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Efficiency Gains vs. Internalization of Rivalry: Brand-Level Evidence from a Merger in the Mobile Telecom Market*

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Abstract

The paper empirically investigates the price effects of the merger between Telia and Tele2 in the Norwegian mobile telecommunications market in early 2015. We employ a difference-in-differences approach to estimate the price effects of the merger based on a unique dataset with product-level (mobile services brands) prices for mobile phone services in Norway and prices in other Nordic countries used as controls. We estimate price decreases for products with substantial expected efficiency gains in marginal cost and price increases for products without large expected efficiency gains. In aggregate, we do not identify significant price effects in either direction, which suggests that the total price effect of the merger was neutral. Our results provide insights into the differential price effects on different products involved in mergers and feedback on the use of ex-ante analysis in competition policy decision.

JEL classification: D22, L11, L13, L42, L96
Keywords: Merger analysis, antitrust, telecommunication

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1 Introduction

Horizontal mergers in concentrated markets may have adverse effects on consumers. The concern is that further market consolidation reduces competition and harms consumers through higher prices, lower product quality, and less innovation. For this reason, competition authorities often conduct thorough ex-ante merger investigations of notified mergers. These merger screenings assess whether anti-competitive effects from the merger may be offset by pro-competitive efficiency gains and potential remedies proposed by the merging parties.[1] However, effects of mergers are seldom evaluated ex-post.

The present paper adds to a growing literature of ex-post merger evaluations by empirically examining the price effects of Telia Company's (henceforth Telia's) acquisition of Tele2 in the Norwegian mobile telecom market in 2015.[2] Before the merger, the parties were the second- and third-largest players, respectively, and the merger was approved by the Norwegian Competition Authority conditional on substantial remedies to facilitate the entrance of a new operator (Ice). The trigger for this merger, that would result in two companies (Telenor and Telia) jointly controlling 96 percent of the market, was a shock to Tele2's costs. Tele2 did not win frequency rights in an auction in December of 2013, which meant that the firm lost the ability to operate its own network after October 2014. Thus, absent the merger Tele2 would have a significant increase in marginal costs from renting access to other operators' network.

A distinguishing feature of our study is that we use brand-level data to investigate the differing predictions for different brands directly involved in the merger. Brand-level analyses are highly relevant if the merger is expected to affect the involved brands differently, e.g., due to differences in efficiency gains or because the remedies affect the competitive pressures on the involved brands differently. Our paper adds to the understanding of merger effects in light of the specific circumstances of the merger and we contribute to the evaluation of merger policy.

To identify price effects, we apply a difference-in-differences (DiD) approach, where we compare the prices of Telia- and Tele2-owned brands (products) in Norway (treated group) with Telia's prices in other Nordic countries as a reference group.[3] The study exploits a unique dataset based on accounting data from Telia in Norway, Sweden, Denmark, and Finland. The dataset includes monthly observations of the number of

[1] See e.g., the horizontal merger guidelines of the European Commission (2004).

[2] Before changing its name to Telia Company in 2016, Telia operated under the name TeliaSonera.

[3] Comparing markets with a merger to markets without a merger can be problematic since mergers may be endogenous to market features – i.e., mergers tend to be "unnatural experiments" (Besley and Case, 2000). Because the Telia/Tele2 merger was the consequence of an exogenous shock, this is not a concern in our case.

customers, revenues, and consumption.

We analyze effects on the prices of three brands directly affected by the merger, as well as for the aggregate residential segment of all Telia and Tele2 brands.[4] The brands are (i) OneCall, originally a low-price Tele2 brand continued after the merger; (ii) Chess, a low-price Telia brand continued after the merger; and (iii) NetCom, a premium Telia brand also continued after the merger. Tele2 also owned another brand (named "Tele2"), which was discontinued after the merger, and customers of the"Tele2" brand were migrated to NetCom.

Our results indicate that OneCall's prices decreased following the merger by 7 to 13 percent. For NetCom, the premium brand, we find that prices likely increased by 6 to 9 percent after the merger. For Chess, the evidence is somewhat less robust, but we find some indication of negative price effects in the long term. For the total of all Telia and Tele2 customers of the involved brands, we do not find robust evidence of price effects of the merger in either direction.On aggregate, the effects on different brands seem to have neutralized each other.

The results are consistent with the ex-ante predictions of the price effects, which expected large efficiency gains for OneCall and no or limited gains for NetCom and Chess. In addition, the remedies supported the establishing of Ice as a rival, which chose to focus on budget oriented customers within the residential segment and therefore would put competitive pressure on the budget brands OneCall and Chess but to a lesser extent on NetCom. The brand-level analysis reveals these different effects at work. The price effects for NetCom are driven by internalization of rivalry. For Chess and OneCall the ex-ante analysis implies similar effects by the remedies and internalization of rivalry. Thus, the price effect for OneCall relative to Chess is likely driven by efficiency gains.

This paper adds to a growing literature on ex-post analyses of mergers. Related contributions include ex-post analysis of mergers within diverse industries like banking (Focarelli and Panetta, 2003; Erel, 2011), beer (Ashenfelter et al., 2015; Miller and Weinberg, 2017), manufacturing (Ashenfelter et al., 2013), media (Sweeting, 2010; Fan, 2013), airlines (Bilotkach, 2011), hospitals (Dafny, 2009), pharmaceuticals (Björnerstedt and Verboven, 2016), retailers (Aguzzoni et al., 2013, 2016), and parking (Choné and Linnemer, 2012). The general conclusion from these studies is that mergers that have been screened ex-ante and passed may have very different effects on prices, leading to increases, decreases or no changes in prices.

[4]We focus on the price effects in the residential segment. The majority of business customers of Tele2 were sold to the new entrant Ice as part of the remedies imposed by the competition authority. The business segment is therefore of less relevance in this merger.

The most closely related studies are a series of recent ex-post analyses of price effects of individual mergers in the telecom sector. This includes RTR-GmbH (2016), Lear et al. (2017), BEREC (2018), Aguzzoni et al. (2018) and Grajek et al. (2019). These contributions all study one or more European mergers, several of them covering the same merger, using a DiD strategy to estimate the merger effects on prices at the operator level. These studies show that also the price effects of allowed mergers in the telecom sector vary. This emphasizes the need for further analyzing merger effects in light of the specific context of the merger.[5]

Our approach departs from the above studies on ex-post merger effects in the telecom market, by studying the price effects on the different brands (products within the same market) of the operators directly involved in the merger. We are able to connect ex-ante expected price effects to the ex-post observed effects on the brand level and therefore add to the understanding of the price effects in the specific circumstances of the merger.

The remainder of the paper is structured as follows. Section 2 explains the details of the Telia/Tele2 transaction and discusses the ex-ante expected price effects, providing predictions for the empirical analysis. Section 3 describes the data. Our empirical strategy is described in Section 4, while results are discussed in Section 5. Robustness analyses and analyses of the timing of effects are presented in Section 6. Section 7 concludes.

2 Details of the merger

In this section, we describe the background for the merger, including the characteristics of and events in the Norwegian market for mobile communications. Given the market characteristics, we then discuss the price effects that could be expected ex-ante.

2.1 Involved products, market shares, and remedies

In the year preceding the merger, there were three main operators in the Norwegian mobile telecom market. In 2014, Telia had a market share of approximately 27 percent in revenues. Tele2 had a market share of approximately 24 percent. The largest operator, Telenor, had a market share of 45 percent.[6]

The two companies that would later merge, Telia and Tele2, offered mobile services under various brand names. Telia offered the brands NetCom and Chess, of which

[5]We discuss some of these papers in more detail in Section 3, where we describe the data used in our analysis.

[6]Information on market shares is from the decision by the Norwegian Competition Authority.

NetCom had offerings within both the residential and business segments, while Chess was a purely residential brand. Tele2 offered the brands Tele2 (henceforth Tele2-brand), Network Norway, OneCall, and MyCall. Tele2-brand had offerings within both the residential and business segments, Network Norway was purely a business brand, and OneCall and MyCall were purely residential brands.

The three main operators all had their own networks, but network coverage differed. Telenor's and Telia's mobile networks covered close to the entire Norwegian population. Tele2's network covered approximately half of Norway's population. In areas with insufficient coverage, Tele2 rented access to the networks of Telia and Telenor (different brands under Tele2 had wholesale agreements with different operators).

In a sealed-bid mobile frequency auction in December 2013, Tele2 lost its right to transmit within the 900 MHz band, and was not awarded any new rights to frequencies. This meant that Tele2 was unable to use GSM (2G) and LTE (3G) technologies over its cellular network and was in practice excluded from operating as an independent mobile operator. Ice, a small operator without a network, won several rights to frequency in the auction.

Telia sought to acquire Tele2 in July 2014, and the acquisition was cleared in February 2015 by the Norwegian Competition Authority, conditional on several remedies meant to counteract concerns of anti-competitive effects from the merger. The remedies, both structural and behavioral, were designed to increase the competitiveness of the newcomer, Ice. The most significant remedies were (i) transfer of Tele2's mobile network to Ice, (ii) transfer of Network Norway's customer portfolio to Ice (approximately two-thirds of Tele2's business portfolio), (iii) commitment to offer wholesale access to Telia's network to Ice at predetermined conditions, and (iv) network co-location offered to Ice (to reduce the costs of Ice's network investments).[7]

After the merger, Tele2-brand was discontinued and its customers were transferred to NetCom. The brands OneCall and MyCall were continued under Telia's ownership.[8] Table 1 provides a summary of the brands involved in the merger.

2.2 Ex-ante analysis: Expected price effects

Ex-ante analyses evaluate expected post-merger prices relative to the most likely counterfactual situation. Since Tele2 lost its frequency rights, it was excluded from using

[7]Co-location means that Ice could install radio transmitters on cell towers owned by Telia.

[8]MyCall is a niche brand specializing in international calls. We do not report results on MyCall in the analysis but assert that doing so does not change our results for the price effects of aggregation of all brands. Results available on request.

Table 1: Brands involved in the merger

Brand	Explanation	Customers in Jan. 2015*
Telia:		
NetCom	Continued. Tele2-brand customers transferred to NetCom.	710,000
Chess	Continued. No changes in customer portfolio.	360,000
Tele2:		
Tele2-brand	Discontinued. Customers transferred to NetCom.	320,000
OneCall	Continued. No changes in customer portfolio.	430,000
MyCall	Continued. No changes in customer portfolio.	230,000
Network Norway**	Discontinued. Customers sold to Ice as part of the remedies.	90,000

*Month before the merger. Numbers rounded to nearest ten-thousand.
**Network Norway had customers only in the business segment which is not subject of this analysis.

its own network infrastructure. The most likely counterfactual situation is that Tele2 would rent access from Telia, Telenor, or both through national roaming agreements, becoming a full mobile virtual network operator (MVNO).

From a theoretical ex-ante perspective, the merger has multiple counteractive effects on prices. This leads to different predictions of the price effects on both the company and the brand level. The two most important effects relate to the internalization of rivalry and efficiency gains from reductions in marginal costs. The remedies likely also had substantial effects, as they were designed to make Ice a stronger rival.

The internalization of the rivalry between Telia and Tele2 is expected to lead to a substantial upward pricing pressure. In its investigation, the NCA estimated diversion ratios to the respective other merging party of around 30 percent for both Telia and Tele2. This indicates that Telia and Tele2 were close competitors, meaning that the merging firms have incentive to raise prices after the merger.[9]

Large efficiency gains are expected for Tele2, which in the counterfactual situation would have to operate as a full MVNO and pay high fees for network access, leading to high marginal costs.[10] After the merger, Tele2 became vertically integrated in Telia, which eliminated the network fees and thus substantially reduced the marginal costs of

[9] After the merger, a significant share of sales diverted by increased prices is expected to be recaptured by the other merging party.

[10] This situation is somewhat different from the pre-merger situation, in which Tele2 operated its own network but still paid high fees for network access where its own network did not have coverage. As a full MVNO, variable costs (roaming fees) for Tele2 were expected to be even higher in the counterfactual situation than in the observed pre-merger period. See below for a discussion of implications for our empirical results.

network access.[11] This reduction in marginal costs creates incentives to compete more aggressively and to lower retail prices.

Table 2 provides a simplified qualitative ex-ante analysis on price effects from the merger based on closeness of competition, efficiency gains, and remedies. For all the involved brands, we would expect a positive price effect from internalization of competition. Efficiency gains from vertical integration only applied to brands that belonged to Tele2 before the merger. Thus, we would expect the strongest negative price effect for OneCall. For NetCom, which after the merger included past Tele2-brand customers, the efficiency gain only applied to a share of the customer portfolio. As NetCom's customer portfolio was more than twice as large as that of Tele2-brand (see Table 1), the efficiency gains are expected not to be very large on average. Remedies (stronger competition from Ice) are expected to reduce prices for all the merging brands.

Table 2: Summary of expected price effects for the brands involved in the merger

Brand	**Competition**	**Eff. gain**	**Remedies**	**Net price effect**
OneCall	positive	strong negative	negative	neg. or neutral
Chess	positive	neutral	negative	uncertain
NetCom+Tele2	positive	light negative	negative	uncertain
All brands	positive	negative	negative	uncertain

In addition, other factors may have consequences for the price effects. First, the merger affected vertical relations. Tele2 rented access to both Telia (the Tele2-brand) and Telenor (OneCall and MyCall) before the merger. This means that Telia's and Telenor's incentives to compete aggressively against Tele2 were limited before the merger, as diverted sales increased wholesale profits from Tele2. These vertical relations limit the upward pricing pressure on Telia after the merger, and Telenor may have incentives to compete more aggressively when the vertical relation to Tele2 is severed.[12]

Second, brands may be affected differently by the structural remedies. The remedies strengthened the position of the rival, Ice, which arguably primarily caters to budget-oriented consumers. Due to differences in branding and differentiation, it is possible that OneCall and Chess, which also targeted budget-oriented consumers, faced stronger competition from Ice after the merger, than NetCom, which was marketed as a premium brand. Thus, the remedies may have had a stronger negative effect on the prices of

[11] In fact, network access fees were not immediately eliminated after the merger because Tele2 was partly roaming on Telenor's network before the merger. It took time for the customers roaming on Telenor's network to be transferred to Telia's network (due to binding contracts), such that the full efficiency gains are expected to occur with delay.

[12] Asphjell et al. (2017) and Bergh et al. (2019) study price effects of changes in vertical relations.

OneCall and Chess than on those of NetCom.

3 Data

Our analysis uses a unique data set based on income statements with monthly observations for Telia Company in Norway, Sweden, Denmark, and Finland for the period January 2013 until December 2016 (i.e., a pre-merger period of 25 months and a post-merger period of 22 months, with one month being the merger period). For simplicity, we will refer to the four countries as the Nordic countries.[13] We refer to Denmark, Finland, and Sweden as the other Nordic countries – in contrast to Norway, where the merger took place.

The income statements include billed revenues and number of subscribers, which are the two components used to calculate average revenue per user (ARPU), which we use as a proxy for prices. In addition, the income statements include consumption data, which we will use to control for usage.

Throughout, we focus on data for the residential (non-business) sector.[14] For Sweden, Denmark, and Finland, we have aggregate data for Telia's residential segment. For Norway, the data are split among the residential brands NetCom, Tele2-brand (after the merger integrated into NetCom and discontinued), OneCall, MyCall, and Chess.

Brand-level data for NetCom and aggregates for Telia are subject to portfolio composition effects in connection with the merger. When Telia acquired Tele2, the composition of customers in Telia's portfolio changed, because Tele2-brand was discontinued and its customers were transferred to NetCom.[15] To avoid our results picking up potential portfolio composition effects, we construct a unit of observations (brand) that aggregates data for NetCom and Tele2-brand before the merger. We will refer to this constructed brand henceforth as NetCom+Tele2. To construct a series for the aggregate residential sector of Telia and Tele2-brand, we sum all of the involved brands over the entire period of the study (i.e., NetCom, Chess, Tele2-brand, and OneCall). Through this aggregation, we measure prices for the average user that was affected by the merger.

3.1 Price measure

Measuring prices in mobile telecoms is challenging, as the operators have several ways of generating revenue from their customers. The final price paid by consumers depends on

[13] We are fully aware that the Nordic countries also include Iceland.
[14] As mentioned, two-thirds of Tele2's business customers were sold to the rival Ice as part of remedies.
[15] The customers who were transferred kept their old Tele2-brand price plan under new ownership.

several components, including (but not limited to) a monthly fixed price on consumption bundles (with a given amount of text, voice and data included), tariffs for consumption exceeding the included consumption bundle, foreign roaming fees, hardware sales, additional services (handset insurance, free music streaming, etc.), and discounts and other benefits to new subscribers.

In the literature, we find two types of approaches to measure prices. The first uses ARPU as a price measure (e.g., Hausman and Ros, 2013; Affeldt and Nitsche, 2014; Lear et al., 2017). The second alternative is the price basket approach, which aims to construct representative (average) consumption baskets and prices them based on the list prices of the most popular products. This approach is preferred in several recent studies of merger effects within telecoms, e.g., RTR-GmbH (2016), BEREC (2018), Aguzzoni et al. (2018), and Lear et al. (2017).[16]

Both approaches have their advantages and disadvantages. The advantage of the price basket approach is that it is not affected by changes in usage patterns, while an approach based on revenue may be affected by such changes. However, the price basket approach has several issues. First, consumption patterns in mobile telecom services change fast; in particular, there has been a tremendous increase in data consumption. Thus, fixed consumption baskets may not be representative over time, and the approach effectively prices a product that is not relevant to consumers any more (c.f. Affeldt and Nitsche, 2014). Second, price basket approaches do not capture price discounts and campaigns, which constitute a significant part of pricing and competition for new customers in the mobile telecom market.

We argue that billed[17] ARPU is the preferable price measure in ex-post merger analyses. First, the ARPU approach is *close to reality*, as it reflects the actual average prices the consumers pay, including discounts and introduction offers. Second, using ARPU ensures *consistency* with ex-ante merger analysis conducted by competition authorities, where ARPU is used as a proxy for prices.[18] The issue that ARPU may be affected by changes in usage patterns can be addressed by controlling for these changes (c.f. Affeldt and Nitsche, 2014). The most important changes in the period we are considering are increases in data usage, and this may be a source of measurement error in our price measure. To the extent that these changes develop in parallel in the Nordic countries, our difference-in-differences approach will resolve the issue. Moreover, we present results

[16] Note that Lear et al. (2017) prefer the consumption basket approach and use it if possible but also use the ARPU approach as an alternative in one of three cases they study due to data availability.

[17] I.e., non-billed revenues, such as termination fees, are not included.

[18] See e.g., Section 3.3.2 of European Commission (2016), Case M.7612 - Hutchison 3G UK/Telefonica UK.

where we control for data usage to address the issue directly.[19]

3.2 Price development in Norway

Figure 1 shows the price development for the brands of Telia and Tele2 in Norway. We have normalized ARPU to 100 in January 2013 (the beginning of our sample period) for each brand/all brands. The figure shows that prices for the three brands OneCall, Chess, and NetCom+Tele2, as well as the total of all brands develop similarly in the period before the merger. The normalized ARPU for all brands is effectively a weighted average of the brand ARPUs. Since NetCom+Tele2 has by far the largest number of customers (see Table 1), it has a relatively high influence on the aggregate price.

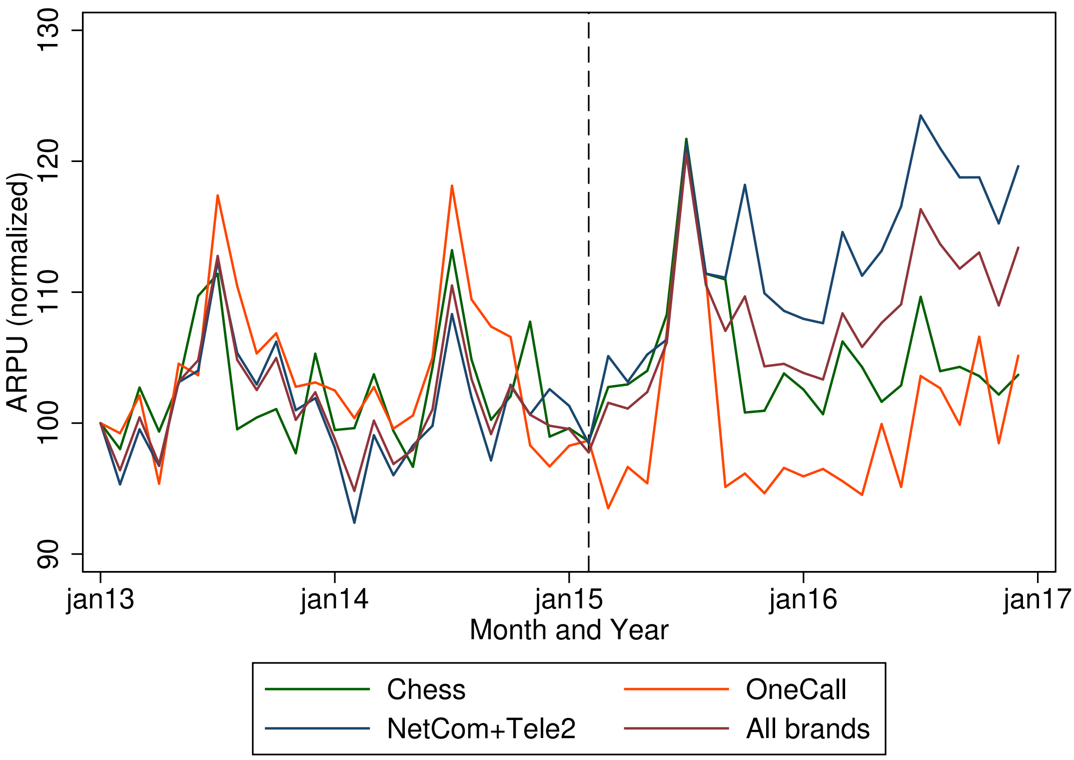
After the merger (February 2015, marked by the dashed line in Figure 1), the ARPUs for the different brands clearly diverge. OneCall's ARPU is generally lower in the period after the merger, whereas that of Chess remains at roughly the same level, possibly with small increases. The ARPU of NetCom+Tele2 appears to have increased after the merger.

Figure 1 gives a first indication that the merger had different impacts on prices for the different brands. It shows that prices follow the same trend in Norway before the merger and diverge afterwards. The divergence is largely consistent with the prediction of differential price effects for different brands summarized in Section 2.2.

In the period 2013–2015 we observe marked spikes in ARPU in the summer months, especially in July and partly in August. The explanation for these spikes is increased revenues from foreign roaming during summer months. Summer holidays in Norway are very concentrated in July and the beginning of August. This marked increase in ARPU is not present (less marked) in 2016, which is the summer after which new EU regulation forbade roaming fees for roaming within the European Economic Area.[20]

[19] An alternative approach to controlling for usage is to use quantity adjusted ARPU and can be found in the literature studying earlier mergers (e.g. Hausman and Ros, 2013, Affeldt and Nitsche, 2014, Lear et al., 2017 Grajek et al., 2019). These contribution typically use voice revenue per minute voice call. This may be an appropriate measure for prices in earlier times of the industry, but is largely irrelevant today given the diminished importance of voice in the consumption of mobile telecom services. An extension to this approach is to convert text message and voice to data and calculate a Data-ARPU. However this relies on somewhat arbitrary assumptions about conversion rates for voice, data and text. We believe that the ARPU approach to measuring prices while controlling for data usage in the regression is more flexible and adequate for our purposes.

[20] In summer 2015, we observe a particularly high spike for OneCall. This may be connected to a potential inconsistency of data for OneCall during the summer months in 2015 that may stem from errors when integrating Tele2's accounts into TeliaSonera's accounting system at that time. See also section 6.1.



ARPU is normalized to 100 for January 2013 for each series. The dashed line indicates the time of the merger.

Figure 1: ARPU for Chess, OneCall, NetCom+Tele2, and all brands in Norway.

4 Empirical strategy

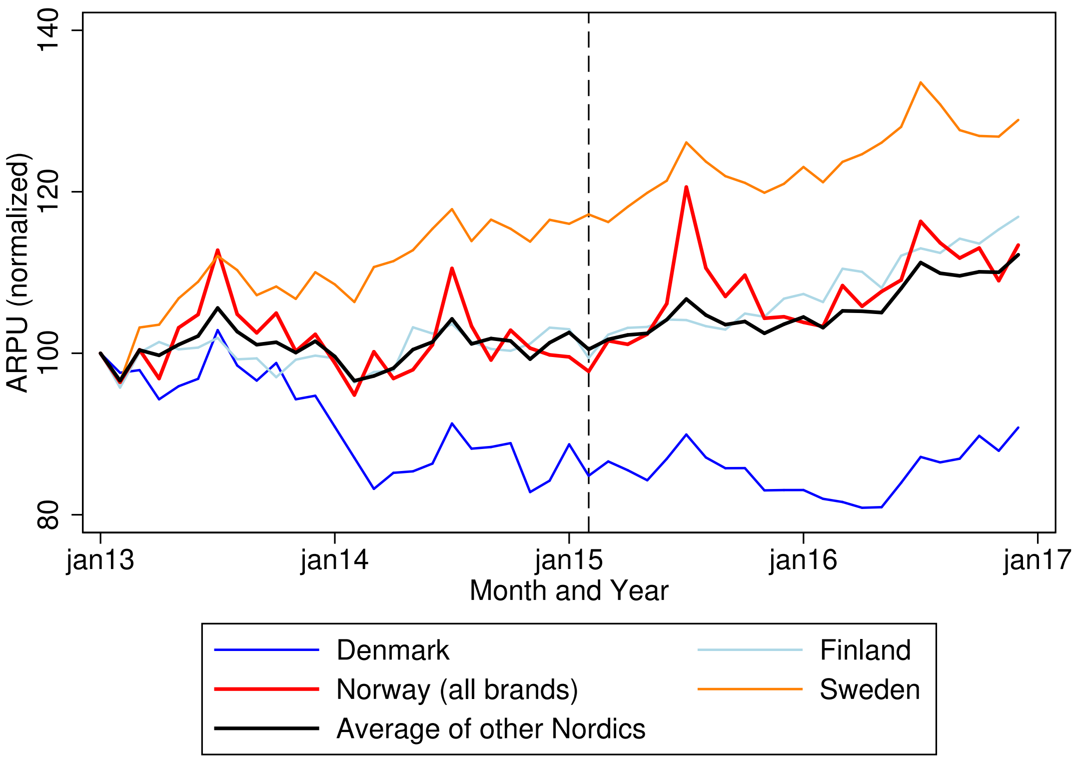
The price effect of the merger is the difference between the actual price that we observe in the market and a counterfactual price that would have prevailed absent the merger. To establish a counterfactual situation and estimate the merger price effect, we employ a difference-in-differences (DiD) strategy. The core idea of the DiD model, applied to merger price effects, is to compare the development of prices in the market that is affected by the merger (the treated market) with prices in similar markets that are unaffected by the merger (the control markets). The underlying assumption necessary for identification of causal effects is that prices in the merger market would have developed in the same way as the prices in the comparison markets. Economically, that means that (unobservable) time-varying price determinants, other than the merger, develop similarly in the treated and control markets. Such factors can, for example, be technological developments, changes in consumption patterns, international economic trends, or regulation across countries. Under this assumption, the price effect of the merger can be identified as the difference in development between the treated and the control markets. Finding a suitable comparison group is therefore an important part of the analysis.

4.1 The comparison markets

We use the development of prices for Telia in three other Nordic countries – Denmark, Finland, and Sweden – as counterfactual. We chose these other Nordic countries because they share many characteristics with Norway and their markets may therefore (a priori) be assumed to be relatively similar and fulfill the assumption of the DiD model. No mergers or significant structural changes have occurred in the other Nordic countries during the period we analyze.

Figure 2 displays the development of Telia's prices measured as (normalized) ARPU in Denmark, Finland, Norway, and Sweden. For Norway, these are the prices for the aggregated Telia and Tele2 (all brands). Prices in Norway and Finland follow largely the same long-term trend. In Sweden, prices increase more, in particular in the beginning of 2013. Finally, in Denmark, prices fall between late 2013 and early 2014 and then stay at roughly the same level.

The figure also shows the average ARPU of Denmark, Finland, and Sweden (i.e., the average without Norway). Before the merger (February 2015, indicated by the dashed line in Figure 2), this average follows the same long term-trend as prices in Norway. The similarity of trends in the pre-merger period can be seen as a first indication that the average of the other Nordic countries can be used as a counterfactual for price



ARPU is normalized to 100 for January 2013 for each series. The dashed line indicates the time of the merger.

Figure 2: ARPU for Telia in Denmark, Finland, and Sweden and all brands in Norway.

development in Norway (we will further explore this issue below).

4.2 The counterfactual in Norway

The counterfactual also depends on the developments in Norway. As mentioned above, the most likely counterfactual is that Tele2 would continue as a full MVNO with higher variable costs than it had before the merger. In this counterfactual, Tele2 customers would profit from the full efficiency gains of being vertically integrated into Telia.

However, our empirical strategy is based on pre-merger data and therefore implies a different counterfactual. In the pre-merger period, Tele2 is still operating its own network. Tele2's customers were partly on its own network and partly roaming on competitors' networks (where Tele2 did not have satisfactory coverage). The efficiency gains that can be expected from the merger in this situation would therefore be partial, as they would only apply to roaming customers.

Because the analysis is based on pre-merger data, the implicit counterfactual is that this situation would have continued – and not the most likely counterfactual, that Tele2 would become a full MVNO. Our results therefore reflect the price effects of a merger from three to two major operators (including the effects of remedies) and are therefore relevant for the understanding of such mergers. When it comes to policy evaluation, the situation with Tele2 as full MVNO (and substantially higher variable costs) is the more relevant counterfactual. Thus, for policy evaluation, our analysis may be subject to an upward bias – i.e., we might underestimate the negative effect on prices and our results may therefore be seen as conservative estimates.[21]

4.3 Econometric model

We are interested in estimating the effects of the merger on prices. In order to be able to distinguish short-run from long-run effects, we separately estimate effects in the first and second years after the merger. Formally, we can write the difference-in-difference model as the following regression equation:

$$ln(ARPU_{i,j,t}) = \mu_i + \tau_t + \gamma^1 D_{i,j,t}^{ShortRun} + \gamma^2 D_{i,j,t}^{LongRun} + X'_{i,j,t}\beta + \varepsilon_{i,j,t} \ , \qquad (1)$$

where i indicates the country, j the brand, and t the period (identified by month and year). μ_i is a country fixed effect, τ_t a time fixed effect, X a vector of control variable,

[21] The efficiency gain is underestimated, as we base Tele2's pricing on a situation with 50 percent own network coverage rather than 0 percent own network coverage, which implies substantially higher variable costs from roaming fees.

and $\varepsilon_{i,j,t}$ is the error term. We estimate the equation by OLS and report standard errors that are robust to heteroscedasticity (robust standard errors).[22]

The key variables $D^{ShortRun}$ and $D^{LongRun}$ are two dummy variables that take the value 1 in the first and second years after the merger (February 2015), respectively, in Norway. Thus, γ^1 and γ^2 are the effects of the merger in the short and in the long run, respectively.

The common trends assumption. The key assumption of the DiD approach is that the trends of prices (conditional on observable) are the same in Norway (the treated country) as the average of the other Nordic countries (control group). A visual analysis in Figure 2 indicates that the pre-merger long-term trend in Norway is similar to that of the average trend in the control group (Figure 3 below confirms this for the brand level). However, since the common trend assumption is the key to identification of causal effects, we apply several checks, including a formal test of the common trend assumptions and controlling for common trends (Section 6), to further substantiate that the common trend assumption holds.[23]

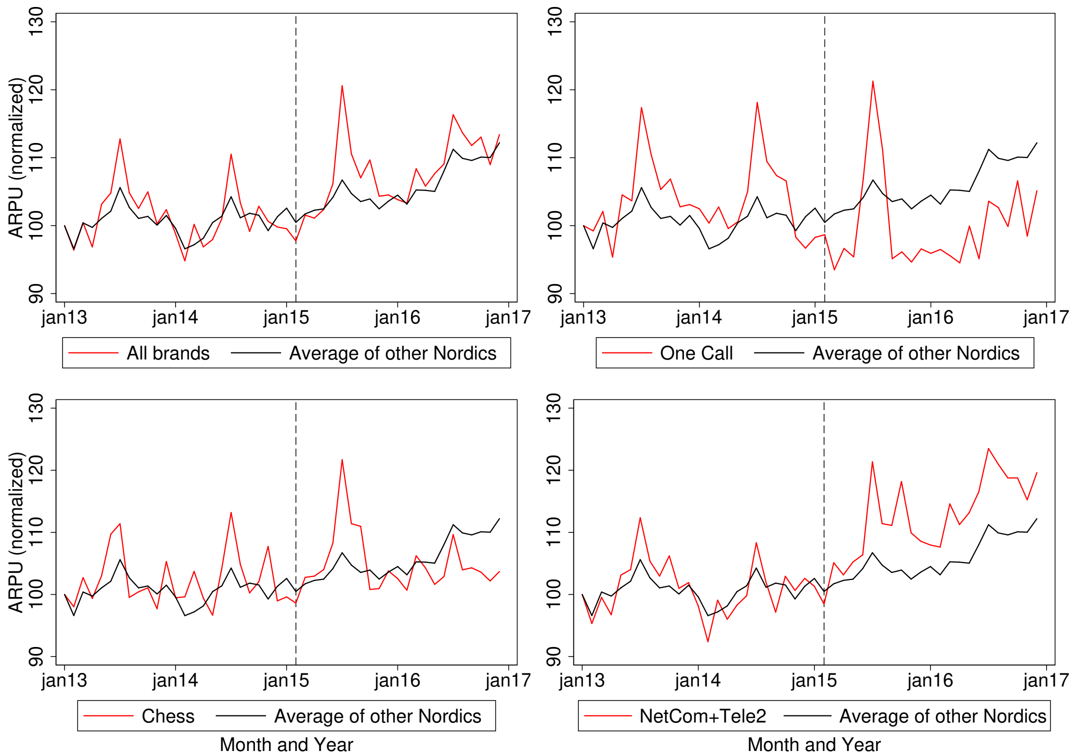
5 Main Results

We begin our analysis with a visual inspection. Figure 3 shows the average ARPU for Telia in Denmark, Finland, and Sweden against the ARPU for all brands in Norway and against each brand in Norway.

The upper-left quadrant displays the aggregated normalized ARPU for all brands

[22]Basing inference on robust standard errors (Huber-White standard errors) is not entirely innocuous. In most DiD models, there is a potential concern of serial correlation in the error terms for a given group (country, in our case). This may lead to problems of power and size. In applications with very few groups, such as our case (four groups), there is no optimal solution for correcting standard errors for these problems. Using Huber-White standard errors for inference when discussing the main results is a pragmatic approach to this challenge. In Appendix A.2, we discuss issues of inference in more detail and present alternative standard errors, confirming the robustness of our main findings.

[23]The formal test of the common trend assumption we employ follows Aguzzoni et al. (2018) and is inspired by the test suggested by Angrist and Pischke (2009) and Ashenfelter et al. (2013). The test is conducted by replacing the two treatment dummies with dummies for each quarter, before and after the merger (excluding the first quarter), that take the value 1 only for the treated country. We then estimate the slope of a linear trend of the estimated coefficients of all pre-treatment quarters. This slope captures differences in the trend in the treated country's price to the trend in the average price in the control countries during the pre-treatment period. A two-sided test of the significance of this test therefore amounts to a test of common trends. A failure to reject the null hypothesis of this test is interpreted as a non-violation of the common trend assumption. In addition, the estimates of the pre-treatment effect provide a placebo test (this is the test suggested by test suggested by Angrist and Pischke, 2009 Ashenfelter et al., 2013 - see Section 6 and Appendix A.1). To address remaining doubt about differential trends, we estimate an extended DiD model where we explicitly control for country-specific time trends (see Section 6).



ARPU is normalized to 100 for January 2013 for each series. The dashed line indicates the time of the merger.

Figure 3: ARPU for OneCall, Chess, NetCom+Tele2, and all brands in Norway, compared to the average of Telia in other Nordic countries.

(the aggregate of teh investigated Telia and Tele2 brands) in Norway against the average of normalized ARPU in the other Nordic countries. As noted above, this average follows roughly the same long-term trend before the merger in Norway and thus indicates that the common trend assumption holds. In the post-merger period, prices in Norway appear slightly higher than average normalized prices in the other Nordic countries. Nonetheless, the graphical analysis does not suggest a clear merger effect on prices.

The other three quadrants display the normalized ARPU at the brand level for Norway against the average of the other Nordic countries. For all three brands, we observe no clear difference in long-term price trend in the pre-merger period in Norway compared to the trend of the average price of other Nordic countries. After the merger, prices for Chess do not appear to substantially depart from those of the other Nordic countries, except for a somewhat smaller price increase in 2016. In contrast, after the merger, we can observe marked differences for OneCall and NetCom+Tele2 compared to the other Nordic countries. For NetCom+Tele2, prices appear to increase immediately after the merger before stabilizing at a higher level. For OneCall, the development is the opposite: Prices decrease after the merger and appear to stabilize below the average price of the other Nordic countries.

This visual inspection of price development in Norway relative to prices in the group of comparison countries gives a good indication of the merger's effects on prices. These effects appear to be different for different brands, with negative price effects for OneCall, positive price effects for NetCom+Tele2, and no clear effect for Chess and the aggregate of all involved brands. These price effects are roughly in line with the direction predicted by the ex-ante analysis.

5.1 Estimated merger effects

To identify effects of the merger formally, we estimate the regression DiD model specified in equation 1. This section presents the estimates and discusses the main results for different brands and the aggregate for all investigated Telia and Tele2 brands (all brands) in Norway.

Table 3 presents the main results. Columns 1–2 show the estimates for OneCall, columns 3–4 for Chess, columns 5–6 for NetCom+Tele2, and columns 7–8 for all brands. Odd-numbered columns contain estimates from a baseline model including country and month fixed effects. In even numbered columns, we add additional variables in order to control for several country-specific factors that can affect price levels. These are GDP per capita growth, the log of data usage, and a dummy for summers in Norway from 2013 to 2015.[24] Throughout, we separately estimate the short-run (first-year) and long-run (second-year) effects. The test for the common trend assumption indicates that we cannot reject the null hypothesis of common trends. This holds for all brands and specifications in Table 3. Hence, the test indicates that the common trend assumption cannot be rejected and the DiD model is appropriate.

For OneCall (columns 1–2), we find that the merger leads to a statistically significant reduction in prices. The magnitude of the estimated effect is around 7 percent in the short run (first-year) and 12 to 13 percent in the long run (second-year). This is a sizable price reduction. Moreover, the results indicate that the effect of the merger increases

[24]The OECD Database is the source of consumer price indices and GDP per capita. GDP data are only available at quarterly observations, and we therefore interpolate the data linearly when we use GPD per capita a as control variable.

over time. The price reduction after the merger is in line with the predictions from the ex-ante analysis. The findings indicate that the efficiency gains and remedies (Ice became a stronger rival) more than outweighed the effects of eliminating competition with Telia on OneCall's prices.

Table 3: Main Results – Difference-in-Differences Estimates

	OneCall		Chess		NetCom+Tele2		All brands	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st-year Effect	-0.0735***	-0.0703***	0.0015	0.0046	0.0462***	0.0507***	0.0121	0.0154
	(0.0234)	(0.0229)	(0.0183)	(0.0203)	(0.0166)	(0.0171)	(0.0163)	(0.0150)
2nd-year Effect	-0.1314***	-0.1198***	-0.0763***	-0.0689**	0.0486***	0.0592***	-0.0095	-0.0003
	(0.0193)	(0.0249)	(0.0192)	(0.0320)	(0.0177)	(0.0197)	(0.0174)	(0.0174)
GDP pc growth		0.0111		0.0094		0.0034		0.0063
		(0.0108)		(0.0106)		(0.0101)		(0.0102)
Log data per user		-0.0032		-0.0022		-0.0215		-0.0205
		(0.0515)		(0.0523)		(0.0559)		(0.0576)
Summer in Norway		0.1115***		0.0670**		0.0507*		0.0657**
		(0.0307)		(0.0277)		(0.0273)		(0.0269)
Common trend test	passed	passed	passed	passed	passed	passed	passed	passed
(p-value)	(0.986)	(0.793)	(0.704)	(0.556)	(0.835)	(0.674)	(0.776)	(0.603)
Observations	188	188	188	188	188	188	188	188
Adjusted R^2	0.67	0.68	0.66	0.66	0.67	0.67	0.67	0.67

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

The results for Chess (columns 3–4) indicate no effect of the merger in the short run, but a statistically significant reduction of prices in the long run of about 7 percent. Given that there where no efficiency gains for Chess, this result may be surprising. A possible explanation is that the remedies caused Ice to become a stronger rival, which in turn led to a price reduction for Chess. This explanation is also in line with the fact that we only find evidence for long-run effects, as it would have taken time for Ice to be able to exercise effective competitive pressure.[25] Price reductions may also occur as a recalibration of prices due to internalization of OneCall's price reduction.[26] However, the result for Chess is not always robust, as we will show in further analyses in Section 6.

In columns 5–6, we show results for NetCom+Tele2, which comprises the customers of

[25] Ice's market share (measured in revenues) in the residential mobile telecom sector where 0.1 percent in 2015 and then grew to 1.8 percent in 2016 and 4.7 percent in 2017 (according to data from the Norwegian Communications Authority (Nkom), the telecom regulator in Norway).

[26] Chess and OneCall catered to similar types of consumers. In 2018, Telia Company decided to discontinue Chess, and customers were transferred to the brand "Telia" (formerly NetCom).

the brands NetCom (Telia) and Tele2-brand (Tele2) in both the pre- and the post-merger period to eliminate composition effects. The empirical results suggest a statistically significant price increase for NetCom+Tele2 after the merger. The magnitude of the effect is 5 percent in the short run and 5–6 percent in the long run.

Finally we analyze the effects on the average price of all brands (the aggregate of OneCall, Chess, and NetCom+Tele2). The results for all brands in columns 7–8 indicate that there was likely no price effect of the merger. Point estimates for the short- and long-run effects are relatively small and never significant. These for all brands can be interpreted as the effect on the average customer directly affected by the merger. The absence of evidence for price effects indicates that the merger on average was likely neutral.[27]

6 Robustness and timing of the effects

In this section, we study the price effects of each brand in more detail. We conduct robustness checks using an extended DiD model with country-specific trends and excluding potentially problematic observations. We also explore the timing of effects, which, among other things, allows us to better understand the somewhat varying results for Chess and for all brands (the aggregate of considered Telia and Tele2 brands).

A main concern with the standard DiD approach is a potential violation of the common trend assumption. The formal test for common trends shows that we cannot reject the common trend assumption in all specifications presented in the previous section. We thus believe the standard DiD model to be appropriate. Nevertheless, due to the centrality of the common trend assumption, we conduct further checks to probe the sensitivity of our results.

The DiD model with country-specific trends. An alternative to testing for common trends is to control for country-specific trends by including state-specific time trends among the regressors (see Besley and Burgess, 2004).[28] Denoting the country-specific time trend $S_{i,t}$, this extended DiD model with country-specific trends (henceforth trend

[27]The results for all brands can be seen as a weighted average of the results for the individual brands with the weights being proportional to the number of customers for each brand. While the number of customers for each brand changes somewhat over time, numbers in Table 1 provide an indication of the relative size of the brands at the time of the merger.

[28]This approach is routinely used as an alternative specification for robustness checks in the recent contributions to ex-post merger-evaluations in the telecom sector – see, for example: Aguzzoni et al. (2018), RTR-GmbH (2016), BEREC (2018), or Lear et al. (2017).

specification) can be written as,

$$ln(ARPU_{i,j,t}) = \mu_i + \tau_t + \gamma^1 D^{ShortRun}_{i,j,t} + \gamma^2 D^{LongRun}_{i,j,t} + X'_{i,j,t}\beta + S_{i,t} + \varepsilon_{i,j,t} \ . \qquad (2)$$

By controlling for a country-specific trend, the model investigates the identification assumption of the DiD approach. If the estimated merger effects change much when adding or removing the country-specific time trend, this may indicate potential problems with the common trend assumption.

However, the trend specification also has some important shortcomings. Even if the results change, this does not necessarily indicate a violation of the common trend assumption. Intuitively, the identification of the merger price effects in the trend specification relies on sudden changes occurring at the time of the merger (treatment). If, instead, the treatment effect has interesting dynamics, these may be confused with the country-specific trend in the trend specification (c.f. Wolfers, 2006). In our specific case, one may expect that the effects of the merger strengthens over time. Efficiency gains from vertical integration may take time to be fully realized because the existing national roaming agreements between Tele2 and Telenor will take time to phase out. Similarly, it will take time for remedies to fully take effect because Ice first has to become strong enough to exercise sufficient competitive pressure.

We should therefore interpret the results of the trend specification with care. If the trend specification leads to similar results to the standard DiD approach, the results appear reliable. If the results instead are sensitive, further examination is needed to determine if this is due to country-specific trends or dynamics of the merger effect. Dynamics of the treatment can be revealed by increases or decreases in the treatment effect from the first to the second year after the merger. This will be further examined by replacing yearly treatment effects with quarterly treatment effects, which will reveal the effects' dynamics in more detail.

6.1 OneCall

The results of the robustness analysis of various model specifications are displayed in Table 4. Odd-numbered columns display estimates of specifications without controls, and even-numbered columns show specifications that include GDP per capita growth, log of data usage, and a dummy for summer in Norway as control variables. Whether we include additional controls or not has little impact on the results.

In columns 1–2 of Table 4, we repeat the results from above using the main sample and the standard DiD model (Table 3, columns 1–2) for comparison purposes. As

Table 4: OneCall – Robustness Checks

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st-year Effect	-0.0735***	-0.0703***	-0.0401	-0.0340	-0.1019***	-0.0926***	-0.0707***	-0.0565**
	(0.0234)	(0.0229)	(0.0303)	(0.0250)	(0.0182)	(0.0228)	(0.0255)	(0.0245)
2nd-year Effect	-0.1314***	-0.1198***	-0.0787**	-0.0629**	-0.1314***	-0.1232***	-0.0824**	-0.0692**
	(0.0193)	(0.0249)	(0.0345)	(0.0314)	(0.0194)	(0.0246)	(0.0340)	(0.0314)
GDP pc growth		0.0111		0.0148**		0.0036		0.0088
		(0.0108)		(0.0060)		(0.0110)		(0.0055)
Log data per user		-0.0032		-0.0367		0.0016		-0.0393
		(0.0515)		(0.0275)		(0.0508)		(0.0272)
Summer in Norway		0.1115***		0.1116***		0.0850**		0.0895***
		(0.0307)		(0.0202)		(0.0346)		(0.0145)
Common trend test	passed	passed	na	na	passed	passed	na	na
(p-value)	(0.986)	(0.793)			(0.985)	(0.888)		
Country specific trends	no	no	yes	yes	no	no	yes	yes
Observations	188	188	188	188	180	180	180	180
Adjusted R^2	0.67	0.68	0.92	0.94	0.68	0.68	0.94	0.95

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

mentioned, the formal test for common trends shows that we cannot reject the common trend assumption. We thus believe the standard DiD model to be appropriate and consider the results in columns 1–2 to be our best estimates of the effects.

The results for the trend specification, where we nevertheless control for country-specific trends, are shown in columns 3–4 of Table 4. The sign on the estimated price effects remains negative, but the magnitude of the effect is about 4 to 6 percentage points lower than in the standard specification. In the short term, the estimated effect is no longer significantly different from zero. However, the long-run effect remains statistically significant. As discussed above, the trend specification can result in misleading findings if merger effects change over time. Specifically, if the intensity of the merger effect increases over time, as the results in column 1 indicate, then the trend specification will underestimate the effects. Thus, we can expect a reduction in both magnitude and significance in the trend specification. However, the estimated effects for the long run remain at a reasonable size and significance. Overall, we interpret these results therefore as a confirmation that prices for OneCall were reduced as an effect of the merger.

Our results show weaker effects in the short term. As mentioned, this can be expected when effects are dynamic. A further potential explanation for the weaker effect in the short term is issues with data and confounding determinants of ARPU in the summer of 2015. First, we observe a very large increase in ARPU in Norway in July and August

2015. Even if ARPU increases in earlier summers in Norway, the increase in 2015 is proportionally much larger and would not fully be captured by our control dummy for summers in Norway in the period 2013–2015. It is reasonable to assume that these increases in ARPU are not due to the merger, as the summer increases are typically driven by costly roaming abroad during holidays. Second, when analyzing the data series for this project, we found some inconsistencies in the data for Tele2 in July and August 2015 that likely stem from integrating Tele2's accounts into Telia's accounting system at that time.[29] This represents potential measurement error. For this reason, we check the robustness of our analysis to excluding data for summer (July and August) 2015.

The results of this exercise are shown in columns 5–8 of Table 4. Column 5–6 show the results for the standard DiD model and columns 7–8 for the trend specification. The coefficients for the short-term effect are now larger in absolute terms compared to the corresponding specifications when including data for summer 2015. Moreover, we see that with the trend specification, the short term effect is also significantly negative. This indicates that the large observed increase in ARPU in Norway in the summer of 2015 contributes to lower effects estimated in columns 1–4 and lack of significance in columns 3–4. The results in columns 5–8 therefore further strengthen the finding that the merger had a negative price effect for OneCall.

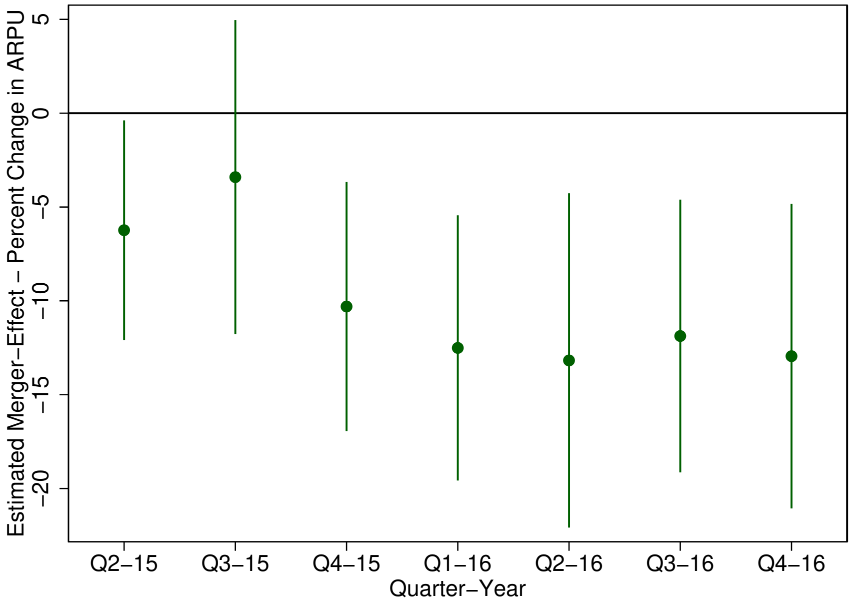
Timing of effects. As discussed above, the merger effects seem to be stronger in the long term, and dynamics in the merger effects may interact with country-specific trends and lead to misleading results in columns 3–4 and 7-8 of Table 4. We explore the issue further by looking more closely at the timing of effects. This is done by replacing the dummies for the long-run and short-run effects with a separate dummy for each quarter after the merger in Norway. The results are displayed in Figure 4. The figure shows point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger.[30] The figure shows estimates for the standard DiD specification, which we believe to be the more appropriate specification based on the discussion above. Using the trend specification leads to similar patterns.[31]

The results confirm that the merger effect tends to grow stronger (more negative) over time. The estimated effects for all quarters are negative and statistically significant,

[29] The integration occurred during the six months after the merger while both accounts were continued separately. In the summer of 2015, Telia discontinued Tele2's accounting system, and at this point, we find some inconsistency comparing data from the two systems.

[30] Quarter 1 of 2015 in which the merger lies is excluded from the dataset when estimating quarterly merger effects.

[31] See Appendix A.2 for the underlying results with point estimates and standard errors in table format, including the standard DiD and trend specification.

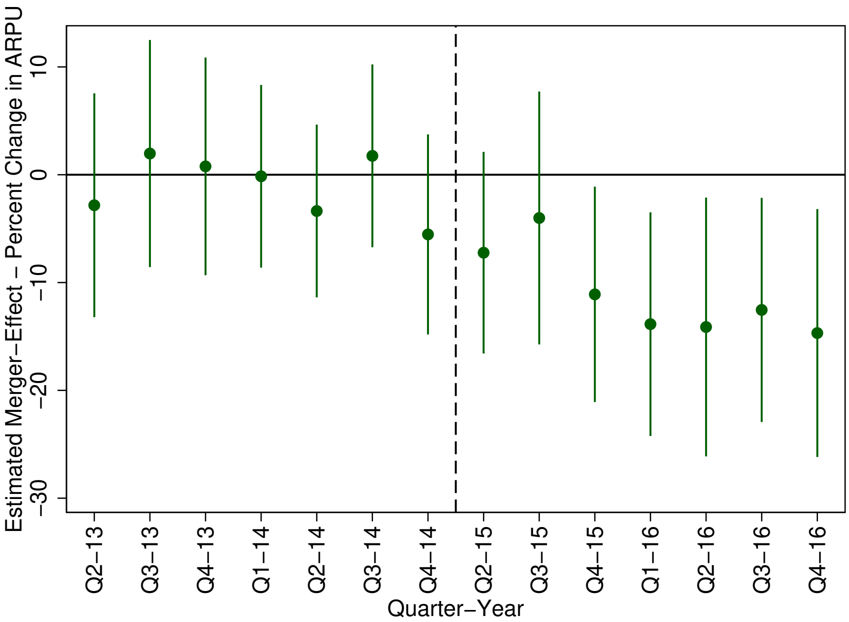


Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway.

Figure 4: OneCall – Timing: estimated effects for each post-merger quarter.

with the exception of quarter three in 2015. The effects are markedly larger (in absolute value) in quarter four of 2015 (even though the point estimates are not statistically different from each other). Quarter three in 2015 is a clear outlier in both specifications, where the estimated effect is positive – though not statistically different from zero. This quarter includes July and August, and we discussed above that these may be affected by data issues. All in all, the analysis of the quarterly merger effect confirms our result from above that it is the summer of 2015 that drives part of the smaller size of the short-term effect (compared to the long-run effect) and that the short-run effect sometimes becomes non-significant. Moreover, because the effect grows stronger over time, the trend specification may confound some of the dynamics with the treatment effect.

We can also extend the model with quarterly effects to execute another check on the common trend assumption. This is done by adding dummies for each quarter before the merger in Norway (except the first quarter in our dataset), as suggested by Angrist and Pischke (2009). The intutition behind this placebo test is that if the treatment effects are simply driven by country-specific trends, there would likely be measurable differences also before the merger, not only after. Obviously, this test is executed without controlling for country-specific trends, since it is these trends we want to detect.[32] Note, however, that this model attempts to estimate many treatment effects (and many parameters in total). The estimates may indicate overall patterns, but estimates of individual effects and their precision should be interpreted with caution.



Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway). The dashed line indicates the time of the merger.

Figure 5: OneCall – Placebo test: post-merger and pre-merger effect.

The results of this exercise are shown in Figure 5. The figure shows point estimates and 95-percent confidence intervals for estimated effects for each quarter before and after the merger. The dashed vertical line divides the graph between the pre-merger period (left) and the post-merger period (right). In the pre-merger period, the effects are never statistically significant, and point estimates are sometimes negative and sometimes positive. This placebo test is an additional piece of evidence suggesting that there are no pre-merger trends and that we have successfully identified effects of the merger.[33]

[32] It is these estimated quarterly pre-treatment effects that are used to calculate the slope for the formal test of the common trend assumption.

[33] In the quarter before the merger, we observe the most negative point estimate. This may already

6.2 Chess

In this section, we look more closely at the results for Chess. The main results indicate that prices may have decreased in the long term after the merger. These results are repeated in columns 1–2 of Table 5. The formal test cannot reject the common trend assumption, but we nevertheless conduct robustness checks using the trend specification. The results are shown in columns 3–4. We find that the results change when adding country-specific trends to the model. The long-run effects remain negative but are no longer significant. The short-run effects, on the other hand, are now statistically significant, with a positive sign and a clear increase in magnitude compared to the estimates in columns 1–2. The standard specification and the trend specification thus seem to lead to contradictory results. Given that the common trend assumption cannot be rejected, we would tend to put more weight on the results based on the basic DiD model. In the following, we will discuss how data issues and the dynamics of the effect may lead to misleading results in the trend specification.

Table 5: Chess – Robustness Checks

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st-year Effect	0.0015	0.0046	0.0417^{*}	0.0460^{**}	-0.0142	-0.0083	0.0248	0.0310
	(0.0183)	(0.0203)	(0.0221)	(0.0186)	(0.0173)	(0.0233)	(0.0202)	(0.0198)
2nd-year Effect	-0.0763^{***}	-0.0689^{**}	-0.0128	-0.0065	-0.0763^{***}	-0.0724^{**}	-0.0151	-0.0163
	(0.0192)	(0.0320)	(0.0282)	(0.0277)	(0.0193)	(0.0319)	(0.0278)	(0.0277)
GDP pc growth		0.0094		0.0140^{***}		0.0042		0.0102^{**}
		(0.0106)		(0.0050)		(0.0112)		(0.0051)
Log data per user		-0.0022		-0.0103		-0.0034		-0.0211
		(0.0523)		(0.0254)		(0.0514)		(0.0245)
Summer in Norway		0.0670^{**}		0.0652^{***}		0.0491		0.0486^{***}
		(0.0277)		(0.0180)		(0.0347)		(0.0176)
Common trend test	passed	passed	na	na	passed	passed	na	na
(p-value)	(0.704)	(0.556)			(0.700)	(0.581)		
Country specific trends	no	no	yes	yes	no	no	yes	yes
Observations	188	188	188	188	180	180	180	180
Adjusted R^2	0.66	0.66	0.94	0.94	0.65	0.65	0.94	0.94

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

First, we exclude observations for summer 2015 from our data set to eliminate bias

be affected by the merger and capture some forward-looking behavior of both the merging parties and consumers, as the merger-plan was public knowledge by that time. However, this remains speculative, and the point estimate is not statistically different from zero. If some forward-looking effects exist, these would bias our estimated towards zero and make it less likely to find merger effects. In this context, our estimates may be seen as conservative. We have conducted additional robustness checks not reported in this paper where we exclude three or six month before and after the merger. This confirms our main results. Results available upon request.

from potentially faulty data (and potentially uncontrolled summer effects), as discussed above. The results are reported in columns 5–8 of Table 5. The negative significant effect in the standard DiD specification (columns 5–6) is robust to this procedure. In the trend specification (columns 7–8), the signs are maintained, but none of the estimated effects are statistically significant. This indicates that the data for summer 2015 contributes to the significant positive short-term effect in the trend specification.

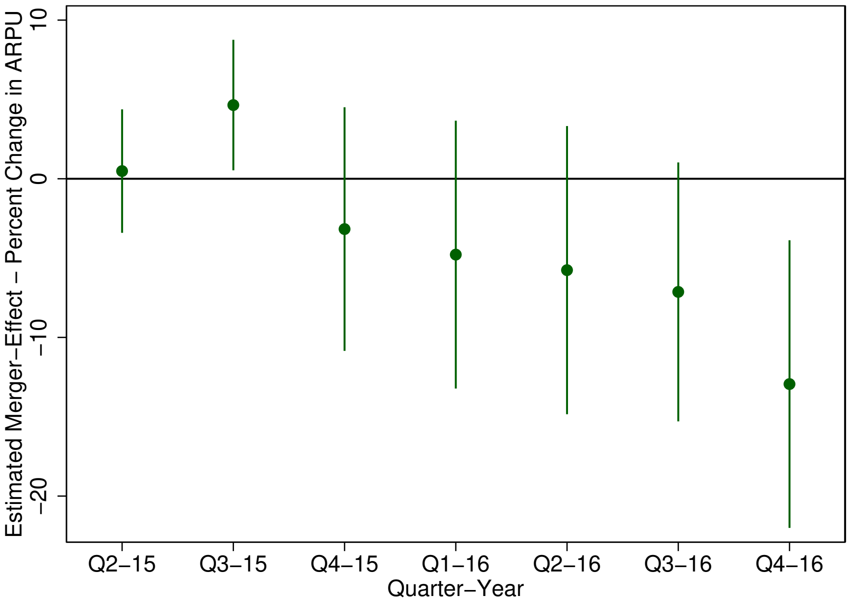
Timing of effects. We explore the second issue of effect dynamics further by replacing the dummies for the long-run and short-run effects with a separate dummy for each quarter after the merger in Norway. The results are displayed in Figure 6. The figures show point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger from the standard DiD approach.[34] The results indicate that the negative price effect of the merger grows stronger over time. In the first two quarters after the merger, the estimated effect is positive, and even significantly so for Q3 2015. However, from Q4 2015, we observe only negative estimates, and the absolute size of the effects increases. Even though point estimates are not statistically significant at the 5-percent level for most quarters, there is a negative trend (and the point estimate in the third quarter of 2016 is negative and statistically significant at the 10-percent level – see Table 9 in Appendix A.1).

As discussed, this sort of dynamics can be masked by the trend specification. Together with the outlier of high ARPU in Norway in the summer of 2015, these dynamics are likely the reason why in Table 5 the results from the trend specification differ from those of the standard DiD approach.

The findings from the models with quarterly effects indicate that prices decreased gradually for Chess as a consequence of the merger. This conclusion is further supported by estimates from a model that also includes leads of the treatment effect. The coefficient estimates and 95-percent confidence intervals are displayed graphically in Figure 7. Before the merger, prices do not systematically develop differently in Norway compared to the other countries. This does not change in the first two quarters after the merger. From the third quarter onward, we observe an increasingly negative impact on prices. However, the coefficients are not statistically significant, except for the last quarter observed.

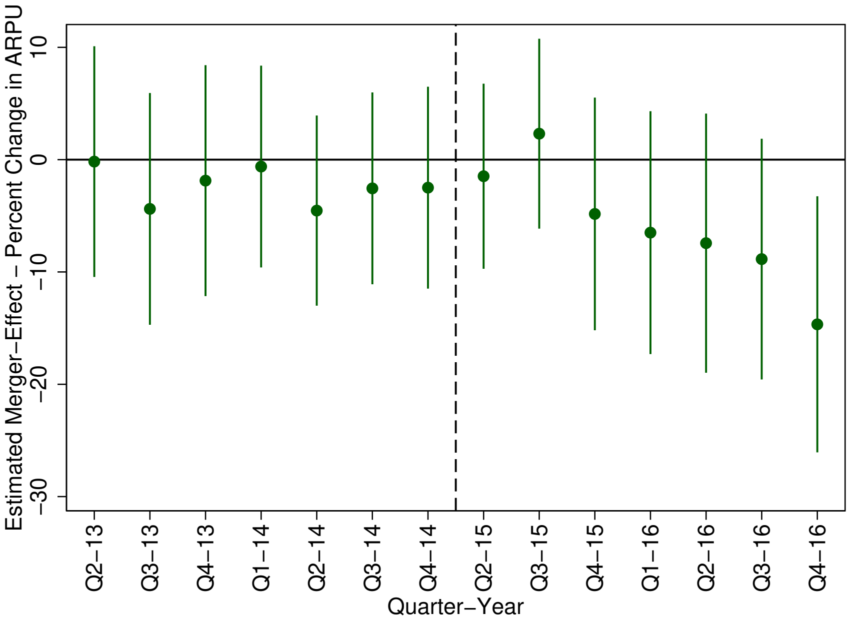
Overall, the evidence suggests that the price effect for Chess was likely negative in the long run. While this finding is not robust to the trend specification, the evidence suggests that the basic model is more appropriate in this case. Nevertheless, we interpret

[34] Quarter 1 of 2015, in which the merger lies, is excluded from the dataset when estimating quarterly merger effects.



Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway).

Figure 6: Chess – Timing: estimated effects for each post-merger quarter.



Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway). The dashed line indicates the time of the merger.

Figure 7: Chess – Placebo test: post-merger and pre-merger effect.

the results for Chess with caution.

6.3 NetCom+Tele2

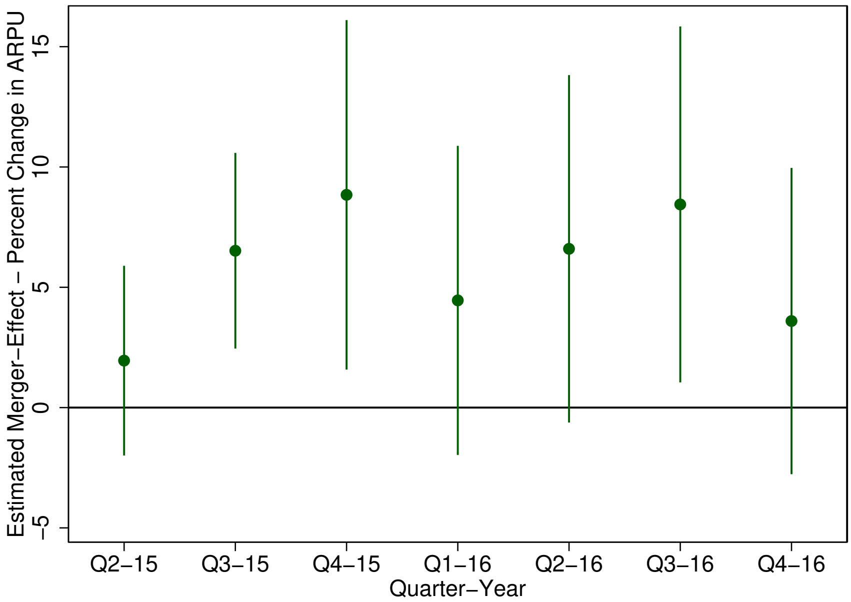
This section further explores the price effects for NetCom+Tele2, the aggregate of NetCom and Tele2-brand (aggregated to avoid that the analysis picks up composition effects). Columns 1–2 of Table 6 repeat the main results (see columns 5–6 of Table 3) for comparison. Again, we explore whether the results are driven by country-specific trends by estimating the trend specification (results in columns 3–4 of Table 6), even though the formal test cannot reject common trends. The trend specification confirms the finding that ARPU increased after the merger. Excluding data for the summer of 2015 leads to very similar results (columns 5–8). We thus conclude that the positive effects of the merger on prices for NetCom+Tele2 are robust.

Table 6: NetCom+Tele2 – Robustness Checks

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st-year Effect	0.0462***	0.0507***	0.0712***	0.0746***	0.0381**	0.0444**	0.0624***	0.0694***
	(0.0166)	(0.0171)	(0.0173)	(0.0149)	(0.0175)	(0.0200)	(0.0168)	(0.0162)
2nd-year Effect	0.0486***	0.0592***	0.0881***	0.0967***	0.0486***	0.0569***	0.0867***	0.0943***
	(0.0177)	(0.0197)	(0.0196)	(0.0181)	(0.0178)	(0.0197)	(0.0194)	(0.0179)
GDP pc growth		0.0034		0.0033		-0.0010		-0.0005
		(0.0101)		(0.0043)		(0.0107)		(0.0042)
Log data per user		-0.0215		-0.0983***		-0.0199		-0.1098***
		(0.0559)		(0.0255)		(0.0555)		(0.0252)
Summer in Norway		0.0507*		0.0471***		0.0429		0.0405***
		(0.0273)		(0.0125)		(0.0372)		(0.0131)
Common trend test	passed	passed	na	na	passed	passed	na	na
(p-value)	(0.835)	(0.674)			(0.833)	(0.720)		
Country specific trends	no	no	yes	yes	no	no	yes	yes
Observations	188	188	188	188	180	180	180	180
Adjusted R^2	0.67	0.67	0.94	0.95	0.66	0.65	0.95	0.95

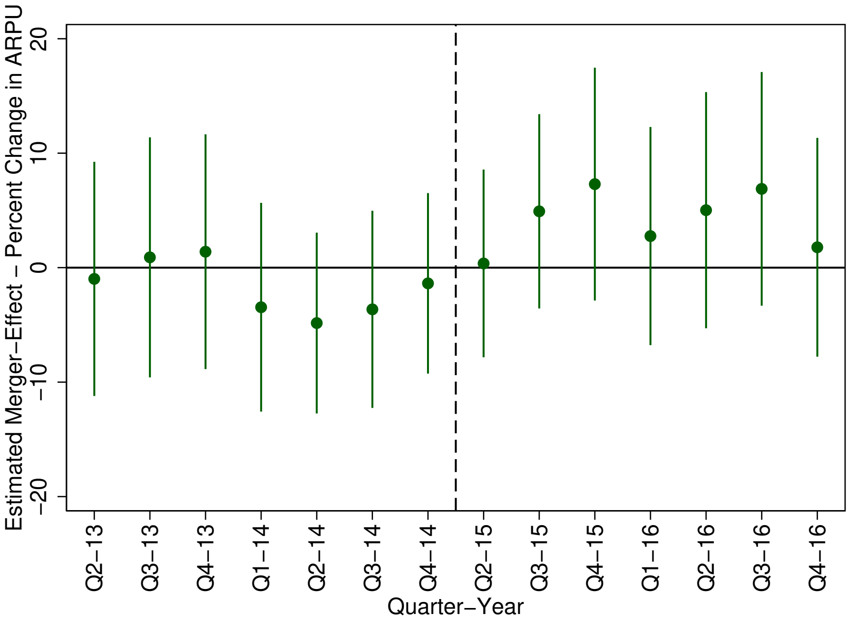
Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

Timing of effects. Figures 8 and 9 further explore the effects' dynamics. Figure 8 shows quarterly treatment effects which are all positive, albeit not always statistically significant. Figure 9 shows the results for the model that adds leads to treatment. While the estimated effects are never significant, there is a visible upward shift in the estimated effects from the pre- to the post-merger periods. Overall, these results indicate further support for the finding that the merger led to increased prices for the aggregate of the brands NetCom and Tele2.



Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway).

Figure 8: NetCom+Tele2 – Timing: estimated effects for each post-merger quarter.



Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway). The dashed line indicates the time of the merger.

Figure 9: NetCom+Tele2 – Placebo test: post-merger and pre-merger effect.

6.4 All brands: Aggregate effects

For the investigated brands of Telia and Tele2 as a whole (all brands), we find no consistent evidence of a merger effect. Table 7 repeats the main results using the standard DiD approach in columns 1–2. The estimated coefficients are not statistically significant and very small in magnitude. This changes for estimates of the specification (columns 3–4). The effects seem to indicate that prices increased after the merger. When we exclude summer 2015 from the sample (column 5–8) the results are largely the same as in the corresponding specifications for the full sample.

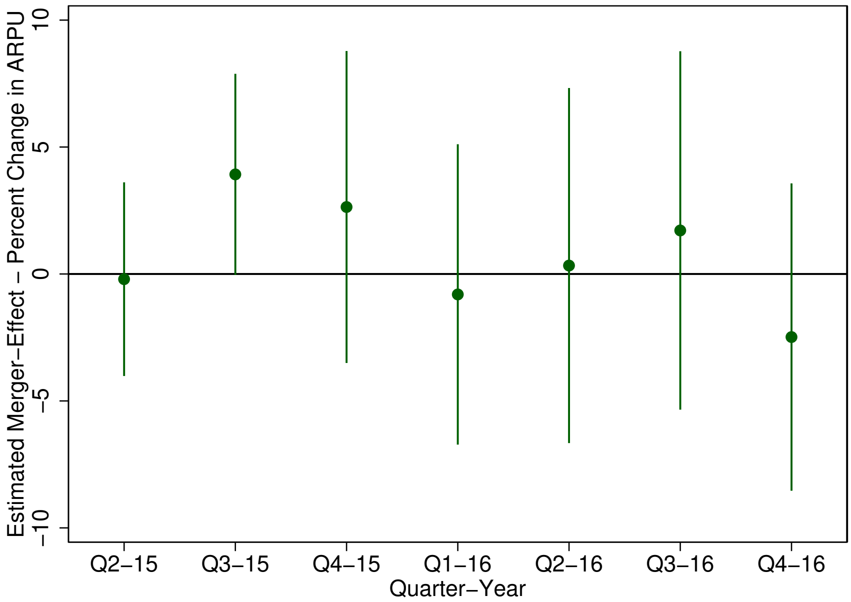
Table 7: All brands – Robustness Checks

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st-year Effect	0.0121	0.0154	0.0454***	0.0471***	-0.0013	0.0048	0.0310**	0.0366***
	(0.0163)	(0.0150)	(0.0170)	(0.0129)	(0.0153)	(0.0171)	(0.0142)	(0.0128)
2nd-year Effect	-0.0095	-0.0003	0.0431**	0.0493***	-0.0095	-0.0032	0.0411**	0.0452***
	(0.0174)	(0.0174)	(0.0188)	(0.0166)	(0.0176)	(0.0172)	(0.0184)	(0.0164)
GDP pc growth		0.0063		0.0071*		0.0011		0.0027
		(0.0102)		(0.0043)		(0.0107)		(0.0040)
Log data per user		-0.0205		-0.0897***		-0.0183		-0.1007***
		(0.0576)		(0.0245)		(0.0571)		(0.0237)
Summer in Norway		0.0657**		0.0635***		0.0526		0.0520***
		(0.0269)		(0.0131)		(0.0354)		(0.0109)
Common trend test	passed	passed	na	na	passed	passed	na	na
(p-value)	(0.776)	(0.603)			(0.773)	(0.653)		
Country specific trends	no	no	yes	yes	no	no	yes	yes
Observations	188	188	188	188	180	180	180	180
Adjusted R^2	0.67	0.67	0.95	0.96	0.66	0.65	0.95	0.96

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

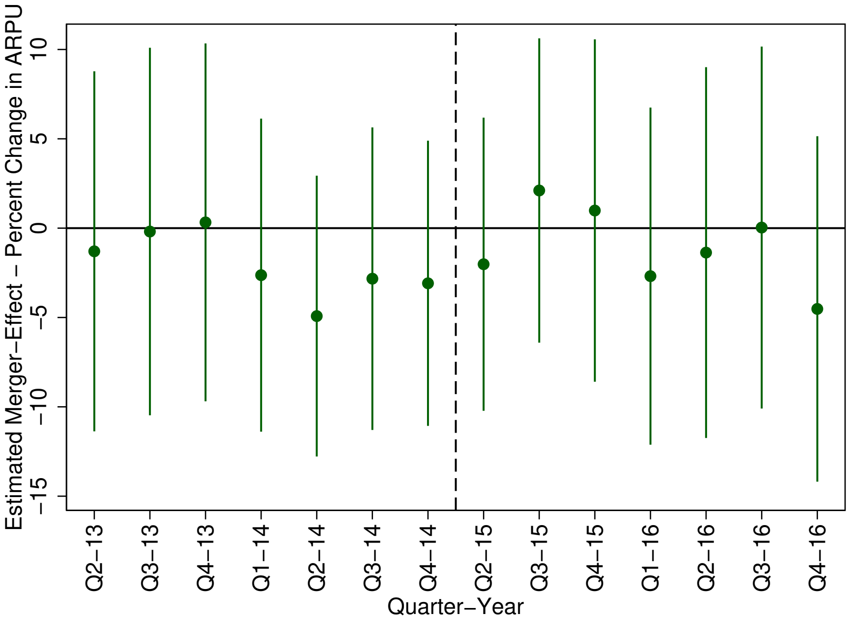
Timing of effects. To analyze the timing, we again estimate effects per quarter in the post-merger period and including leads in Figures 10 and 11. The results do not suggest any clear pattern for effects post-merger nor a differential trend in the pre-merger period. Altogether, there is no clear indication for either a reduction or an increase of the prices in aggregate as a consequence of the merger.

The aggregated effects can be understood as a weighted average of the effects from NetCom, Chess, Tele2, and OneCall, as mentioned previously. Weights are given by the number of customers for each brand. Considering the findings for each brand can therefore explain the finding of diverging results for standard DiD and the trend specification. First, for Chess, the trend specification leads to the finding of positive price effects in the long term. However, this is likely at least partly a consequence of the added country-specific trends in the specification masking the dynamics of the treatment effect.



Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway).

Figure 10: All brands – Timing: estimated effects for each post-merger quarter.



Displayed are point estimates and confidence bands for the 95-percent confidence interval for the effect within each quarter after the merger. Estimates of a standard DiD model including additional controls (GDP pc growth, Log data per user, Summer in Norway). The dashed line indicates the time of the merger.

Figure 11: All brands – Placebo test: post-merger and pre-merger effects.

Second, NetCom has the largest number of subscribers, so the positive price effect will therefore have a strong influence on the prices of NetCom and Tele2 jointly. The positive effect for NetCom+Tele2 appeared stronger in the trend specification and will therfore also contribute to the positive coefficients for all brands in the trend specification. As discussed on several occasions, the trend specification is a good approach for exploring the sensitivity of results. However, we find that the common trend assumption is not rejected in the formal test for any of the brands. Neither do we find evidence of diverging trends in Norway compared to the average of the control group in the graphical analysis in Figure 3 or when exploring the timing of effects (Figure 11 for all brands). We therefore believe the standard DiD model produces more reliable results. The overall evidence thus suggest that there is likely no price effect of the merger on the overall price level, i.e., that the merger likely was price-neutral in aggregate.

7 Discussion and conclusion

This paper empirically investigated the price effects of the merger between Telia and Tele2 in the Norwegian mobile telecommunications market in 2015.

From an ex-ante perspective the merger is predicted to affect the prices of the brands involved in the merger differently. Reduced competition would put upward pricing pressure on all brands, but efficiency gains and remedies could be expected to affect brands differently. OneCall (Tele2) would profit from efficiency gains. OneCall (Tele2) and Chess (Telia) were expected to meet increased competition from Ice, which was strengthened by the remedies. NetCom+Tele2 might be slightly affected by Tele2's efficiency gains as well as increased competition from Ice. However, it remained uncertain if these effects would compensate for reduced competition. These differential expected effects gave rise to the predictions summarized in Table 2.

The ex-post analysis largely confirms these predictions, at least in their qualitative direction. First of all, we find a negative price effect on OneCall. This effect is stronger in the long term, which one might expect, as efficiency gains take time to realize and it would take time before Ice became an efficient rival. The estimated long-term reduction of prices is 7 to 13 percent. For Chess, the evidence is somewhat less robust, but we find some indication of negative price effects in the long term. Since prediction for Chess and OneCall imply similar effects by the remedies and internalization of rivalry, the price effect for OneCall relative to Chess is likely driven by efficiency gains.

For NetCom+Tele2, we find that the elements exercising upward pricing pressure dominated: Prices increased by about 6 to 9 percent after the merger. This finding can be explained by the fact that Tele2-brand's customer portfolio was small relative to NetCom's customer portfolio, and efficiency gains therefore were not expected to be large. In addition, it seems that Ice did not exercise sufficient competitive pressure on NetCom. Ice chose to establish itself as a budget-friendly brand and was likely viewed as a closer substitute for customers of OneCall and Chess relative to NetCom.

For the aggregate of Telia and Tele2 (all brands), we find that there was likely no price effect. Conservatively interpreted, the results suggest that there is no consistent evidence for an effect on overall prices in either direction. This indicates that the average consumer affected by the merger likely did not have to pay higher prices as a consequence of the merger. Moreover, as we discussed above, the empirical analysis implies a counterfactual situation for Tele2 with lower costs for Tele2 than the most likely counterfactual. This suggests that the true effects for consumers was likely a stronger reduction of prices, relative to the most likely counterfactual, than that found by the analysis. Overall, our analysis suggests that the merger control that lead to allowing the merger with remedies was successful in this case.

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A Appendices

This appendix presents further results. Appendix A.1 presents the estimates that are shown in the figures in Section 6 in table format and additional specifications. Appendix A.2 discusses issue with inference in DiD models and presents results with alternative standard errors as well as GLS results.

A.1 Timing and dynamics of merger effects

In this section, we show further results that explore the effects' dynamics. The shown results include the estimates underlying the figures for each brand in the robustness sections (Section 6) in table format. The figures in Section 6 are based on specifications with control variables. In addition, we present specifications without controls and for the trend specification.[35] This does not change our main findings. We point to the discussion of the timing of effects and placebo tests for each brand above for a discussion of results.

Table 8 displays estimates from the model with quarterly treatment effects and leads for OneCall. The results in columns 2 and 6 correspond to Figures 4 and 5, respectively.

[35]When leads are added to the model, the trend specification is not relevant, as discussed above.

Table 8: OneCall - Timing of Effects

	(1)	(2)	(3)	(4)	(5)	(6)
Lead Q2 2013					-0.0246	-0.0283
					(0.0540)	(0.0524)
Lead Q3 2013					0.0461	0.0197
					(0.0546)	(0.0532)
Lead Q4 2013					0.0038	0.0078
					(0.0513)	(0.0510)
Lead Q5 2014					0.0024	-0.0014
					(0.0448)	(0.0428)
Lead Q6 2014					-0.0284	-0.0336
					(0.0426)	(0.0404)
Lead Q7 2014					0.0410	0.0175
					(0.0447)	(0.0428)
Lead Q8 2014					-0.0458	-0.0553
					(0.0464)	(0.0468)
Effect Q2 2015	-0.0727**	-0.0624**	-0.0540	-0.0363	-0.0734	-0.0723
	(0.0293)	(0.0296)	(0.0332)	(0.0307)	(0.0496)	(0.0472)
Effect Q3 2015	-0.0070	-0.0341	0.0150	-0.0116	-0.0077	-0.0401
	(0.0497)	(0.0423)	(0.0531)	(0.0412)	(0.0646)	(0.0592)
Effect Q4 2015	-0.1182***	-0.1030***	-0.0927***	-0.0740**	-0.1188**	-0.1110**
	(0.0240)	(0.0335)	(0.0307)	(0.0312)	(0.0465)	(0.0504)
Effect Q1 2016	-0.1302***	-0.1251***	-0.1013***	-0.0961***	-0.1309**	-0.1386***
	(0.0303)	(0.0357)	(0.0352)	(0.0339)	(0.0503)	(0.0524)
Effect Q2 2016	-0.1444***	-0.1317***	-0.1121***	-0.0961**	-0.1451**	-0.1412**
	(0.0388)	(0.0450)	(0.0423)	(0.0428)	(0.0562)	(0.0606)
Effect Q3 2016	-0.1352***	-0.1187***	-0.0995**	-0.0659	-0.1358***	-0.1254**
	(0.0295)	(0.0367)	(0.0421)	(0.0410)	(0.0498)	(0.0525)
Effect Q4 2016	-0.1277***	-0.1295***	-0.0887*	-0.0903*	-0.1284**	-0.1468**
	(0.0306)	(0.0410)	(0.0505)	(0.0491)	(0.0505)	(0.0580)
Control variables	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no
Observations	180	180	180	180	180	180
Adjusted R^2	0.66	0.66	0.93	0.94	0.65	0.65

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

Table 9 displays estimates from the model with quarterly treatment effects and leads for Chess. The results in columns 2 and 6 correspond to Figures 6 and 7, respectively.

Table 9: Chess - Timing of Effects

	(1)	(2)	(3)	(4)	(5)	(6)
Lead Q2 2013					0.0052	-0.0017
					(0.0536)	(0.0519)
Lead Q3 2013					-0.0199	-0.0438
					(0.0558)	(0.0521)
Lead Q4 2013					-0.0225	-0.0187
					(0.0520)	(0.0519)
Lead Q1 2014					-0.0049	-0.0061
					(0.0464)	(0.0454)
Lead Q2 2014					-0.0425	-0.0453
					(0.0444)	(0.0427)
Lead Q3 2014					-0.0083	-0.0256
					(0.0465)	(0.0431)
Lead Q4 2014					-0.0199	-0.0249
					(0.0482)	(0.0454)
Effect Q2 2015	-0.0033	0.0048	0.0133	0.0120	-0.0174	-0.0148
	(0.0197)	(0.0197)	(0.0223)	(0.0214)	(0.0443)	(0.0416)
Effect Q3 2015	0.0618**	0.0465**	0.0814***	0.0513**	0.0477	0.0231
	(0.0243)	(0.0208)	(0.0283)	(0.0239)	(0.0466)	(0.0427)
Effect Q4 2015	-0.0414*	-0.0317	-0.0188	-0.0384	-0.0555	-0.0483
	(0.0247)	(0.0388)	(0.0267)	(0.0335)	(0.0469)	(0.0523)
Effect Q1 20165	-0.0430	-0.0478	-0.0174	-0.0579	-0.0571	-0.0650
	(0.0299)	(0.0426)	(0.0295)	(0.0364)	(0.0499)	(0.0546)
Effect Q2 2016	-0.0645*	-0.0576	-0.0358	-0.0628	-0.0785	-0.0743
	(0.0354)	(0.0459)	(0.0332)	(0.0386)	(0.0537)	(0.0582)
Effect Q3 2016	-0.0821***	-0.0713*	-0.0505	-0.0703*	-0.0962*	-0.0885
	(0.0298)	(0.0412)	(0.0354)	(0.0421)	(0.0499)	(0.0541)
Effect Q4 2016	-0.1141***	-0.1294***	-0.0794**	-0.1413***	-0.1282***	-0.1466**
	(0.0256)	(0.0458)	(0.0399)	(0.0463)	(0.0474)	(0.0576)
Control variables	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no
Observations	180	180	180	180	180	180
Adjusted R^2	0.65	0.65	0.94	0.95	0.63	0.63

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

Table 10 displays estimates from the model with quarterly treatment effects and leads for NetCom. The results in columns 2 and 6 correspond to Figures 8 and 9, respectively.

Table 10: NetCom+Tele2 - Timing of Effects

	(1)	(2)	(3)	(4)	(5)	(6)
Lead Q2 2013					-0.0014	-0.0098
					(0.0523)	(0.0516)
Lead Q3 2013					0.0301	0.0090
					(0.0535)	(0.0529)
Lead Q4 2013					0.0140	0.0139
					(0.0514)	(0.0518)
Lead Q1 2014					-0.0300	-0.0346
					(0.0470)	(0.0460)
Lead Q2 2014					-0.0432	-0.0484
					(0.0416)	(0.0399)
Lead Q3 2014					-0.0229	-0.0364
					(0.0455)	(0.0435)
Lead Q4 2014					-0.0079	-0.0137
					(0.0416)	(0.0398)
Effect Q2 2015	0.0088	0.0195	0.0384**	0.0505***	0.0011	0.0037
	(0.0187)	(0.0199)	(0.0166)	(0.0146)	(0.0439)	(0.0414)
Effect Q3 2015	0.0747***	0.0652***	0.1097***	0.0980***	0.0671	0.0492
	(0.0236)	(0.0205)	(0.0229)	(0.0167)	(0.0463)	(0.0429)
Effect Q4 2015	0.0684**	0.0884**	0.1088***	0.1326***	0.0607	0.0730
	(0.0295)	(0.0367)	(0.0258)	(0.0253)	(0.0498)	(0.0513)
Effect Q1 2016	0.0350	0.0446	0.0807***	0.0925***	0.0273	0.0276
	(0.0310)	(0.0324)	(0.0242)	(0.0230)	(0.0507)	(0.0481)
Effect Q2 2016	0.0480	0.0660*	0.0991***	0.1178***	0.0403	0.0502
	(0.0341)	(0.0365)	(0.0241)	(0.0225)	(0.0528)	(0.0521)
Effect Q3 2016	0.0648**	0.0844**	0.1213***	0.1402***	0.0571	0.0688
	(0.0289)	(0.0374)	(0.0258)	(0.0251)	(0.0494)	(0.0515)
Effect Q4 2016	0.0327	0.0360	0.0946***	0.0966***	0.0250	0.0178
	(0.0260)	(0.0322)	(0.0316)	(0.0285)	(0.0476)	(0.0483)
Control variables	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no
Observations	180	180	180	180	180	180
Adjusted R^2	0.65	0.65	0.95	0.95	0.64	0.63

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

Table 11 displays estimates from the model with quarterly treatment effects and leads for NetCom. The results in columns 2 and 6 correspond to the figures 10 and 11, respectively.

Table 11: All brands (aggregated TeliaSonera plus Tele2) - Timing of Effects

	(1)	(2)	(3)	(4)	(5)	(6)
Lead Q2 2013					-0.0050	-0.0130
					(0.0524)	(0.0509)
Lead Q3 2013					0.0214	-0.0019
					(0.0538)	(0.0519)
Lead Q4 2013					0.0023	0.0032
					(0.0508)	(0.0506)
Lead Q1 2014					-0.0221	-0.0263
					(0.0458)	(0.0442)
Lead Q2 2014					-0.0440	-0.0492
					(0.0418)	(0.0397)
Lead Q3 2014					-0.0117	-0.0283
					(0.0452)	(0.0427)
Lead Q4 2014					-0.0242	-0.0309
					(0.0420)	(0.0403)
Effect Q2 2015	-0.0119	-0.0020	0.0176	0.0290**	-0.0223	-0.0202
	(0.0191)	(0.0193)	(0.0165)	(0.0138)	(0.0440)	(0.0414)
Effect Q3 2015	0.0536**	0.0392*	0.0884***	0.0714***	0.0431	0.0211
	(0.0264)	(0.0200)	(0.0249)	(0.0149)	(0.0478)	(0.0430)
Effect Q4 2015	0.0094	0.0264	0.0496**	0.0662***	-0.0011	0.0099
	(0.0254)	(0.0310)	(0.0197)	(0.0186)	(0.0472)	(0.0484)
Effect Q1 2016	-0.0142	-0.0080	0.0314	0.0350*	-0.0247	-0.0269
	(0.0297)	(0.0299)	(0.0212)	(0.0193)	(0.0498)	(0.0476)
Effect Q2 2016	-0.0116	0.0033	0.0394*	0.0519**	-0.0220	-0.0137
	(0.0342)	(0.0353)	(0.0224)	(0.0207)	(0.0528)	(0.0524)
Effect Q3 2016	-0.0002	0.0172	0.0562**	0.0732***	-0.0106	0.0003
	(0.0288)	(0.0357)	(0.0239)	(0.0233)	(0.0493)	(0.0511)
Effect Q4 2016	-0.0243	-0.0248	0.0374	0.0320	-0.0347	-0.0452
	(0.0262)	(0.0306)	(0.0301)	(0.0266)	(0.0477)	(0.0488)
Control variables	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no
Observations	180	180	180	180	180	180
Adjusted R^2	0.65	0.65	0.95	0.96	0.63	0.63

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

A.2 Inference – alternative standard errors

The main concern for inference in most DiD models is potential serial correlation in the error terms for a given group (country, in our case). Serial correlation can lead to underestimation of the standard error and therefore to falsely high rejection rates of the null hypothesis. Bertrand et al. (2004) suggest that a correction of standard errors for clustering at the group level can achieve more reasonable rejection rates. Unfortunately, this solution will work less well in our case due to the small number of groups. Moreover, Brewer et al. (2018) argue that clustered standard errors lead to a power problem when the number of groups is small. That means that we would be less likely to reject the null hypothesis of zero effects even if the true effects are non-zero. They suggest that a feasible GLS estimator in combination with clustered robust standard errors (that account for serial correlation) can remedy the power problem and lead to a (more) correct test size (especially in cases with observations for many periods (large T) as in our panel). Unfortunately, this solution works again less well for a very small number of groups.

There is thus no optimal solution to correct the standard errors, given that our application has very few groups (four groups). As a pragmatic solution, we base inference in the main body of the paper on standard errors that are robust to arbitrary patterns of heteroscedasticity. In this section, we present and discusses further results that explore the issue of inference. This is done by calculating additional standard errors, including i.i.d. standard errors and cluster robust standard errors. We also present feasible GLS estimates in combination with cluster robust standard errors, which Brewer et al. (2018) suggest as a possible solution to the power and size problems. There is some variation in accordance with the issues to be expected from the different types of standard errors when there are few groups. Nevertheless, overall, the results of this exercise confirm our main findings.

Panel A of Table 12 repeats our main results (see Table 3) and reports various standard errors. Standard errors in brackets are i.i.d. standard errors. Standard errors in parentheses are our preferred robust standard errors, which correspond to those presented above. Stars indicating signficance are attached to the standard errors instead of the point estimates. We see that i.i.d. and robust standard errors lead to almost identical results when it comes to the signifcance of effects.

In braces, we present the cluster-robust standard errors suggested by Bertrand et al. (2004). These standard erorrs are larger, and if tests are based on clustered standard errors, none of the the estimated coefficients are significant. As Brewer et al. (2018) point out, cluster robust-standard errors lead to a power problem when there are few groups. We therefore cannot rely on these standard errors. To further explore the issue, we follow Brewer et al. (2018) and combine robust standard errors with feasible GLS. This is still not optimal with so few groups as four but should alleviate the power problem somewhat. The results are presented in panel B. Obviously, using GLS also affects the point estimates. This leads to somewhat different results for some specifications for Chess and all brands. The main effects for OneCall and NetCom+Tele2 are, however,

Table 12: Alternative standard errors and Feasible GLS estimation for main results

	OneCall		Chess		NetCom+Tele2		All brands	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A - OLS								
1st-year Effect	-0.0735	-0.0703	0.0015	0.0046	0.0462	0.0507	0.0121	0.0154
i.i.d. SE	[0.0270]***	[0.0277]**	[0.0263]	[0.0274]	[0.0259]*	[0.0276]*	[0.0258]	[0.0265]
Robust SE	(0.0234)***	(0.0229)***	(0.0183)	(0.0203)	(0.0166)**	(0.0171)***	(0.0163)	(0.0150)
Cluster robust SE	{0.0686}	{0.0931}	{0.0686}	{0.0958}	{0.0686}	{0.0530}	{0.0686}	{0.0614}
2nd-year Effect	-0.1314	-0.1198	-0.0763	-0.0689	0.0486	0.0592	-0.0095	-0.0003
i.i.d. SE	[0.0270]***	[0.0282]***	[0.0263]***	[0.0303]**	[0.0259]*	[0.0287]**	[0.0258]	[0.0266]
Robust SE	(0.0193)***	(0.0249)***	(0.0192)***	(0.0320)**	(0.0177)***	(0.0197)***	(0.0174)	(0.0174)
Cluster robust SE	{0.0893}	{0.1181}	{0.0893}	{0.1486}	{0.0893}	{0.0776}	{0.0893}	{0.0817}
Panel B - Feasible GLS:								
1st-year Effect	-0.1349	-0.1046	0.0026	0.0751	0.0937	0.0985	0.0432	0.0495
Cluster robust SE	{0.0402}**	{0.0168}***	{0.0349}	{0.0271}*	{0.0227}**	{0.0263}**	{0.0260}	{0.0195}*
2nd-year Effect	-0.1212	-0.1055	-0.0110	0.0512	0.1037	0.1107	0.0485	0.0548
Cluster robust SE	{0.0469}*	{0.0283}**	{0.0419}	{0.0210}*	{0.0305}**	{0.0406}*	{0.0331}	{0.0332}
Control variables	no	yes	no	yes	no	yes	no	yes
Country specific trends	no	no	no	no	no	no	no	no

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

confirmed (although the size of the coefficients may be different). This is in line with Brewer et al. (2018) finding that this combination can alleviate the power problem. Nevertheless, we are not fully convinced of these results because GLS is basesd on a stronger assumption (compared to OLS) and it is not clear that GLS with clustered standard errors alleviates the power problem of clustering with only four groups. We therefore prefer OLS with robust (but not cluster-robust) standard errors.

In Table 13, we repeat the analysis for the additional results for OneCall (see Table 4). This confirms our discussion of different standard errors and overall confirms our main finding of a negative price effect of the merger on prices for OneCall.

In Table 14, we repeat the analysis for the additional results for Chess (see Table 5). This confirms our discussion of different standard errors. The GLS results are somewhat more different from the OLS results than for most other brands, which underlines that the results for Chess are somewhat mixed.

In Table 15, we repeat the analysis for the additional results for NetCom+Tele2 (see Table 6). This confirms our discussion of different standard errors and overall confirms our main finding of a positive price effect of the merger on NetCom+Tele2 .

Finally, Table 16 repeats the analysis for the additional results for all brands (see Table 7). This confirms our discussion of different standard errors and overall confirms our main finding of no robust evidence for price effects in either direction. Thus the merger likely had no significant impact on overall prices.

Table 13: Alternative standard errors and Feasible GLS estimation for OneCall

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<u>OLS:</u> 1st-year Effect	-0.0735	-0.0703	-0.0401	-0.0340	-0.1019	-0.0926	-0.0707	-0.0565
i.i.d. SE	[0.0270]***	[0.0277]**	[0.0221]*	[0.0195]*	[0.0286]***	[0.0303]***	[0.0200]***	[0.0192]***
Robust SE	(0.0234)***	(0.0229)***	(0.0303)	(0.0250)	(0.0182)***	(0.0228)***	(0.0255)***	(0.0245)**
Cluster robust SE	{0.0686}	{0.0931}	{0.0129}*	{0.0082}**	{0.0705}	{0.0937}	{0.0166}**	{0.0126}**
2nd-year Effect	-0.1314	-0.1198	-0.0787	-0.0629	-0.1314	-0.1232	-0.0824	-0.0692
i.i.d. SE	[0.0270]***	[0.0282]***	[0.0310]**	[0.0271]**	[0.0266]***	[0.0284]***	[0.0272]***	[0.0257]***
Robust SE	(0.0193)***	(0.0249)***	(0.0345)**	(0.0314)**	(0.0194)***	(0.0246)***	(0.0340)**	(0.0314)**
Cluster robust SE	{0.0893}	{0.1181}	{0.0318}*	{0.0166}**	{0.0893}	{0.1160}	{0.0322}*	{0.0219}*
<u>Feasible GLS:</u>								
1st-year Effect	-0.1349	-0.1046	-0.0245	-0.0313	-0.1424	-0.1188	-0.0754	-0.0639
Cluster robust SE	{0.0402}**	{0.0168}***	{0.0132}	{0.0129}*	{0.0241}***	{0.0181}***	{0.0154}**	{0.0174}**
2nd-year Effect	-0.1212	-0.1055	-0.0333	-0.0439	-0.1290	-0.1125	-0.0536	-0.0501
Cluster robust SE	{0.0469}*	{0.0283}**	{0.0158}	{0.0192}	{0.0309}**	{0.0273}**	{0.0146}**	{0.0218}
Control variables	no	yes	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no	yes	yes

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

Table 14: Alternative standard errors and Feasible GLS estimation for Chess

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<u>OLS:</u> 1st-year Effect	0.0015	0.0046	0.0417	0.0460	-0.0142	-0.0083	0.0248	0.0310
i.i.d. SE	[0.0263]	[0.0274]	[0.0193]**	[0.0192]**	[0.0284]	[0.0306]	[0.0189]	[0.0202]
Robust SE	(0.0183)	(0.0203)	(0.0221)*	(0.0186)**	(0.0173)	(0.0233)	(0.0202)	(0.0198)
Cluster robust SE	{0.0686}	{0.0958}	{0.0129}**	{0.0172}*	{0.0705}	{0.1034}	{0.0166}	{0.0207}
2nd-year Effect	-0.0763	-0.0689	-0.0128	-0.0065	-0.0763	-0.0724	-0.0151	-0.0163
i.i.d. SE	[0.0263]***	[0.0303]**	[0.0271]	[0.0282]	[0.0264]***	[0.0309]**	[0.0257]	[0.0282]
Robust SE	(0.0192)***	(0.0320)**	(0.0282)	(0.0277)	(0.0193)***	(0.0319)**	(0.0278)	(0.0277)
Cluster robust SE	{0.0893}	{0.1486}	{0.0318}	{0.0244}	{0.0893}	{0.1486}	{0.0322}	{0.0257}
<u>Feasible GLS:</u>								
1st-year Effect	0.0026	0.0751	0.0612	0.0763	-0.0154	0.0681	0.0388	0.0637
Cluster robust SE	{0.0349}	{0.0271}**	{0.0129}**	{0.0119}***	{0.0379}	{0.0271}*	{0.0167}	{0.0136}**
2nd-year Effect	-0.0110	0.0512	0.0252	0.0458	-0.0219	0.0479	0.0171	0.0404
Cluster robust SE	{0.0419}	{0.0210}*	{0.0164}	{0.0121}**	{0.0434}	{0.0226}	{0.0184}	{0.0125}**
Control variables	no	yes	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no	yes	yes

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

Table 15: Alternative standard errors and Feasible GLS estimation for NetCom+Tele2

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OLS: 1st-year Effect	0.0462	0.0507	0.0712	0.0746	0.0381	0.0444	0.0624	0.0694
i.i.d. SE	[0.0259]*	[0.0276]*	[0.0180]***	[0.0170]***	[0.0281]	[0.0308]	[0.0181]***	[0.0175]***
Robust SE	(0.0166)**	(0.0171)***	(0.0173)***	(0.0149)***	(0.0175)**	(0.0200)**	(0.0168)***	(0.0162)***
Cluster robust SE	{0.0686}	{0.0530}	{0.0129}**	{0.0170}**	{0.0705}	{0.0555}	{0.0166}**	{0.0211}**
2nd-year Effect	0.0486	0.0592	0.0881	0.0967	0.0486	0.0569	0.0867	0.0943
i.i.d. SE	[0.0259]*	[0.0287]**	[0.0252]***	[0.0236]***	[0.0262]*	[0.0293]*	[0.0246]***	[0.0234]***
Robust SE	(0.0177)***	(0.0197)***	(0.0196)***	(0.0181)***	(0.0178)***	(0.0197)***	(0.0194)***	(0.0179)***
Cluster robust SE	{0.0893}	{0.0776}	{0.0318}*	{0.0179}**	{0.0893}	{0.0793}	{0.0322}*	{0.0203}**
Feasible GLS:								
1st-year Effect	0.0937	0.0985	0.0905	0.0859	0.0810	0.0836	0.0735	0.0717
Cluster robust SE	{0.0227}**	{0.0263}**	{0.0118}***	{0.0148}**	{0.0265}*	{0.0293}*	{0.0156}**	{0.0198}**
2nd-year Effect	0.1037	0.1107	0.1056	0.1020	0.0956	0.1010	0.0981	0.0979
Cluster robust SE	{0.0305}**	{0.0406}*	{0.0123}***	{0.0175}**	{0.0328}*	{0.0408}*	{0.0149}***	{0.0200}**
Control variables	no	yes	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no	yes	yes

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.

Table 16: Alternative standard errors and Feasible GLS estimation for All brands (aggregated TeliaSonera plus Tele2)

	Main sample				Excluding Summer 2015			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OLS: 1st-year Effect	0.0121	0.0154	0.0454	0.0471	-0.0013	0.0048	0.0310	0.0366
i.i.d. SE	[0.0258]	[0.0265]	[0.0175]**	[0.0159]***	[0.0279]	[0.0296]	[0.0170]*	[0.0162]**
Robust SE	(0.0163)	(0.0150)	(0.0170)***	(0.0129)***	(0.0153)	(0.0171)	(0.0142)**	(0.0128)***
Cluster robust SE	{0.0686}	{0.0614}	{0.0129}**	{0.0155}*	{0.0705}	{0.0637}	{0.0166}	{0.0197}
2nd-year Effect	-0.0095	-0.0003	0.0431	0.0493	-0.0095	-0.0032	0.0411	0.0452
i.i.d. SE	[0.0258]	[0.0266]	[0.0245]*	[0.0222]**	[0.0260]	[0.0271]	[0.0232]*	[0.0217]**
Robust SE	(0.0174)	(0.0174)	(0.0188)**	(0.0166)***	(0.0176)	(0.0172)	(0.0184)**	(0.0164)***
Cluster robust SE	{0.0893}	{0.0817}	{0.0318}	{0.0152}**	{0.0893}	{0.0821}	{0.0322}	{0.0184}
Feasible GLS:								
1st-year Effect	0.0432	0.0495	0.0652	0.0607	0.0274	0.0371	0.0413	0.0431
Cluster robust SE	{0.0260}	{0.0195}*	{0.0123}**	{0.0132}**	{0.0278}	{0.0238}	{0.0159}*	{0.0172}*
2nd-year Effect	0.0485	0.0548	0.0711	0.0660	0.0383	0.0471	0.0610	0.0608
Cluster robust SE	{0.0331}	{0.0332}	{0.0130}**	{0.0164}**	{0.0337}	{0.0351}	{0.0152}**	{0.0189}**
Control variables	no	yes	no	yes	no	yes	no	yes
Country specific trends	no	no	yes	yes	no	no	yes	yes

Robust standard errors in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for country and month fixed effects.