating that the effect is statistically significant

Table 23 and Table 24 show our results from our robustness checks using only the two cheapest tariffs. Our Base results' conclusions remain the same as our original findings, showing statistically significant price decreases in Norway following the merger. This conclusion is similar for our Trend specification: the robustness check implies statistically significant lower prices in Norway following the merger. *Note,* that for the Trend specification with AR(1) error term, we had to manually include country-fixed effects dummies in the AR(1) specification, rather than using the Stata command, as this gave an error for the medium bundle in the regressions.

Table 23

The standard fixed effects model, robustness of two cheapest tariffs

Specification	Base Specification			Trend Specification		
	(1)	(2)	(3)	(4)	(5)	(6)
Usage bundle	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Short-term effect	-0.242**	-0.238**	-0.192**	-0.089***	-0.055*	-0.002*
	(0.051)	(0.052)	(0.047)	**0.000**	**0.060**	**0.093**
Medium-term effect	-0.289**	-0.311**	-0.238*	-0.209***	-0.144***	0.006***
	(0.061)	(0.065)	(0.072)	**0.000**	**0.000**	**0.000**
Observations	117	117	117	117	117	117
R-squared	0.861	0.857	0.774	0.921	0.937	0.938
Country-specific trend	No	No	No	Yes	Yes	Yes
Common trends hypothesis						
Conclusion of test	Pass	Pass	Fail	Fail	Fail	Fail
P-value of test	0.264	0.067	0.037	0.000	0.000	0.000

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; using only the two cheapest tariffs; 2005Q3-2006Q1 excluded from the synthetic control estimation. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

Table 24

AR(1) regression, robustness of two cheapest tariffs

Specification	Base Specification			Trend Specification		
	(1)	(2)	(3)	(4)	(5)	(6)
Usage bundle	Low	Medium	High	Low	Medium	High
Short-term effect	-0.193	-0.193	-0.137	-0.087*	-0.064	-0.012
	(0.097)	(0.108)	(0.120)	**0.062**	**0.368**	**0.695**
Medium-term effect	-0.230*	-0.205	-0.14	-0.201**	-0.171**	-0.021
	(0.107)	(0.120)	(0.134)	**0.020**	**0.020**	**0.123**
Observations	108	108	108	108	108	108
R-squared	N/A	N/A	N/A	N/A	N/A	N/A
Country-specific trend	No	No	No	Yes	Yes	Yes
Coefficient of AR(1) error term (with p-value)	0.746	0.846	0.846	0.500	0.701	0.653
	0.019	0.051	0.193	0.157	0.346	0.653

Note: Dependent variable: log prices; standard errors in parentheses (clustered at country level); significance of F-test in bold; time fixed effects and country-fixed effects; cheapest four tariffs; significance level: * 10%, ** 5%, *** 1%; The AR(1) error term is statistically significant if the test that the correlation between past error terms is rejected at 5 % level; using only the two cheapest tariffs; 2005Q3-2006Q1 excluded from the synthetic control estimation. For the linear trend, we "pass" the common trend test is we cannot reject the coefficient of the interaction between Norway and the linear trend at 5% level. For the quarter-specific dummies we use a joint F-test to test the joint significance of the time dummies interacted with Norway.

The robustness check of the synthetic control using only the two cheapest tariffs (see Table 25) is similar to what we've previously found: prices fell in Norway following the merger. For the medium and high usage, this effect is statistically insignificant, however, when comparing to the placebo tests using the benchmark countries. For the low usage bundle, the effect does seem to be statistically significant.

Table 25

Robustness of two cheapest tariffs: synthetic control estimation

USAGE BUNDLE	PERIOD	EFFECT	RANK	CONTROL COUNTRIES
Low	Short	-0.420	1/9	Belgium, France, Hungary
	Medium	-0.449	1/9	
Medium	Short	-0.326	3/9	Belgium, France, Hungary
	Medium	-0.385	2/9	
High	Short	-0.021	9/9	Switzerland, Hungary
	Medium	-0.145	6/9	

Note: A rank of 1/9 implies that Norway has seen the largest difference between the post- and pre-merger RMSPE, thus indicating that the effect is statistically significant; 2005Q3-2006Q1 excluded from the synthetic control estimation (treatment time is assumed to be *starting at* 2006Q2)