Alma Mater Studiorum - Università di Bologna

DOTTORATO DI RICERCA IN
ECONOMICS

Ciclo 32

Settore Concorsuale: 13/A1
Settore Scientifico Disciplinare: SECS-P/01

Evaluating non-price effects of regulatory and competition enforcement interventions

Presentata da
Alessia Marrazzo

Coordinatore del Dottorato
Prof.ssa Maria Bigoni

Supervisore
Prof. Vincenzo Denicolò

Esame finale anno 2020

Abstract

This thesis provides an ex-post evaluation of the effects of regulatory and competition policy enforcement interventions on non-price dimensions of competition. Chapter 1 examines the effects of a merger between two large Dutch supermarket chains on the variety and composition of product assortment. Chapter 2 and Chapter 3 investigate, both theoretically and empirically, the effects of access regulation in fixed telecoms markets on incentives to invest in superior infrastructure technologies. Non-price effects, together with price effects, are crucial to shed light on the extent of competition in a market and assess the effectiveness of regulatory and competition authorities' interventions. When evaluating non-price effects, however, it is harder to draw conclusions on the overall impact on consumers' welfare.

Acknowledgements

I would like to thank my supervisor, Vincenzo Denicolo, for his insightful comments and encouragement during the drafting of this thesis. I would also like to express my sincere gratitude to Elena Argentesi for her continuous support and her patience: Elena encouraged me to start this journey, and her guidance has helped me throughout the entire PhD, from the exams to the writing of this thesis.

I also want to thank my colleagues at Lear, who advised me on my thesis with enthusiasm, and always had my back when conciliating study and work was hard.

A very special and heartfelt thank you goes to my husband: he patiently stood by my side every minute of this PhD, he encouraged me every time I needed, and he pushed me farther than I thought I could go.

Last but not the least, I would like to thank my family, whose support has been fundamental.

Contents

Introduction

Regulatory and competition policy enforcement interventions aim at promoting the better-functioning of markets, ensuring the entry of efficient firms, protecting and fostering firm's incentives to innovate. Competition policy is often described as the "set of policies and laws which ensure that competition in the marketplace is not restricted in such a way as to reduce economic welfare".[1] Firms may indeed restrict competition in a way that is not necessarily detrimental (for instance, there is a hot and ongoing debate on mergers and their effects on innovation). Regulation, instead, generally applies to upstream markets where fixed costs are so high that it would be not efficient for more than one firm to operate. Regulatory authorities ensure efficient entry and a fair level of competition in the markets downstream. While regulation may stimulate competition in the short-term, it may reduce the incentives to invest in the long term.

Over the past decade competition authorities and academic researchers have become increasingly interested in conducting ex-post economic evaluations of competition policy enforcement. Most of the existing work has focused on the price effects of individual merger and cartel decisions. Quite limited are instead the attempts to evaluate ex-post the efficacy of regulatory frameworks.

This thesis provides an evaluation of the non-price effects of a merger decision and assesses, both theoretically and empirically, the impact of the EU regulatory telecommunications framework on investment.

Chapter 1 studies the effects of a national merger between two large Dutch supermarket chains on prices and on the depth as well as composition of product assortment.[2] The empirical strategy exploits the geographic variation in the intensity of local competition and market structure to causally identify the effect of the merger. This local variation is particularly appropriate for analyzing non-price strategies such as assortment decisions, since product assortment in grocery markets is typically chosen at the local level to respond to local demand conditions and store characteristics. The estimate of the effect of the merger is based on a Difference-in-Differences (DiD) method and relies on the com-

[1] Competition policy: theory and practice. M. Motta. Cambrige University Press.

[2] This chapter has been coauthored with Elena Argentesi, Paolo Buccirossi, Tomaso Duso, Roberto Cervone.

parison between areas where both merging parties were active before the merger and areas where only one of them was active. The intuition behind this identification strategy is that the anti-competitive effects of the merger (if any) are likely to be stronger in the former areas than in the latter ones, as only in overlap areas the intensity of competition has changed. Results show that the local change in competitive conditions due to the merger did not affect individual products' prices but it led the merging parties to reposition their assortment. While the low-variety and low-price target's stores reduced the depth of their assortment when in direct competition with the acquirer's stores, the latter increased their product variety. By analyzing the effect of the merger on category prices, the analysis also finds that the target most likely dropped high-priced products, while the acquirer added more of them. Thus, the merging firms reposition their product offerings in order to avoid cannibalization and lessen local competition.

Chapter 2 and Chapter 3 provide a theoretical and empirical model aimed at investigating the impact of access regulation on investment in telecoms infrastructure. Telecoms markets are characterized by high barriers of entry and high sunk cost. Following the liberalization of telecoms markets, European regulatory agencies have intervened to ensure a fair level of competition. The EU regulatory framework indeed imposes operators with significant market power to provide access to their legacy copper infrastructure at fair, transparent and non discriminatory prices. Both chapters are based on the outcomes observed in the Slovak fixed telecom market, where the incumbent has infringed its regulatory obligations by refusing to properly provide access to the legacy copper network and setting excessively high wholesale access price. Having no access to the incumbent's copper network, alternative operators started investing in a superior technology, the fiber. The Slovak incumbent has subsequently been fined by the European Commission for having abused its dominant position and infringed Art. 102 of the Treaty of the Functioning of the European Union.

Chapter 2 presents a theoretical model aimed at explaining the mechanisms that makes the Slovak outcome possible. I have developed a two-stage model which unfolds as follows: in the first stage the incumbent decides the access price; in the second stage, both the entrant and the incumbent decide whether investing in a fiber network. If the entrant does not invest in fiber, it will purchase access to the incumbent's network. When making its decisions, the incumbent does not know the entrant's costs to deploy the fiber infrastructure. Results show that, for intermediate values of investments costs, the incumbent will set an access price higher than the fair price would have been set by the regulator, and the entrant invests alone in the fiber network. The paper also shows that, when the entrant's investment generates some positive spillovers or reduces the incumbent's uncertainity on its own investment's costs, the incumbent reacts to the entrant's investment by investing

itself.
Chapter 3 empirically assesses the effects of the abuse of dominance in the Slovak fixed telecoms market on the investment in fiber made by alternative operators. By exploiting the anticompetitive conduct engaged by the Slovak incumbent, this chapter empirically evaluates the impact of access regulation on investment in fiber. To reach an identification of the effects of the abuse, I adopt a DiD approach and compare the variation in fiber investment made by alternative operators (AOs) in Slovakia, before and after the abuse, to the variation in fiber investment made by AOs in the Central Eastern European (CEE) countries. CEE countries shows indeed favourable conditions to early investment in fiber, as much as in Slovakia. The empirical analysis aim indeed at isolating the effect of the abuse from any other confounding factors (e.g. less developed copper network and more urgent need of superior networks) which may explain the investment effort made by alternative operators in Slovakia. Results show that, by banning access to its copper network, the Slovak incumbent has triggered alternative operators to invest in fiber connections. Further, the analysis shows that, due to the abuse, Slovakia has attained a higher level of fiber investment. This effect is likely to be driven by the investment made by alternative operators: there is no evidence, indeed, that the incumbent has invested in fiber more than would have done in the counterfactual.

Non-price dimensions are crucial for shedding light on the extent of competition in the market and evaluate the effects of a competition policy decision. The analysis of the merger between two large Dutch supermarket chains (Chapter 1) showed that when shaken by a change in market structure, local managers may not change prices but adapt their product assortment. It is empirically documented that retail chains often choose nearly-uniform pricing despite the profit loss that this strategy might entail ([DellaVigna and Gentzkow, 2017]). Since changing prices might be too costly, local managers may indeed react by increasing differentiation, so that local supermarkets can avoid cannibalization, soften competition and consequently increase their profits even without changing products' prices.
Dynamic effects on investment, rather than short-term effects on prices, should be carefully taken into account when evaluating the efficacy of regulation. The analysis of the investment strategies pursued by alternative operators in the Slovak market (Chapter 2 and 3) shows that, by infringing its regulatory obligations and banning access to its copper network, the incumbent has triggered alternative operators' incentive to invest in a superior technology (the fiber).
Yet, conclusions on consumers welfare are far from obvious. The welfare effects of strategic assortment repositioning in grocery retail markets are difficult to measure: while an

increase in price has an obvious negative impact for all consumers, a modification of other characteristics that consumers value differently might benefit some of them and harm others. The investment effort made by alternative operators in the Slovak fixed telecom market has been limited to urban areas where costs were expected to be lower. The lack of access regulation may strengthen the position of the incumbent in rural and intermediate areas, and ultimately harm consumers in those areas.

Chapter 1

Price or Variety? An Evaluation of Mergers Effects in Grocery Retailing

Acknowledgements

This chapter has been co-authored with Elena Argentesi (University of Bologna), Paolo Buccirossi (Lear), Roberto Cervone (Financial Conduct Authority), Tomaso Duso (Deutsches Institut für Wirtschaftsforschung (DIW Berlin)). This chapter is partially based on a research project we undertook for the Dutch Competition Authority (ACM). We thank the ACM staff for their support throughout the course of that study, in particular Ron Kemp and Martijn Wolthoff. We also thank Luca Aguzzoni for his extremely valuable support during the early stages of the project, Lorenzo Migliaccio for his excellent research assistance, as well as Itai Ater, Pio Baake, Jan Bouckaert, Claudio Calcagno, Giacomo Calzolari, Federico Ciliberto, Alon Eizenberg, Luke Froeb, Alessandro Gavazza, Alessandro Iaria, Adam Lederer, Szabolcs Lorincz, Anna Lu, Franco Mariuzzo, Mattia Nardotto, Carlo Reggiani, Thomas Ross, Daniel Sokol, Hannes Ullrich, Christine Zulehner, as well as audiences at various conferences and seminars for helpful comments and suggestions.

1.1 Introduction

Analyzing how supermarket chains adjust prices and non-price variables in response to local market conditions is important for the understanding of how competition works in retail markets. Most existing papers study this issue by analyzing price variations across different local areas with a cross-sectional approach (e.g. [DellaVigna and Gentzkow, 2019, Hitsch et al., 2019]). We instead consider variations along different strategic dimensions in response to a major change in the local market structure. Specifically, we assess the relative importance of price and non-price strategies in response to an exogenous shock, namely a national merger that differently affects various local markets. Unlike most of the previous literature, we not only focus on prices but also consider the effect on non-price variables, such as variety of assortment. Indeed, it is documented that assortment choices and product positioning play a key role for competition in grocery retail [Draganska et al., 2009], where non-price attributes are important determinants of customer choice and satisfaction [Matsa, 2011] and that retailers tailor assortments in response to differences in local demand [Quan and Williams, 2018].

We study the merger between two large Dutch supermarket chains – Jumbo and C1000 – that was conditionally approved by the Dutch competition authority – Autoriteit Consument & Markt (ACM) – in 2012. We use a particularly rich database that entails quarterly information on average prices as well as variety for all the 125 product categories sold in a sample of 171 stores of the merging parties and their main competitors located in different areas scattered across the Netherlands for the 2010-2013 period. These categories cover the entire space of grocery products offered in the country during the sample period. As commonly done in the literature on retail markets, we define variety as the depth of assortment, i.e. the number of stock keeping units (SKUs) sold in each product category [Ren et al., 2011]. We enrich this category-level dataset with more fine-grained monthly information on a sample of 33 specific products that were sold throughout the whole sample period and chosen to represent a typical basket for Dutch households.

The Jumbo/C1000 merger is well suited to study firms' reaction to changes in local market conditions, as it is likely to unequally affect different local areas. Our empirical strategy exploits the geographic variation in the intensity of local competition and market structure to causally identify the effect of the merger. We estimate the effect of the merger by means of a Difference-in-Differences (DiD) strategy that relies on the comparison between areas where both merging parties were active before the merger (overlap areas) and areas where only one of them was active (non-overlap areas). The intuition behind our identification strategy is that the competitive effects of the merger, if any, are likely to be stronger in the former areas than in the latter ones, as, other things equal, only in overlap areas did the intensity of competition change. By matching overlap and non-overlap areas with a procedure that is based on observable characteristics, we account for differences in demand and supply conditions across treated and non-treated areas. This identification strategy based on local variation is particularly appropriate for analyzing non-price dimensions of competitions such as assortment decisions, which are often made at the local level [Quan and Williams, 2018].[1] The advantage of focusing on a relatively small and homogeneous market such as the Dutch retail market is that we have very granular data on the location of stores and on the characteristics of local areas. This allows us to cleanly identify the effect of the merger, and therefore of a change in the competitive conditions, on pricing and assortment decisions.

We find that the merger did not have any significant effects on prices of individual products. However, the merger led to a reduction in product variety and to an increase in average category prices, which would suggest a move toward a smaller and more expensive assortment. Yet, these average effects are the result of two opposing forces. On the one hand, the acquirer (Jumbo), the high-variety chain, raised its assortment as well as its average category prices, with respect to what happens in couterfactual stores. This suggests that Jumbo added high-priced products to its assortment line. On the other hand, C1000 (the target) decreased both its assortment and its average category prices, which implies a move toward a smaller and cheaper assortment. Thus, looking behind average effects allows understanding the logic of the local managers' decisions. The repositioning of the assortment's depth and composition of the two merging chains in a way that reduces the similarity between them responds to an incentive to internalize the effects on the other chain and soften competition between the merging parties.

Overall, these findings show that the local managers' reaction to a change in local conditions, such as a merger between two retail chains, may lead to an adjustment in terms on assortment rather than on prices. Managers may find it more costly to change prices instead of assortment, given that they have more discretionality on the latter policy.

We build a simple theoretical model where variety can be both a vertical and horizontal attribute of a store and show that, after a merger between two close competitors like the one that we consider, the new entity optimally reduces assortment in the low-variety store because this entails an increase in the other store's demand. This is consistent with previous theoretical and empirical findings. For instance, [Gandhi et al., 2008] show in a theoretical setting that merging parties move away from each other in the product space to avoid cannibalization. [Rhodes and Zhou, 2019] find that an asymmetric market structure might arise where some retailers decide to remain small (in terms of product range) to soften competition. As in our case, the flexibility in product offerings is therefore a tool

[1] Since the evidence on local variation on prices is not conclusive, we also use an alternative identification strategy based on the comparison between the merging parties and competitors (see section 5.2.1).

that managers have to target different types of consumers thereby avoiding fierce competition. Similarly, in an empirical study [Sweeting, 2010] finds that firms buying competing radio stations tend to differentiate them, thereby avoiding audience cannibalization.

We assess the effects of the merger on prices and variety not only for the merging parties but also for their main competitors. Methodologically, this is important as the study of rivals' reactions to a merger might help to identify its competitive effect (see for instance [Ashenfelter et al., 2013b] and [Aguzzoni et al., 2016b]). Moreover, from a policy perspective, the joint assessment of the merger's price and variety effects for both the merging parties and competitors allows us to draw richer conclusions on the merger's implications in terms of consumer surplus, as we can better approximate its effect at the market level. We find that the response of individual prices to the merger is not different between the merging parties and their competitors. This indicates that the merger did not have a national effect on prices that could derive from either increased market power or from efficiency gains. Furthermore, we observe a limited response by competitors in terms of assortment (slight increase) and no response in terms of average category prices. This implies that rivals' reaction is unlikely to compensate for the changes in the merging parties' strategies at the local level.

Our study is not only important to shed new light on retailers' price and non-price reactions to local market conditions, but it also helps us to better evaluate the effects of mergers in such a crucial sector that accounts for about 20% of global GDP [Bronnenberg and Ellickson, 2015]. While the growing literature on retrospective merger evaluation substantially helped to improve the understanding of the effect of realized mergers, most of these studies focus solely on price effects [Hosken and Tenn, 2016]. Thus, our paper also contributes to this discussion by complementing more traditional approaches and providing new evidence of the effect of mergers not only on prices but also on non-price attributes such as variety and assortment decisions. This seems to be particularly timely and important since, surprisingly, the competitive effect of mergers on variety in grocery retailing is still largely unexplored, despite remaining one of controversial and unresolved issues in merger control [OECD, 2013, p. 9].[2] In particular, mergers' effects on variety are ambiguous, as they may "lead firms to spread similar products apart, to withdraw duplicative products, or to crowd products together to preempt entry" [Berry and Waldfogel, 2001, p. 1009].

This chapter is structured as follows. In Section 1.2, we summarize the relevant

[2]The 2010 revision of the US Horizontal Merger Guidelines emphasize the importance of non-price dimensions of competition stating that "enhanced market power can also be manifested in non-price terms and conditions that adversely affect customers, including reduced product quality, reduced product variety, reduced service, or diminished innovation. Such non-price effects may coexist with price effects, or can arise in their absence" (Horizontal Merger Guidelines, U.S. Department of Justice and the Federal Trade Commission, 2010, p. 2).

literature. In Section 1.3, we provide some background information on the Dutch grocery market and on the merger under consideration. Section 1.4 describes the data. We present our econometric model in Section 1.5. Section 1.6 presents the empirical results and a simple theoretical model of competition in variety. Section 1.7 presents robustness check and Section 1.8 concludes.

1.2 Related Literature

Our paper relates to several strands of literature. First, it speaks to the literature discussing pricing strategies in retailing. In general, retail chains may have national or local pricing strategies. [Ater and Rigbi, 2017] and [Eizenberg et al., 2018] show significant local price dispersion in grocery prices in Israel, and [Rickert et al., 2018] document local pricing in Germany. Other papers document instead a uniform pricing strategy, i.e. the fact that in many retailing markets, firms held prices fixed across multiple goods sold in a single market [Orbach and Einav, 2007, Cho and Rust, 2010, Shiller and Waldfogel, 2011] but also across separate markets [DellaVigna and Gentzkow, 2019,Hitsch et al., 2019]. [Dobson and Waterson, 2005] analyze in a theoretical setting the relative profitability of uniform and local pricing if compared to a national pricing strategy. Compared to this literature we add evidence that firms do use alternative strategies other then prices when facing local shocks.[3]

Second, our paper contributes to the literature studying the link between market concentration and product variety. In particular, both [Gandhi et al., 2008] and [Mazzeo et al., 2014] theoretically study the issue of product repositioning after mergers and highlight the importance of considering effects on variety together with price effects. [Lommerud and Sørgard, 1997] show that merged firms might have a strategic incentive to narrow product ranges and that this is generally welfare detrimental. More recently, [Rhodes and Zhou, 2019] show that the impact of mergers on the structure of retail markets may depend on consumer search frictions, and in particular that firms with narrow product ranges can coexist with firms with larger offerings when search costs are low. The empirical evidence on this issue is also mixed. [Bauner and Wang, 2019] explore the effect of competition, and in particular of wholesale warehouse entry, on pricing and product positioning. They

[3]In contrast to our study, [DellaVigna and Gentzkow, 2019] show that, in the US, there is limited within-chain variation not only in prices but also in product assortment as well. Similarly to what we do in one of our analyses, they define an assortment index based on the average national-level prices of the products sold by a local store. They find that this index varies more across than within chains. While cloking at such indexes is useful to understand the depth of assortment, it does not allow studying the breadth of assortment across categories as we do. Moreover, the analysis of [DellaVigna and Gentzkow, 2019] does not exploit any source of exogenous variation at the local level to identify the extent of the local store reactions in the different strategic competitive dimensions.

find that the incumbents adopt a strategy of differentiation from the entrant firm. Most existing studies focus on very different industries from grocery retail and do not focus on the effect of a specific merger but rather consider several mergers or changes in concentration due to other factors such as entry or exit. A number of papers analyze the effects of the merger wave that took place in the US radio industry at the end of the 1990s. [Berry and Waldfogel, 2001] find that these mergers increase variety and [Jeziorski, 2014] quantifies the effect of this increased variety on both sides of the market (listeners and advertisers). [Sweeting, 2010] finds that these mergers do not affect aggregate variety, because changes affecting the merging parties and competitors offset. The evidence on other markets is mixed. [George, 2007] finds that content variety increases with ownership concentration in the US daily newspaper market on prices and product characteristics. Based on the estimation of a structural demand model, [Fan, 2013] simulates the effect of a hypothetical merger between two local newspapers in the United States. She finds that, following the merger, newspaper publishers have an incentive to reposition their product and decrease their variety. This leads to welfare losses for readers. She also shows that the effects of mergers would be underestimated if one ignored the adjustments of product characteristics. Similarly, [Chu, 2010] builds a structural model to analyze the cable TVs' response to satellite entry in terms of prices and quality (measures as number of channels), showing through a counterfactual scenario that eliminating quality competition implies softer price competition and reduced consumer welfare. [Götz and Gugler, 2006] find evidence of a reduction of variety after mergers in retail gasoline markets. [Watson, 2009] finds mixed evidence on the effect of geographic differentiation on competition and variety in retail eyeglasses. Finally in an extension of their main price analysis, [Ashenfelter et al., 2013b] analyze the effects of a merger between home appliance manufacturers on the length of their product line. They find a substantial reduction in variety by the merging parties.

Third, our paper is related to the growing literature on *ex-post* merger evaluation and, in particular, to the relatively small number of papers analyzing the effect of mergers in retailing sectors.[4] [Hosken et al., 2018] highlight the importance of looking at local competition in retail markets, as they find that price effects of mergers in the U.S. grocery retailing industry significantly depend on the degree of local concentration. [Barros et al., 2006] estimate the effect of additional concentration on prices in the Portuguese food retailing market, and find that prices generally increased. Similarly, [Allain et al., 2017] find that grocery mergers in France significantly raised prices, especially in local markets experiencing larger increases in concentration. [Rickert et al., 2018] find a similar result on the effect of a merger between German supermarkets. On the contrary, [Chakraborty

[4] See [Hosken and Tenn, 2016] for a survey of retail mergers.

et al., 2014] show that the 2004 Safeway/Morrison merger in the U.K. lowered prices and led to a change in the form of price competition. [Hanner et al., 2015] assess the effect of retail mergers on entry in the U.S. and show that the relative position of brands changes over time but these changes are rarely determined by entry or exit of new, large, firms. In a field experiment on the retail sector in the Dominican Republic, [Busso and Galiani, 2019] show that increased competition leads to a decrease in prices and to an increase in perceived service quality.

Despite the potentially relevant welfare implications of non-price effects of retail mergers, we are only aware of one paper analyzing mergers' variety effects within this literature on mergers retrospectives. [Pires and Trindade, 2018] study a series of 14 different supermarket merger events, which affected 61 US cities. They show that these mergers did not have any effect on prices but increased variety on average by 3%. Their analysis differs from ours in several dimension. As for the econometric approach, they do not account from selection on observables when constructing the control group. Secondly, their estimates mix the effect of several mergers that are potentially different one from the other. Therefore the average treatment effect that they measure must be taken cautiously. Moreover, their data only include five categories of beverage products, while we have information on the whole range of product categories (125) that are sold in Dutch supermarkets. Differently from [Pires and Trindade, 2018], we also have information on average category prices, which allows us to draw implications on the composition of assortment. More fundamentally, we can cleanly identify the different reactions of the two merging parties in terms of product repositioning. Understanding that this is the driver of the average effect of the merger on variety is the main novel contribution we offer in this paper.

Finally, we also relate to the literature that analyzes variety and, more generally, non-price attributes in retail markets. [Bronnenberg, 2015] builds a general equilibrium model that explains the optimal provision of variety in the market. [Brynjolfsson et al., 2003] estimate the effect of increased variety offered by online bookstores on consumer welfare and show that increased variety generates gains to comsumer that are 7 to 10 times larger than the gains coming from price effect. [Quan and Williams, 2018] quantify the value of increased variety due to online retail taking into account the role of local tastes and retailer responses, and show that the positive welfare effect of increased variety are much lower than previously estimated. [Hwang et al., 2010] explain the drivers of local variation in assortment choices by US supermarket chains. [Ren et al., 2011] analyze instead the role of product variety as a tool of differentiation in consumer electronic retailing. Finally, [Richards and Hamilton, 2006] studies price and variety competition among grocery retailers in the U.S. These contributions highlight the importance of variety as a strategic variable in retail markets, although they do not focus on the impact of mergers as we do.

1.3 The Dutch Grocery Sector and the Merger

Between 2009 and 2012, several mergers took place in the Dutch grocery sector. The Dutch competition authority (ACM) cleared all of them, mostly subject to remedies. In this paper we focus on the last of these mergers, Jumbo's acquisition of C1000.[5] In the following subsections, we first describe the functioning of the market as well as the issues related with this merger.

1.3.1 The Dutch Grocery Market

The main market players at the time of the mergers included the merging parties – Jumbo and C1000 – and several other supermarket chains. Jumbo is a full-service supermarket formula operating across the country. It had a regionally strong position in the southern regions of the Netherlands, which had already expanded thanks to the previous acquisition of Super de Boer (SdB) and Schuitema. The most important characteristic of the Jumbo core marketing proposition is the "every day low price" guarantee. Jumbo stores used to run few promotions. C1000 was also a full-service supermarket formula, which operated across the country. Its core strategy was on deep, short-lived, promotions. Its assortment was reportedly smaller than the other major national players.

Among competitors with a national footprint, Albert Heijn (AH) is the largest full-service supermarket chain and is perceived as the market leader. It operates across the country adopting various store formats. Its commercial offering is similar to Jumbo's offering, especially in terms of product variety. Moreover, it is the only other major chain of supermarkets operating across the whole of Dutch territory. Two large hard discounters have an important presence in the Dutch market: Aldi and Lidl. During the first half of the 2010s, hard discounters progressively increased their assortment and started selling a (limited) list of branded goods. However, significant differences with traditional supermarket formulas still exist. Finally, the market is characterized by a series of other, smaller, regional players, including Coop, Detail Group, Spar (part of an international group with a stronger position in other countries), Hoogvliet, and Jan Linders.

[5] We only focus on the last merger because it was the most relevant one concluding the acquisition process that started in 2009 and because the data on product assortment are only available for a limited period. In order to isolate the effect of the Jumbo/C1000 merger from previous mergers, we selected areas in which no other merger had occurred.

[insert Figure 1.1 here]

Figure 1.1 represents the time evolution of the market shares of all supermarket chains and discounters (at the national level) both in terms of net sales floor area (left panel) and in terms of the number of stores (right panel). AH is clearly the largest chain. The combination of SdB, C1000, and Jumbo has a net sales area similar to AH. A considerable number of stores belong to chains other than the ones listed. Overall, the total number of supermarkets has essentially remained constant from the beginning of 2009 through the end of 2011.

1.3.2 The Merger between Jumbo and C1000

In our analysis, we study Jumbo's acquisition of over 400 locations (the entire C1000 supermarket chain) that took place in February 2012. C1000 stores initially continued to operate under the C1000 insignia and were expected to be re-branded under Jumbo brand during the years following the merger. At the end of our sample period, the re-branding from C1000 to Jumbo was not yet fully completed. The Jumbo/C1000 merger approval was conditional on the divestiture of eighteen stores. Jumbo complied in July 2012 to this set of remedies by selling the eighteen locations – along with additional stores – to Coop and Ahold (owner of the Albert Heijn chain).

The geographic market definition adopted by the ACM was based on a 15-minute isochrone around the analyzed stores. However, the ACM noted that Dutch consumers are not inclined to shop outside their town. Hence, in practice, the geographic market definition is a mixture between a 15-minutes isochrone and the administrative borders of each municipality.[6] In our analyses, we adopt the definition put forward by the ACM and control for a number of explanatory variables measured at the municipal level to account for local demand and supply drivers as well as levels of competition.[7]

With respect to the product dimension, the relevant markets defined by the ACM include both supermarket chains and hard discounters. In our study, we embrace the product market definition adopted by the ACM. However, we restrict our analysis to a particular format (i.e., regular supermarket), in order to maximize the similarity between the different stores analyzed and make our final sample more homogeneous. Moreover, given the increasing role covered by hard discounters (e.g., Lidl and Aldi) in the Dutch market in recent years, we explicitly control for their presence and strength in each relevant geographic market.

[6]The large majority of our areas (63%) have a radius that is smaller than 15 minutes by car. The mean size of such areas is 60 square kilometres. The other 37% of the areas are small towns, which are only slightly larger, with a mean area of 73 square kilometers.

[7]We drop all large cities from our sample since the geographic market definition is more complex in this case as there are clearly several geographical markets within a city.

1.4 Data and Sample

For our empirical analysis, we collected store-level data for an appropriately selected sample of stores from Information Resources Incorporated (IRI), a firm specialized in collecting and analyzing data on retailing.[8] The period under analysis is January 2009 to December 2013 and the date of the merger is defined by the date of the ACM decision in February 2012.

The composition of the estimation sample is affected by budget limitation and the willingness of the data provider to share only specific information. The supermarkets included in our sample are selected from areas where the merging parties overlap and from comparable areas where they do not overlap.[9] To define comparable areas, we pairwise match cities where the merging parties overlap with non-overlap cities by applying a propensity score matching approach, a technique that allows collapsing a set of different characteristics into a single dimension.

We have very precise location data for our sample of stores [10] Thanks to this fine-grained information on local markets, we assess the level of similarity taking into account a full range of observable factors that could vary across overlap and non-overlap areas, such as demand and supply characteristics (for a similar approach see [Aguzzoni et al., 2016b]). Specifically, we use the average density population, average store size, HHI, number of stores, average income, stores' rental cost, and the presence of hard discounters. Our selection ensures a widespread geographic coverage of the Dutch territory and a balanced representation of all merging parties and of the selected subset of competitors.[11]

Within areas of overlap and areas of non-overlap, we select a suitable number of stores both from the merging parties and from competing chains. Our final selection includes 171 different stores representing the merging parties' chains and two competitors (Albert Heijn and Coop).[12]

For this list of stores, we obtained data both at the product level and at the category level. In particular, we have information on turnover, volumes, and number of products (SKUs) for each of the 125 product categories collected in the IRI database. Moreover,

[8] See http://www.iriworldwide.nl/.

[9] Two further mergers affected the Dutch market in the previous four years (2009-2012). In order to isolate the effect of the merger under analysis, we restrict the choice of the areas and, consequently, of the stores in such a way that the average behavior of the treated and control group could not be biased by the occurrence of the other events. For a further discussion of this issue we refer to [Argentesi et al., 2015].

[10] These data come from the 'Supermarkt gids' database, which lists geographic data (including addresses, postal code, city, province) together with additional information (e.g., availability of parking or automatic counters) for all supermarkets in the Netherlands.

[11] Further details on the propensity score matching procedure used in the analysis are reported in Appendix 1.10.

[12] A description of the criteria for choosing the stores in our sample is in Appendix 1.10.

we have information on turnover and volumes on a selection of specific products within several categories. Hence, we have two separate databases to study the merger's effect on price and variety, which we discuss in the next subsections.

1.4.1 Product-level Data

In order to quantify the effect of the merger on SKU prices, we collected information on a balanced sample of products that were sold throughout the entire sample period. This allows us to use SKU-specific fixed effects that significantly enhance the quality of our specification. Due to several constraints, we could not collect product-level price data on all products sold in each store. Hence, we based our selection of categories and products on best practices from the academic literature and ideas originating from the 2014 inquiry in the food retail sector carried out by the German Cartel Office ([Bundeskartellamt, 2015]). The final list of categories includes coffee, cola, cleaners, diapers, fresh milk, traditional Dutch sausage (frikandel), mayonnaise, olive oil, sanitary napkins, shampoo, and toilet paper.

Our selection of these categories is based on the following criteria: i) the inclusion of both 'food' and 'non-food' items; ii) the inclusion of traditional items for which comparisons across geographic markets are easier; iii) the inclusion of items belonging to the basket of goods typically consumed in the Netherlands; and iv) the inclusion of items whose characteristics set them apart from other items, either because we expect lower price sensitivity or due to higher level of differentiation and innovation (e.g., diapers).

To measure price changes, it is important that the selected products are comparable both over time and across stores. Dutch supermarket assortments usually include at least one A-brand item, such as 'Coca-Cola', one private label, and one first-price (i.e., cheapest) item for each product. We exclude first-price items from our sample, as the data provider indicates that these may differ significantly in quality. Similar problems hold for fresh articles, which we also exclude. For each product defined at SKU level, we have three time series: two SKUs for 'A-brands' and one SKU for private labels. We try to ensure comparability across stores using the same quality and format (e.g., 'fresh whole milk, 1 liter bottle') as well as comparability over time (e.g., not mixing different SKU over time unless necessary to ensure a sufficient coverage of the period under scrutiny).[13]

Out weekly SKU prices are defined as total turnover over volumes, and are net of promotional measures. Panel A of Table 1.1 reports descriptive statistics on prices for our sample of products distinguishing between overlap and non-overlap areas as well as between the pre-merger and post-merger periods. Because we have very different products in our sample, the price variation is large, ranging from few cents to 20 EUR:

[13] The list of selected SKUs for the price analysis is reported in Appendix 1.10.

some products are quite cheap, while other very expensive. While we do not observe large differences between overlap and non-overlap areas both pre- and post-merger, prices appear to have increased on average after the merger (11% and 9% in overlap and non-overlap areas respectively).

1.4.2 Category-level Data

To analyze the effect of the merger on product variety and category prices, we collected quarterly data on the number of SKUs for each of the 125 product categories sold in each of the 171 stores in our sample. This variable represents the depth of assortment and measures the product offerings available to consumers in each store. In addition, we compute an average price per category using quarterly data on turnover and sales volumes for each product category. Our database includes total turnover (in EUR), volume (sales), promotional turnover (in EUR), and promotional share (as a percentage of total sales) measured at store level for the 2009-2013 period. Measurements are weekly but are provided with a four-week periodicity starting with week 4 of 2009. Hence, also our monthly price data is determined as total turnover over volumes, and is net of promotional measures.

Panel B and C of Table 1.1 reports descriptive statistics on the average category prices and variety, separately for the overlap and non-overlap areas as well as pre-merger and post-merger periods. While for the average category prices we do not observe large differences between overlap and non-overlap areas nor before and after the merger, variety seems to differ in both respects. With over 90 SKUs per category, assortment size appears to be very large as it is the variation across categories, stores, and time. Some categories are not offered at all in some stores in a given quarter, while other categories have up to 1,689 different SKUs (for instance sauces). Assortment is ca. 5% lower in overlap areas before the merger but is slightly higher in non-overlap areas after the merger. In both areas variety increases on average after the merger.

[**insert Table 1.1 here**]

1.4.3 Control Variables

To identify the appropriate control areas as well as to disentangle the effect of the merger on prices and variety from the effect of market conditions, we collected data on demand and supply shifters in order to control for them in our analysis. We used two main sources: the Central Bureau of Statistics – Statistics Netherlands (http://www.cbs.nl/en-GB/menu/home/default.htm) and the Department of Spatial Economics & Spatial Information laboratory of VU University Amsterdam. Local demand and market conditions are summarized in Table 1.2, which also reports preliminary statistics for each variable. As shown, data have different time references.

[insert Table 1.2 here]

1.5 Empirical Model

The aim of the study is to analyze the impact of the merger on prices and variety. We implement a Difference-in-Differences (DiD) approach, in which we exploit both time and cross-sectional variation of prices and product variety in order to identify the effect of the merger. The DiD approach entails a comparison of two properly identified groups: the treated group – which is affected by the 'treatment', i.e., the merger – and the control group – which is not affected by the 'treatment'– before and after the merger decision. The strength of this method is that it isolates the effect of the merger from any other factors that (i) may affect the trend in price (variety); and (ii) may be related to the differences between the treated and the control group.

The matching procedure that we adopted to define the control group controls for selection into the treatment due to observable characteristics, while the double differencing entailed in the DiD approach removes the time-invariant group-specific unobserved heterogeneity as well as the common time effects that might be otherwise confounded with the effect of the merger.

As more thoroughly discussed in Section 1.5.2, the basic hypothesis of our empirical strategy is that competition in grocery markets works at the local level. This is in line with the geographic market definition commonly adopted by competition authorities and by the ACM in this specific case. The competitive effects of a merger are expected to be potentially stronger in areas characterized by an overlap between the merging parties – i.e., areas where stores of both chains were present at the time of the merger – than in areas where the parties did not compete with each other door to door. The former areas, in fact, would be the ones experiencing stronger changes in competitive conditions as a decrease in the number of competitors occurs. Therefore, we can identify the potential effect of mergers by comparing prices and variety of the merging parties in areas of overlap (treated group) vis-à-vis areas of no overlap (control group).[14]

[14]This identification strategy is very similar to the one used in, for instance, [Aguzzoni et al., 2016b] to evaluate the price effect of a merger between U.K. book retailers, [Hosken et al., 2018] to study the effect of U.S. grocery mergers on prices, as well as [Allain et al., 2017] to study the price effect of mergers across French supermarkets.

1.5.1 Econometric Specification

We run our analysis for the full sample, including the merging firms and competitors, as well as separately for each of the two merging parties and their competitors. The estimation on the full sample aims at measuring the overall effect of the merger at the market level, which is possibly the most relevant for consumers. The estimations on the sub-samples aim to identify the strategic reactions of the different players in the market, which helps us study the mechanism driving the average effects and better explain the post-merger competitive dynamics.

We compare the change in an outcome variable in a selection of stores that were located in overlap areas with the change in the same outcome variable in other stores picked from the best-matched non-overlap areas before and after the merger.We estimate the following equation:[15]

$$Out_{isjt} = \alpha + \beta overlap_s + \gamma post_t + \delta post_t \times overlap_s + \lambda Z_{sjt} + \mu_{ij} + \tau_t + \varepsilon_{isjt}, \quad (1.1)$$

where Out_{isjt} is the price (variety, category price) level for product (products' category) i at store s of insignia j during month (quarter) t; $overlap_s$ is a dummy variable that takes on the value of one if the store is located in an overlap area; $post_t$ is a dummy variable that takes on the value of one if the products' price (variety, category price) is observed in the post-merger period (i.e. after February 2012 for the price regression and after the first quarter of 2012 for the variety and category price regressions); Z_{st} is a set of variables that control for local market features (on the demand and supply side) that change over time.

We control for the average difference in the price (variety, category price) across different products (product categories) and supermarket chains by including fixed effects μ_{ij} for all combinations of products (product categories) and supermarket insignias. By following this approach, we are able to control for the effect on price and variety determined by the change in insignia. Moreover a time trend together with a set of quarterly dummies τ_t is used to capture aggregate shocks affecting all stores.[16] The error term ε_{isjt} is assumed to be heteroskedastic and correlated at the product-insignia level in the price analysis and products' category-insignia level in the analyses based on category data (i.e. the average category prices and variety).[17]

The main variable of interest is $post_t \times overlap_s$, whose coefficient measures the average treatment effect on the treated of the merger by identifying the additional variation in

[15] Estimating this equation in logarithms leads to qualitative and quantitative similar results.
[16] We also tried a specification with time fixed effects and obtained similar results.
[17] We experimented with different correlation structures but our results were not significantly affected.

price, variety, and category prices experienced by the treated stores compared to the control stores moving from the pre-merger to the post-merger period.

1.5.2 Identification

The first key ingredient of our identification strategy is to assess whether competition in grocery retail works at the local level, as we compare the different evolution of treated and not-treated local markets. Thus, in Section 1.5.2, we discuss the descriptive empirical evidence supporting this claim in detail.

Second, to causally identify the effect of the merger on the outcomes of interest, we need to ensure that the difference in the average behavior in the control group adequately represents the change with respect to the average behavior that would have occurred absent the merger (i.e. the counterfactual scenario). Thus, we need to make sure that the control group is comparable to the treatment group in terms of observables characteristics before treatment. Our matching approach for the selection of the relevant areas and stores should help ensure this condition is met.[18] In Appendix 1.10 we show that observables are balanced between overlap and non-overlap areas. In Section 1.5.2 we show that the evolution of the dependent variables in treated and control areas was similar before the merger and we formally test the common trend assumption.

Local or National Competition?

The choice of the most appropriate counterfactual to evaluate the effects of a merger strictly depends on the geographic extent of competition. A comparison between the price – or other variables of interest – in areas where the merging parties overlap (i.e. areas affected by the merger) vis-à-vis areas of no overlap (i.e. not affected by the merger) identifies the effect of the merger only if competition is, at least to some extent, local.

Since this issue was not fully explored during the review of the Jumbo/C1000 merger, we carry out a more in depth assessment, examining both qualitative evidence – such as questionnaires to market participants and evidence collected during phone interviews – and quantitative evidence on the variation of retail offers across stores (see [Argentesi et al., 2015]).

With respect to pricing strategies, both the questionnaires and the interviews support the view that prices are generally set at the national level, although promotions are occasionally set at store level. However, the interviews also indicated a consensus that Jumbo allows for greater degree of autonomy in price setting at store level than other

[18] The matching procedure is made store by store and separately for each of the two merging parties and for the competitors. For instance, for each merging party store in overlap areas, we find the store that best matches among those in non-overlap areas.

chains. Given that the qualitative evidence is not conclusive, we complement it with an analysis of the geographic extent of price variability.

First, we graphically analyze the price distribution for different supermarket chains of each SKU at different points in time by means of boxplots. Second, we compute, for each SKU and each month, the standard deviation of price from SKU's average price of that month. We then divide the standard deviation of each SKU's price by the average price of that SKU in order to obtain a measure of the price dispersion (the coefficient of variation) that is independent of the price level. These analyses for several products in our sample are shown in Appendix 1.10. Although price variation appears to be limited –both by looking at boxplots and by a close examination of the cumulative distribution function of the coefficient of variation– the figures show that some variability exists. Therefore, given the existence of some variation, local competition cannot be ruled out. Studying the reaction to the local shock due to a merger that differently affected different regional markets can be a way to shed further light on this issue.

Since the evidence on the existence of a national pricing policy is not conclusive, we perform a robustness check for the analysis of the merger's effect on SKU prices where we use the competitors to the merging parties as a control group instead than comparing overlap and non-overlap areas. The underlying assumption, based on the Bertrand model by [Deneckere and Davidson, 1985]), is that if the merging parties increase their prices after the merger, competitors will also increase their prices, but by less.[19] The results of this extension are discussed in Section 1.6.1.

As for variety, most of the interviewed market participants report that, although the overall range of assortment is generally set at central level, individual stores are allowed a substantial degree of autonomy in their individual assortment decisions. Stores belonging to each chain may adapt their own assortment to the local conditions of supply (e.g., competitive pressure coming from the other local players), demand (e.g., distribution of consumer preferences), and individual constraints (e.g., size of the stores, shelf space, etc.). For this reason, it is quite safe to assume that decisions on product assortment are set locally. To provide more formal evidence on this assumption, we perform a similar analysis as we did it for prices in Appendix 1.10. By means of box-plots and the analysis of the coefficient of variation we show the existence of substantial local variation in assortment decisions for several exemplifying categories.

[19]This identifying assumption has been used in previous merger retrospective studies, see for instance [Ashenfelter et al., 2013b] and [Aguzzoni et al., 2016b].

Common trends

To support our identification strategy based on selection on observables and check whether our empirical approach is appropriate, we analyze whether the pre-merger common trend assumption is empirically verified in our data. If this assumption is met, with the treatment and control groups behaving similarly pre-merger, we can be confident that the control group is a good comparator for the treatment group after the merger. For each of our variables (individual prices, variety, and average category prices), we first provide a descriptive visual inspection of the trends and, then, perform a formal test of the common trend assumption. In what follows, we show the average evolution of the outcome variables in treated and control stores without differentiating between the merging parties and the competitors, in order to obtain the aggregate picture at the market level, which is possibly the one most relevant for consumers. We get similar findings if we test the common trend assumption by insignia, as in our main empirical specifications (results are available upon request).

Figure 1.2 shows the average trend of product-level prices for stores in the overlap and non-overlap areas across all product categories (panel a) and by product category (panel b). The average price evolution faced by consumers in the treatment and control areas are almost identical, i.e. are subject to the same common trend during the pre-treatment period.[20]

[insert Figure 1.2 here]

As for variety, Figure 1.3 compares the evolution of the total number of SKUs per store – our measure of variety – in the overlap areas to the average level of product variety in non-overlap areas, across all product categories (panel a) and for some selected product categories (panel b).[21] Although trends seem to differ across categories, in this case the figures also show quite similar trends before the merger within each category. However, almost all series seem to diverge post-merger.[22]

[insert Figure 1.3 here]

Finally, Figure 1.4 plots the series of average prices per category in overlap and non overlap areas across all product categories (panel a) and for a subset of products in the

[20] The exact same patterns can be observed if we disaggregate the price by insigna as shown in Appendix 1.10.

[21] Note that the sample for this analysis is not exactly the same as the one used for the price analysis due to data quality issues that forced us to drop a number of observations. Hence, we undertook a separate matching procedure to identify overlap and non-overlap areas for the analysis on variety, since the relevant variable for this analysis is different from the one relevant for the price analysis.

[22] Again, very similar patterns can be observed by disaggregating the data per insigna (Appendix 1.10).

analyzed categories (panel b). We can see in panel a) that the two series seem to follow the same trend in the pre-merger period, meeting the key assumption for the identification of the average treatment effect through the DiD approach. They start to diverge some time after the merger, when prices in overlap areas become higher than prices in non-overlap areas.[23]

[insert Figure 1.4 here]

In addition to this graphical evaluation, we also perform a formal test of the common trend hypothesis. Similarly to [Ashenfelter et al., 2014], we first estimate the deviation of the treated areas prices (variety, category price) from the average price (variety, category price) of the control areas in each quarter. Then, we compute the slope of a linear trend of these deviations in the pre-merger period and test whether the estimated slope is statistically different from zero. The test confirms that individual prices show a common trend in treated and control areas. For variety, only one category out of 125 does not show a common trend. For average prices, 10 categories out of 125 do not show a common trend. If we exclude categories without common trend from our sample the estimated treatment effect is not affected. Similar results are obtained if we run these regression by insigna. [24]

1.6 Results

1.6.1 The Average Merger Effects by Insignia

In this Section, we discuss the results of our analysis of the average effect of the merger both on the entire sample and by insignia. In particular, for our three outcome variables (individual SKUs' prices, variety, and category-level prices) we disentangle the effect for each of the two merging parties and for their main competitors (Albert Heijn and Coop). This additional analysis is particularly relevant as it allows a heterogenous response to the merger of the different market players that help us better identifying the mechanism at play.

The Merger Effects on Prices

We start by looking at the evolution of prices on the selected sample of products across a subset of categories discussed in Section 1.4.1. This exercise is meant to assess whether the merger led to an increase in the price of a set of SKUs that is chosen to be representative of the consumption bundle of Dutch consumers.

[23] Again, very similar patterns can be observed by disaggregating the data per insigna (Appendix 1.10).
[24] The results of this test are available upon request.

The graphs shown in Figure 1.2 already offered a preliminary glimpse of the result of the following econometric analysis: prices in the treated and control stores seem to mostly maintain the same trend and level throughout the period of the analysis. If prices were set locally and the merger had any negative impact on prices, we would expect the distance between the two price trends to increase in the post-merger period.

To confirm the result of this graphical analysis, we perform several regressions using the aforementioned DiD methodology. Results are reported in Table 1.3. Overall, product-level prices seem to have significantly decreased in the post-merger period for both treated and control stores. However, our regressions show that the price change post-merger is not different between overlap and non-overlap stores. The average result estimated in the full sample (column 1) holds both for both merging parties' (columns 2 and 3 for C1000 and Jumbo respectively) and for the competitors' prices (column 4), suggesting that the merger did not have any significant effect on prices at the individual product level.

[insert Table 1.3 here]

These results might have two main explanation. First, it might be that the merger did not have any competitive effect on prices. Second, the findings are consistent with nearly-uniform pricing strategies at the national level. Because prices seem not to respond to any other local conditions, as all control variables other than seasonality dummies are not significant determinants of prices, it seems that the second explanation might be more reasonable.

To complement this analysis based on local variation, we also test whether the merger effect on SKU prices differs between merging parties and competitors.[25] First, we test that the post-merger effect reported in Table 1.3 is not different between these groups of firms. While the coefficients' estimates for Jumbo, C1000, and their competitors seem to diverge, this difference is not statistically significant. However, this regression is not adequate to compare prices if these are indeed set nationally. We therefore perform an additional analysis where we use the average price for each SKU and each period of time across all stores of a given chain in the sample. In this way, we smooth out the limited local variation in prices and obtain a sort of 'national' price for each chain. Our identification then consists of using the prices of the competitors as a counterfactual for the prices of the merging parties. The results of this analysis, available upon request, are consistent with those obtained with our main identification strategy: The merging parties' prices do not change significantly after the merger with respect to rival chains' prices. These findings show that the merger does not seem to have any effect on prices at the national

[25] Also in this case, we test that the development of competitors' prices mimics that of merging parties' prices before the merger. We cannot reject the hypothesis of a common trend. These results are available upon request.

level either. This not only implies that the merger does not seem to have increased market power nationally. It also implies that the merger does not seem to have produced efficiency gains at the national level that are passed on to consumers, else the prices of the merging parties should have decreased with respect to their competitors Albert Heijn and Coop.

The Merger Effects on Variety

We then turn to the analysis of the effects of the merger on decisions about product assortments and variety. This analysis might be particularly informative, as this seems to be one of the key strategic variables for supermarkets at the local level.

As before, the graphical analysis presented in Figure 1.3 indicates a common trend before the merger within each category, which seemed to diverge post-merger for almost all series. Specifically, we observe a decrease in variety for most categories. To gain a precise estimate of these effects and to understand where the post-merger decrease in product variety originates, we perform a formal econometric analysis. According to our results presented in Table 1.4, the merger negatively affected the average level of the product variety at the market level (column 1). Considering that the average variety level in the control stores in the post-merger period is equal to 97.2 SKUs per category and the coefficient estimate for the treatment effect is -3.065, the merger caused an average reduction in variety by 3.2%.

If we separately look at the effect on the two merging parties and on their competitors (columns 2, 3, and 4), we see however that this average effect is the result of opposing trends. In particular, C1000, the low-assortment chain, sharply reduced variety after the merger, by 15%, whereas Jumbo increased its assortment by 8%.[26] This is compatible with a repositioning in terms of the depth of assortment whereby the two chains tend to differentiate themselves after the merger when they compete in the same local market.

The estimated effect of the merger on competitors' variety (column 4) is weakly significant and indicates that competitors slightly increase their assortment in overlap areas, where the merger is supposed to have produced a stronger effect. Note, however, that the magnitude of the effect on competitors is much smaller than the first-order effect on the merging parties, therefore has a limited impact on the market-level effect.

[insert Table 1.4 here]

The fact that stores strategically reposition their assortment as a reaction to changes in local conditions, while they do not adjust prices, strongly suggests that this competitive dimension might be the main instrument for local managers to maximize their profits.

[26]The average variety for C1000 (Jumbo) is 96.6 (98.2) and the coefficient estimate for the treatment effect is -14.70 (8.66).

It is interesting to notice that the effect on variety is not driven by rebranding of the merging parties' stores (see table 1.10 in appendix 1.10). The repositioning of assortment also takes place in C1000 stores that are rebranded to Jumbo (about 30% in our sample). This suggests that the strategic repositioning effect prevails over the effect of adaptation of assortment towards Jumbo's.

The Merger Effect on Category-level Prices

In order to get an indication on the variation in the composition of assortment after the merger, we analyze the post-merger dynamics in average category prices, both for each of the two merging parties and for their competitors. Since the merger does not seem to lead to a change in the price of individual products while the length of assortment did change, looking at average category prices may give us an indication on how retail chains modify the *composition* of their assortment within each category.

As shown in Figure 1.4, the series of average prices per category in overlap and non-overlap areas start to diverge some time after the merger, when prices in overlap areas become higher than prices in non-overlap areas. This graphical evidence is confirmed by our regression results, which are reported in Table 1.5. First, average category prices in the full sample significantly decreased in the post-merger period for both treated and control stores. This mimics the results observed for the individual prices, which could be the driver of category price dynamics as well. However, and more interestingly for this study, our regressions show that, on the full sample, post-merger prices are higher in stores located in the overlap areas compared to stores located in the non-overlap areas ('Overlap × Post'). This means that the merger led to an increase in the average category prices. This effect appears to be driven by the merging parties' stores, whereas the effect on the main competitor's prices is insignificant. Specifically, C1000 decreased category prices on average by almost 4 cents (a decrease of 2%), while Jumbo increased prices by almost 15 cents (an increase by 8%).[27]

[insert Table 1.5 here]

The evidence so far suggests that the effect on average category prices is not due to price changes, but rather to a composition effect. Consider C1000: since SKU prices did not change and variety was substantially reduced in overlap area compared to control areas, the decrease in the average category price can be explained by the choice to drop high-priced SKUs after the merger in overlap areas. Jumbo instead increased its assortment as well as category prices, which suggests that it added high-priced SKUs to its assortment. In other words, the high-variety and high-price chain Jumbo became

[27] The average category price for C1000 was 1.80 EUR, while it was 1.83 EUR for Jumbo.

even more high-variety and high-price, whereas the low-variety and low-price chain C1000 became even more low-variety and low-price.[28]

Our interpretation of this evidence is that the merging chains repositioned their products in terms of depth as well as composition of assortment in order to avoid cannibalization and soften competition. This explanation is consistent with a theoretical literature on the effect of mergers on product positioning (Gandhi et al., JIE 2008; Mazzeo et al., 2014). In the next section, we present a simple theoretical model of competition in variety that rationalizes this evidence.

1.6.2 A Simple Model of Variety Competition

The model of variety competition presented in this section should help us to better understand the mechanisms behind the empirical results discussed so far. The purpose of this simple model is to study the impact of a merger on retail firms (stores) that compete on variety at local level.

We consider a local market where there are n stores that belong to n independent firms. We study a merger between two firms focusing on the stores' managers decision to adjust the depth of the assortment. We further assume that prices are unaffected. This assumption is consistent with our empirical findings and can be motivated by a national pricing strategy.

To model this situation we assume that each store j $(j = 1, ..., n)$ sells a composite good and sets the value of a variable $v_j \in [0, 1]$, where 0 represents the minimum level and 1 the maximum level of variety. The vector $v = (v_1, ..., v_n)$ identifies a strategy profile. A store offering a variety v_j bears a cost equal to $c(v_j)$, with $c(0) = 0$, $c'(v_j) > 0$, and $c''(v_j) \geq 0$. Marginal cost is assumed constant and normalized to zero. We order the stores according to their pre-merger level of variety so that:

$$v_j < v_{j+1}, \; j = 1, ..., n - 1.$$

Moreover, we assume that stores that pre-merger offer a higher level of variety charge a higher price.[29] This assumption has empirical validation: in our sample, chains with larger variety tend to have higher prices.

Consumers make their purchasing decisions taking into account both the price a store charges for the composite good and the store's variety. For some consumers, variety is a

[28]It should be noted that, for category prices, the former effect is stronger than the latter, i.e. the coefficient of the 'Overlap × Post' dummy for C1000 is smaller and less significant than the corresponding coefficient for Jumbo.

[29]Note that this condition will hold in the equilibrium of a game in which stores have to decide both the level of variety and the price.

quality feature. They prefer shopping at the store with the highest variety if all stores charge the same price. These consumers will be referred to as "vertical consumers" (v-consumers, hereafter) because for them variety is a feature that vertically differentiates stores. Other consumers incur decision costs that increase in the level of variety offered by the store at which they shop. These consumers have a preferred level of variety. They are named "horizontal consumers" (h-consumers, hereafter), because they consider variety a feature that horizontally differentiates stores.

To model this demand heterogeneity, we assume that there is a unit mass of consumers with a unitary demand for the composite good offered by the n stores and that this mass of consumers can be split in two disjoint subsets; the first subset, of size α, with $0 \leq \alpha \leq 1$, includes v-consumers; the second subset, with size $1-\alpha$, includes h-consumers.

V-consumers, indexed by i, vary according to the intensity of their preference for variety. Thus the level of gross utility (in monetary terms) v-consumer i obtains when she buys from store j is described by the following C^2 function:

$$u\left(v_j, w_i\right),$$

with $u_{v_j} > 0$, $u_{v_j v_j} \leq 0$ and where w_i is an idiosyncratic v-consumer's characteristic such that $u_{v_j w_i} > 0$; w_i represents how much consumer i cares about variety (i.e. consumers with a higher w obtain a higher marginal utility from variety). This idiosyncratic characteristic is distributed according to the cumulative $G\left(w_i\right)$ over a compact set that can be normalized to $[0,1]$, without any loss of generality. We assume that $G''\left(w_i\right) \leq 0$.

H-consumers have a preferred level of variety. If a h-consumer, indexed by h, buys from store j, her level of gross utility (in monetary terms) is described by the following C^2 function:

$$b\left(v_h\right) - t\left(d\left(v_h, v_j\right)\right),$$

where v_h is the preferred level of variety for h-consumer h, $b\left(v_h\right) > 0$ is the gross benefit of buying at the (ideal) store that offers the preferred assortment, $d\left(v_h, v_j\right)$ is a measure of the distance between v_h and the level of variety in store j, v_j, and $t\left(\cdot\right)$ is a "transportation cost" function that is increasing in $d\left(\cdot\right)$, with $t\left(0\right) = 0$ and $t'' \geq 0$. H-consumers are distributed over the variety space, $[0,1]$, according to the cumulative $H\left(v_h\right)$, with $H''\left(v_h\right) \leq 0$.

Let us define w_j and h_j as the v-consumer and the h-consumer that are indifferent between buying from store j and store $j+1$, respectively. We assume that the price differential between two adjacent stores is such that $h_j < v_{j+1}$, i.e. that the h-consumer that is indifferent between j and $j+1$ has a preferred level of variety that is below that offered by store $j+1$. The overall demand for firm j is $q_j(v) = q_{vj}(v) + q_{hj}(v)$ where:[30]

$$q_{vj}(v) = \alpha \left[G(w_j) - G(w_{j-1})\right]$$

is the demand function for store $j = 1, ..., n$ stemming from v-consumers, and

$$q_{hj}(v) = (1-\alpha)\left[H(h_j) - H(h_{j-1})\right]$$

is the demand function for store $j = 1, ..., n$ stemming from h-consumers.

We assume that before the merger the equilibrium profile $v^* = (v_1^*, ..., v_n^*)$ is such that the following FOCs are satisfied:

$$\frac{\partial \pi_j}{\partial v_j} = \frac{\partial q_j}{\partial v_j} p_j - \frac{\partial c}{\partial v_j} = 0 \text{ for any } j = 1, ..., n.$$

Suppose that stores j ($j = 1, ..., n-1$) and $j+1$ merge. In this merger between "close competitors," we refer to store j as the "low-variety store" and to $j+1$ as the "high-variety store."[31] The new entity resulting from the merger, denoted by m, will have to decide the level of variety in the two stores (j and $j+1$) it now controls. It will do so with the aim of maximizing the following profit function:

$$\pi_m(v) = \pi_j(v) + \pi_{j+1}(v).$$

In Appendix 1.10 we prove the following proposition:

Proposition 1.1 *After a merger between two close competitors, the new entity decreases variety in the low-variety store. The new entity decreases variety in the high-variety store only if there are "many" v-consumers.*

If the two merging parties are close competitors, they have an incentive to change variety if this entails an increase in the demand of the other merging party. Let us consider v-consumers first. Both the low-variety store and the high-variety store have an incentive to decrease variety because the demand originating from v-consumers of the other merging party increases if they do so. On the contrary, the two merging parties increase the demand for the other party stemming from h-consumers if they increase the distance between them. This means that the low-variety store has an incentive to decrease variety and the high-variety store has the opposite incentive. As a consequence, the prediction is not ambiguous for the low-variety store: it will decrease variety considering

[30] We derive the stores' demand functions in Appendix 1.10

[31] In Appendix 1.10 we also discuss the case of a merger between distant competitors, i.e. firms whose stores are not adjacent in terms of variety.

the effect of this choice both on v-consumers and on h-consumers. For the high-variety store, the incentive to decrease variety only exists if there are "many" v-consumers, as the former effect dominates the latter. Since the presence of many v-consumers makes the stores' offer a vertically differentiated product and this tends to lead to more concentrated markets, we can argue that the negative impact on variety is likely to be larger in markets that show a higher level of concentration.

The above predictions are consistent with our empirical findings. Indeed, we find that C1000, the low-variety chain, reduces variety as a consequence of the merger. Jumbo increases variety, although to a lower extent, which in our model is possible only if there are not many v-consumers.

1.7 Additional Empirical Results

1.7.1 Heterogenous Effects

In order to explore further the drivers of the previous results, we estimate two different heterogeneous treatment effects. First, we investigate whether the effect of the merger varies across areas depending on the level of post-merger concentration.[32] While we do not find any effect on individual prices, we find that the effect on variety is particularly severe in areas where concentration is high (Herfindal-Hirschmann-Index – HHI – higher than 4,000). Interestingly, this is especially true for competitors. This result suggests that in highly concentrated areas, consumers were strongly and negatively affected by the merger: average assortment is reduced by 50% more than in less concentrated areas as a consequence of the merger. Moreover, the differentiation effect between the merging parties is smaller in highly concentrated areas. Indeed, the reduction in variety in C1000 stores and the increase in variety in Jumbo stores is less pronounced in these areas. This is consistent with the predictions of the theoretical model described in Section 1.6.2, because in highly concentrated areas the incentive to horizontally differentiate is weaker than in other areas.[33]

Second, we further explore whether the effect of the merger was different in areas affected by structural remedies.[34] In particular, the ACM required the merged entity to divest 18 stores, which were sold to Coop and to the Albert Heijn chain. We find no differential effect on individual prices for areas with divestitures if compared to control

[32] These results are reported in Appendix 1.10, Tables 1.11, 1.12, and 1.13.

[33] The effect on average category prices is not significantly different in highly concentrated areas as compared to less concentrated ones, suggesting that overall the composition of assortment is not differentially affected. Consistent with the results on variety, both the reduction in average prices for C1000 and the increase in average prices for Jumbo are weaker in areas where the market is highly concentrated.

[34] These results are reported in Appendix 1.10, Tables 1.14, 1.15, and 1.16.

areas without divestiture.[35] While we still estimate a significant negative effect of the merger on variety in the full sample, this effect is not significantly different in areas affected by the remedies than in other treated areas where no divestiture was required. Yet if we look at the effect by insignia, we observe that remedies did have an effect. Both C1000 and Jumbo reduced variety, which also implies that the differentiation effect between the merging parties is much weaker in areas with divestitures. Finally, and perhaps more interestingly, average category prices seem to have decreased in overlap areas where divestitures were imposed. This is exactly the opposite effect that we observe in overlap areas where no divestiture was imposed. These results indicate that, in areas where remedies were imposed, variety and category prices decreased and the strategic repositioning effect both in terms of depth and composition of the assortment was reduced.

1.7.2 Robustness Checks

In this section, we show that our previous results are robust to several checks (see Tables 1.17, 1.18, and 1.19 in Appendix 1.10). First, since we do not know exactly when the two merging parties became one single entity and because the competitive conditions could have started changing with the notification of the acquisition, we also run specifications where we exclude windows of 3 and 6 months around the merger date from our dataset. Results do not change, regardless of whether we look at the full sample, merging parties, or competitors. In particular, for the analysis on variety (Table 1.18 in the Appendix 1.10), when we drop three and six months of data from around the merger date, the effects are even stronger than in our baseline regressions. Results for average category prices (see Table 1.19 in Appendix 1.10) also show that the effect is larger when we drop 3 or 6 months around the merger decision. This is in line with the qualitative evidence of Figure 1.4, showing that there is a delay in the realization of the effect of the merger.

Second, for the analysis on variety, we exclude from the dataset the products that show a seasonality in their assortment trend (namely sun protection products, insecticides, and greeting cards). Even in this case, our qualitative and quantitative results do not change: the effect of the merger on variety is still significant and negative. Finally, we re-balanced the sample dropping categories without common trend, as explained in Section 1.5.2 and results are not affected.

The results presented so far, even the heterogeneous treatment effects, represent average effects across all 125 categories in our sample. While we think that this is the right approach, as we want to measure the average effect for a consumer who buys a basket of

[35]The divestiture dummy takes value of 1 for all the stores located in the areas where they occurred. We then interact this variable with the 'Overlap × Post' dummy. Thus, the coefficient of this double interaction measures the difference between the treatment effect measured in overlap areas where one of the C1000 stores were divested if compared to areas without a divestiture.

goods potentially including products from all categories, it is interesting to understand which categories drive this average result. In an additional robustness check, we therefore re-run our previous regression at the category level for the merging parties.[36] Reassuringly, 112 out of 125 coefficients' estimate of the average treatment effect on variety are negative.[37] Among these estimates, 37 are significant.[38] Among the categories for which we find significant negative effects, we have both food and non-food products. This means that the average effect discussed in the previous sections captures the main tendency of the merger on merging firms' overall assortment decisions. As for average price, the effect of the merger is positive for 114 out of 125 categories, but only 2 of them have significant coefficients.

1.8 Conclusions

In industries where local competition plays an important role – such as the retail sector – firms might forgo profits for not being able to geographically price discriminate and, thus, respond to local market conditions. The empirical evidence presented in this paper shows that non-price terms and conditions are important strategic tools for managers in such situations. Thus, the analysis of these additional dimensions, in particular assortment decisions, is crucial for shedding light on the extent of competition in the market. This is the major contribution of this paper.

To assess if and how local competitive conditions affect assortment and pricing decisions, we analyze a major merger between the Dutch grocery retailers Jumbo and C1000 that differently affected competition in various local markets. We find that the merger did not have significant price effects at the product level. When shaken by a change in market structure, local managers do not respond by changing prices. This is consistent with the nearly-uniform pricing patterns across heterogenous local markets observed in the literature [DellaVigna and Gentzkow, 2017]. However, we show that the merger caused a significant decrease in the average depth of assortment at the market level. This effect is driven by two opposing forces: on the one hand, assortment in C1000 stores shrank and moved toward cheaper products; on the other hand, Jumbo increased the depth of its assortment and repositioned its offer toward high-price products. Yet, the change in

[36] For the sake of space, we do not report the results of these 125 regressions but they are available upon request.

[37] Only for one category – chilled rice and pasta– we estimate a positive but tiny (0.755) and significant effect of the merger.

[38] Note that by running our model at the category level, we essentially compare the evolution of one time series across the 50 overlap areas to the 37 non-overlap areas for which we have data on the merging parties' assortment (see table 1.8 in appendix 1.10). Hence, the fact that several coefficients are not significant is most likely due to the limited power of our regression.

variety in high-variety stores does not compensate the decrease in variety in low-variety stores, especially in more concentrated markets, in which consumers perceive variety as a quality feature. In these markets, consumers experience an overall reduction in the assortment offered by supermarkets.

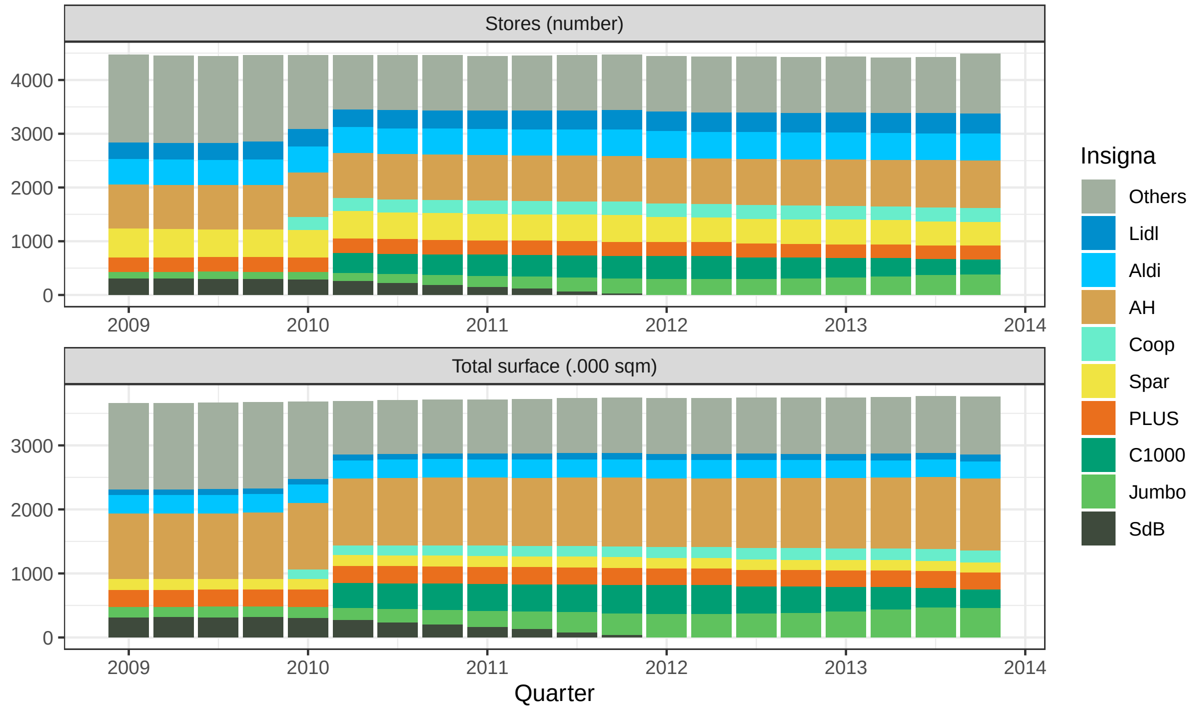
By increasing differentiation and specializing on different types of customers, local supermarkets can avoid cannibalization, soften competition, and consequently increase their profits even without changing products' prices. We rationalize this behavior in a simple theoretical model where stores compete on variety taking prices as given.

These results have important implications for policy and welfare as well. The reduction in product assortment limits consumers' choice and may ultimately harm them. Indeed, [Brynjolfsson et al., 2003] show that changes in variety affect consumer welfare in an order of magnitude of 7 to 10 times larger than price effects. Yet, we show the effect of variety is heterogenous if variety is a vertical differentiation attribute for some consumers and a horizontal one for others for which a deeper retail assortment might increase consumers' shopping costs [Klemperer and Padilla, 1997]. While some consumers could benefit from having a larger set of more expensive products in some stores, other might be hurt by seeing some products disappear from their preferred stores or by the increased distance in terms of variety between the stores they can shop at. In such circumstances, merger policy might have redistributive effects across consumers which are difficult to evaluate. This consideration applies to any competitive dimension that may have a heterogeneous impact on consumers. Indeed, while an increase in price (or a reduction in quality) has an obvious negative impact for all consumers, a modification of other characteristics that consumers value differently might benefit some of them and harm others. In these cases, the consumer welfare standard that is frequently adopted to assess the competitive consequences of a merger seems less appropriate than a total welfare standard.

Even if we do not have enough information to assess how a change in the assortment could have affected total welfare, our price analysis shows that the merger had no impact on individual products' prices charged by the merging stores in overlap areas. Therefore, even if the assortment adjustment promoted cost savings, these might not have been passed on to consumers. Hence, our comprehensive assessment of the effect of the merger reveals that it may have harmed most consumers through an average reduction in product variety that was not compensated by a change in prices. Our findings confirm therefore the importance of considering non-price effects besides price effects in *ex-post* evaluations of mergers in markets where non-price dimensions of competition are relevant for consumers. They however highlight that the welfare effects of strategic assortment repositioning are difficult to measure. This is an area that would deserve further research.

1.9 Figures and Tables

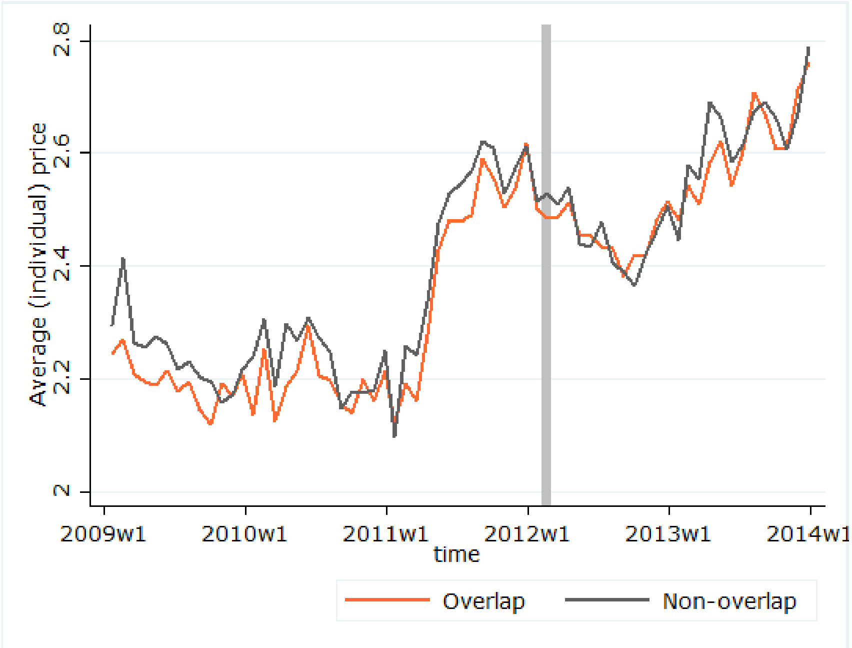
Figure 1.1: Stores' market position (national level) over time: number of stores (top) and net sales floor area (bottom) and



Source: Our elaboration on Supermarket Gids data.

Figure 1.2: Trends for individual SKU prices in treated and control areas

a) Across all categories

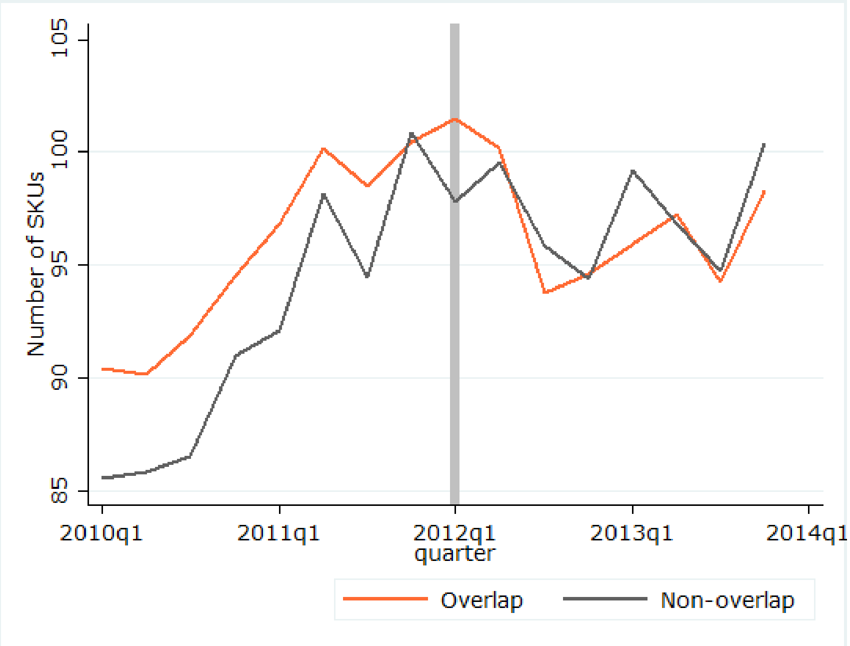


b) Per category

Source: Our elaboration on IRI data

Figure 1.3: Trends for variety in treated and control areas

a) Across all categories

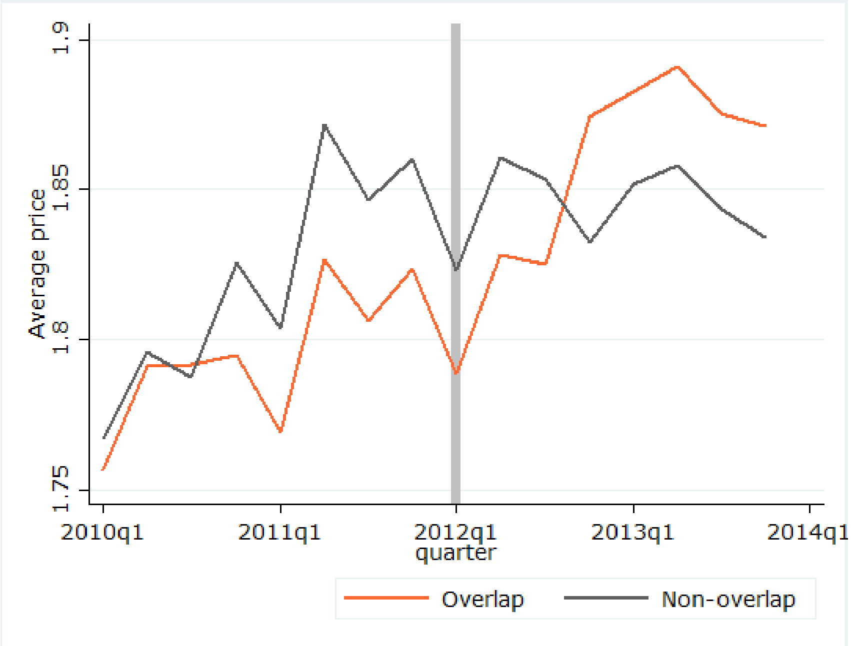


b) Per category

Source: Our elaboration on IRI data

Figure 1.4: Trends for average category prices in treated and control areas

a) Across all categories



b) Per category

Source: Our elaboration on IRI data

Table 1.1: Preliminary Statistics - Dependent variables

	Pre merger				Post merger			
	Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max
Panel A								
Price – Treated	2.28	2.56	0.03	20	2.53	2.89	0.05	20
Price – Untreated	2.33	2.67	0.05	20	2.54	2.96	0.02	20
Panel B								
Average Category Price – Treated	1.80	1.23	0	12.49	1.85	1.27	0	36.5
Average Category Price – Untreated	1.82	1.24	0	12.84	1.84	1.29	0	12.42
Panel C								
Variety – Treated	95.38	114.02	0	1,689	96.96	109.62	0	1,398
Variety – Untreated	91.82	106.96	0	1,452	97.36	111.18	0	1,489

Table 1.2: Description of the Control Variables

Control variables	Description	Time reference	Source	Mean	St. Dev
Local market features: demand side					
Population	Number of inhabitants per City (thousands)	yearly	CBS - NL[1]	1731	1912
Population density	Average number of inhabitants per square kilometer per City	yearly	CBS - NL	2333	2473
Households with children	Percentage of households with children (unmarried couples with children, spouses, couples with children and single-parent households) per city	yearly	CBS - NL	40	10.96
Income	Weighted average of income per capita per city (thousands, weights equal to number of income recipients per city)	yearly	CBS - NL	21.88	4.3
Local market features: supply side					
Rental price	average value of residential real estate	yearly	VU University Amsterdam[2]	281.66	79.03
HHI	Hirschman-Herfindall Index per city (stores market shares are proxied by the net sales floor)	quarterly	Supermarket Gids	3432.2	1824.4
Number of stores	Number of stores per city	quarterly	Supermarket Gids	6.67	4.69
Net sales floor	average net sales floor of all the stores in the City	quarterly	Supermarket Gids	1022.6	515.67
Aldi	Average net sales floor of all the Aldi stores in the city	quarterly	Supermarket Gids	717.57	217.78
Lidl	Average net sales floor of all the Lidl stores in the city	quarterly	Supermarket Gids	849.27	206.32
Discounter market shares	sum of the market shares of Lidl and Aldi stores (computed on the basis of the store's net sales floor) in the city	quarterly	Supermarket Gids	0.125	0.11

[1] Central Bureau Statistics – Statistics Netherlands (http://www.cbs.nl/en-GB/menu/home/default.htm)
[2] Department of Spatial Economics & Spatial Information laboratory, VU University Amsterdam

Table 1.3: Average Treatment Effect per Insigna: Price

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-0.105***	-0.0855***	-0.0979**	-0.139***
	(0.016)	(0.024)	(0.030)	(0.028)
Overlap	-0.00712	-0.00704	-0.00821	-0.0126
	(0.011)	(0.017)	(0.023)	(0.020)
Overlap×Post	0.00133	-0.00390	0.00733	0.0120
	(0.027)	(0.046)	(0.039)	(0.048)
Population	-0.000140	-0.000198	-0.0000585	-0.0000528
	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	0.00210	0.000418	0.00189	0.00339
	(0.001)	(0.003)	(0.004)	(0.002)
Discounters Market Share	0.0459*	0.0135	0.0873	0.0823*
	(0.020)	(0.028)	(0.067)	(0.037)
HHI	0.0000745	-0.000121	0.000314	-0.000279
	(0.000)	(0.000)	(0.000)	(0.001)
Net Sales Floor	0.00000302	0.00000990	-0.00000281	-0.000000980
	(0.000)	(0.000)	(0.000)	(0.000)
House Value	0.0000173	0.0000548	0.0000173	-0.0000110
	(0.000)	(0.000)	(0.000)	(0.000)
Quarter	0.0388***	0.0351***	0.0347***	0.0453***
	(0.002)	(0.003)	(0.005)	(0.004)
Constant	-6.149***	-5.317***	-5.392***	-7.451***
	(0.465)	(0.687)	(0.933)	(0.832)
Observations	122,213	48,362	30,279	43,572
R^2	0.9532	0.9510	0.9612	0.9514

Clustered-robust standard errors at the product-insignia level in parentheses. We control for fixed effect at the product-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.4: Average Treatment Effect per Insigna: Variety

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-2.402***	0.424	-6.504***	-1.099
	(0.559)	(0.656)	(1.052)	(0.727)
Overlap	3.071***	11.41***	-0.0837	-4.153***
	(0.537)	(1.272)	(0.377)	(0.872)
Overlap×Post	-3.065***	-14.70***	8.659***	0.722*
	(0.364)	(1.458)	(0.938)	(0.290)
Population	-0.0798***	-0.145***	0.0753***	-0.00998
	(0.011)	(0.021)	(0.014)	(0.017)
Average Income	0.399***	-1.117***	-0.841***	2.114***
	(0.097)	(0.182)	(0.172)	(0.253)
Discounters Market Share	0.425	-21.50***	24.72***	15.90***
	(1.243)	(2.901)	(2.799)	(2.885)
HHI	-0.0874***	-0.238***	0.0820***	-0.157***
	(0.011)	(0.028)	(0.013)	(0.039)
Net Sales Floor	0.438***	0.869***	0.0165	0.184***
	(0.047)	(0.094)	(0.019)	(0.027)
House Value	0.0229***	0.0422***	0.0583***	-0.0163***
	(0.004)	(0.006)	(0.007)	(0.004)
Quarter	0.532***	1.014***	-0.204	0.294*
	(0.109)	(0.153)	(0.116)	(0.117)
Constant	58.21*	-35.44	216.9***	82.93**
	(22.897)	(31.216)	(23.002)	(26.022)
Observations	225,667	90,484	72,056	63,127
R^2	0.8806	0.8342	0.9047	0.9418

Clustered-robust standard errors at the category-insignia level in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.5: Average Treatment Effect per Insigna: Average price

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-0.0361***	-0.0185	-0.0836***	-0.0215***
	(0.005)	(0.012)	(0.007)	(0.005)
Overlap	-0.00559	0.0219*	-0.00801	-0.0201**
	(0.005)	(0.011)	(0.007)	(0.007)
Overlap×Post	0.0254***	-0.0391**	0.148***	-0.00930
	(0.007)	(0.014)	(0.013)	(0.008)
Population	-0.000178	-0.000467**	0.00110***	-0.000392**
	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	0.00237*	-0.00390	-0.0126***	0.0129***
	(0.001)	(0.003)	(0.002)	(0.002)
Discounters Market Share	0.0883***	0.0644*	0.0329	0.138***
	(0.017)	(0.032)	(0.027)	(0.035)
HHI	0.00119***	0.000451	0.00247***	-0.0000795
	(0.000)	(0.000)	(0.000)	(0.000)
Net Sales Floor	-0.00000197	0.0000142*	-0.0000165***	-0.00000404
	(0.000)	(0.000)	(0.000)	(0.000)
House Value	0.000310***	0.000446***	0.000571***	0.000125
	(0.000)	(0.000)	(0.000)	(0.000)
Quarter	0.0103***	0.0164***	0.00150	0.0102***
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.934***	-0.425	2.975***	0.838***
	(0.107)	(0.223)	(0.228)	(0.148)
Observations	216,060	77,605	71,960	51,881
R^2	0.8873	0.8412	0.8918	0.9499

Clustered-robust standard errors at the category-insignia level in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

1.10 Appendix

1.10.1 Propensity Score Matching for Areas Selection and the Stores' choice

This appendix describes the methodology used to select the stores. The ACM provided us with historical location data on all supermarkets in the Netherlands, the 'Supermarkt gids' database, which lists geographic data (including addresses, postal code, city, province) together with additional information (e.g., availability of parking or automatic counters). In 2013, the guide counts 6,641 stores. Our budget allowed selecting a total of 171 stores. As described in the paper, we compare the merging stores in the overlapping areas (treated stores) and the merging stores in the non-overlapping areas (control stores). To select appropriate stores for our analysis, we started by identifying the overlapping and non-overlapping areas. There were 253 overlapping areas out of a total of 1,145 areas in the whole sample.

In order to identify the areas for the selection of 171 stores, we follow an approach based on the propensity score matching (PSM) methodology. PSM was developed as a technique to correct for sample selection bias that may affect the estimation of the treatment effect in non-randomized experiments. In randomized experiments, the results in the treated and control groups may often be directly compared because the two samples are likely to be similar (the assignment to the treated and control 'status' is indeed random). In non-randomized experiments, the direct comparison between the treated and control units may be misleading because units exposed to the treatment systematically differ from the units not exposed to the treatment. Propensity score matching allows to group treated and control units according to their probability of receiving the treatment based on observable characteristics. The propensity score is defined as the conditional probability of receiving the treatment given a set of pre-treatment variables:

$$p(X) = Pr(D = 1|X)$$

The PSM technique allows for collapsing the multiple dimensions along which treated and control units might differ into one single dimension: the propensity score. In the case under examination, the probability of receiving the treatment may coincide with the probability of being an overlapping area. We computed a propensity score for each area and grouped overlapping and non-overlapping areas according to the similarity of their score. We estimate the probability of treatment running a logistic regression. The dependent variable is a discrete variable that takes value one if the area is overlapping and zero otherwise. The independent variables include demand and supply factors that may influence the decision of a supermarket insignia to locate its stores in a given area.

We then group treated and control cities according their estimated scores. Treated and control units with exactly the same propensity score are rarely found. Instead, each treated unit is usually matched with its closest control, as indicated by the propensity score value. We had to allow for multiple uses of the same control city in order to maximize the number of treated cities included in our final sample (i.e., to prevent some treated cities from falling 'off support').[39]

Post matching, we then checked if treated and control areas are indeed similar in observable characteristics except for the treatment. We do that by testing the equality of means for the relevant explanatory variables and we conclude that the means across the treated and control areas are not statistically different (see Table 1.6).

[39] In some of the control matched cities, there were no merging stores. The empirical strategy underpinning the analysis across areas requires that at least one of the merging chains is present in the non-overlapping (control) cities. For this reason, we could not limit the match to the 'nearest neighbor', but had to extend the match to the third nearest neighbor.

Table 1.6: Equality of the means between treated and control areas

	Means			t-test	
	Treated	Control	%bias	t-test	p > t
Pscore	0.3906	0.3712	10.8	1.18	0.237
Average population density	13,580	11,830	8.4	0.78	0.434
Average store size	922.67	927.57	-1.6	-0.18	0.855
Average income	2,407.7	2,416.4	-2.8	-0.31	0.757
Number of stores (squared)	37.226	31.381	8.0	0.74	0.459
HHI	4,731.1	5,088.7	-11.7	-1.27	0.204
Average land price	142.34	147.41	-5.2	-0.52	0.604
HHI Discounters	1,757.2	1,776.9	-1.0	-0.11	0.916

Table 1.7 presents the list of areas obtained from the matching process and indicates those areas that, among the treated ones, were deemed problematic (i.e. where the merged entity had a combined market share above 50%). Moreover, we highlight in which of the former areas a divestiture was required.

Table 1.7: List of matched areas

City	Province	Treated	Overlap MS>50%	Overlap MS<50%
'S-HEERENBERG	Gelderland	Treated	0	1
DEN BURG	Noord-Holland	Untreated	0	0
DEN HAM OV	Overijssel	Treated	1	0
TERSCHELLING FORMERUM	Friesland	Untreated	0	0
BARNEVELD	Gelderland	Treated	0	1
ASSENDELFT	Noord-Holland	Untreated	0	0
BEMMEL	Gelderland	Treated	0	1
BEST	Noord-Brabant	Untreated	0	0
BODEGRAVEN	Zuid-Holland	Treated	0	1
OOSTERBEEK	Gelderland	Untreated	0	0
CAPELLE AAN DEN IJSSEL	Zuid-Holland	Treated	0	1
LISSE	Zuid-Holland	Untreated	0	0
DE MEERN	Utrecht	Treated	0	1
DALFSEN	Overijssel	Untreated	0	0
LICHTENVOORDE	Gelderland	Treated	1	0
EDE GLD	Gelderland	Untreated	0	0
DIEMEN	Noord-Holland	Treated	0	1
OUDDORP ZH	Zuid-Holland	Untreated	0	0
EERSEL	Noord-Brabant	Treated	0	1
DELFT	Zuid-Holland	Untreated	0	0
ENTER	Overijssel	Treated	0	1
BERGEIJK	Noord-Brabant	Untreated	0	0
GOOR	Overijssel	Treated	0	1

GEMERT	Noord-Brabant	Untreated	0	0
GROESBEEK	Gelderland	Treated	0	1
HATTEM	Overijssel	Untreated	0	0
HARDERWIJK	Gelderland	Treated	0	1
MILL	Noord-Brabant	Untreated	0	0
HEEMSKERK	Noord-Holland	Treated	0	1
ALPHEN AAN DEN RIJN	Zuid-Holland	Untreated	0	0
HOLTEN	Overijssel	Treated	0	1
MAKKUM FR	Friesland	Untreated	0	0
HOOGERHEIDE	Noord-Brabant	Treated	0	1
ANNA PAULOWNA	Noord-Holland	Untreated	0	0
HOUTEN	Utrecht	Treated	0	1
MIDDELBURG	Zeeland	Untreated	0	0
IJSSELSTEIN UT	Utrecht	Treated	1	0
SEVENUM	Limburg	Untreated	0	0
KAATSHEUVEL	Noord-Brabant	Treated	0	1
MAASSLUIS	Zuid-Holland	Untreated	0	0
KERKRADE	Limburg	Treated	0	1
BOXMEER	Noord-Brabant	Untreated	0	0
LANDGRAAF	Limburg	Treated	0	1
HOORN NH	Noord-Holland	Untreated	0	0
LEIDEN	Zuid-Holland	Treated	0	1
EMMER-COMPASCUUM	Drenthe	Untreated	0	0
LOCHEM	Gelderland	Treated	0	1
VROOMSHOOP	Overijssel	Untreated	0	0
OMMEN	Overijssel	Treated	0	1
TIEL	Gelderland	Untreated	0	0
OOST-SOUBURG	Zeeland	Treated	0	1
NORG	Drenthe	Untreated	0	0
STADSKANAAL	Groningen	Treated	1	0
SEVENUM	Limburg	Untreated	0	0
CULEMBORG	Gelderland	Untreated	0	0
ROOSENDAAL	Noord-Brabant	Treated	0	1
ENKHUIZEN	Noord-Holland	Untreated	0	0
SAPPEMEER	Groningen	Treated	0	1
NIEUWE NIEDORP	Noord-Holland	Untreated	0	0
SITTARD	Limburg	Treated	0	1
HILLEGOM	Zuid-Holland	Untreated	0	0
SOEST	Utrecht	Treated	0	1
SMILDE	Drenthe	Untreated	0	0
SOMEREN	Noord-Brabant	Treated	0	1
ZETTEN	Gelderland	Untreated	0	0
SON	Noord-Brabant	Treated	0	1
LIENDEN	Gelderland	Untreated	0	0
STEENBERGEN NB	Noord-Brabant	Treated	0	1

EDE GLD	Gelderland	Untreated	0	0
THOLEN	Zeeland	Treated	0	1
RENESSE	Zeeland	Untreated	0	0
TWELLO	Gelderland	Treated	0	1
OOSTERWOLDE FR	Friesland	Untreated	0	0
URK	Overijssel	Treated	0	1
KROMMENIE	Noord-Holland	Untreated	0	0
VELDHOVEN	Noord-Brabant	Treated	0	1
OSS	Noord-Brabant	Untreated	0	0
VINKEVEEN	Utrecht	Treated	0	1
ZEVENHUIZEN ZH	Zuid-Holland	Untreated	0	0
WASSENAAR	Zuid-Holland	Treated	0	1
KOLLUM	Friesland	Untreated	0	0
WESTERBORK	Drenthe	Treated	1	0
OPHEUSDEN	Gelderland	Untreated	0	0
WIERDEN	Overijssel	Treated	0	1
SCHAGEN	Noord-Holland	Untreated	0	0
WIJCHEN	Gelderland	Treated	0	1
GENNEP	Limburg	Untreated	0	0
WINSCHOTEN	Groningen	Treated	0	1
EERBEEK	Gelderland	Untreated	0	0
WOUDENBERG	Utrecht	Treated	0	1
ZEEWOLDE	Flevoland	Untreated	0	0
ZELHEM	Gelderland	Treated	0	1
AALSMEER	Noord-Holland	Untreated	0	0
IJSSELSTEIN UT	Utrecht	Treated	1	0
CULEMBORG	Gelderland	Untreated	0	0
ZEVENBERGEN	Noord-Brabant	Treated	0	1
WOERDEN	Utrecht	Untreated	0	0
DEURNE	Noord-Brabant	Treated	Divestiture	0
LIENDEN	Gelderland	Untreated	0	0
GRAVE	Noord-Brabant	Treated	Divestiture	0
BERGEIJK	Noord-Brabant	Untreated	0	0
KAMPEN	Overijssel	Treated	Divestiture	0
EERBEEK	Gelderland	Untreated	0	0
OIRSCHOT	Noord-Brabant	Treated	Divestiture	0
DALFSEN	Overijssel	Untreated	0	0
RAALTE	Overijssel	Treated	Divestiture	0
VROOMSHOOP	Overijssel	Untreated	0	0
RAAMSDONKSVEER	Noord-Brabant	Treated	Divestiture	0
HILLEGOM	Zuid-Holland	Untreated	0	0
ZUIDLAREN	Drenthe	Treated	Divestiture	0
BOXMEER	Noord-Brabant	Untreated	0	0
IJSSELMUIDEN	Overijssel	Treated	1	0
BRUMMEN	Gelderland	Untreated	0	0

To conclude, the propensity score matching technique allows us to identify the areas from which we finally selected our sample of stores. In the next section, we describe this second selection exercise.

1.10.2 The choice of stores

Within areas of overlap and areas of non-overlap, we select a suitable number of stores from both the merging parties and the competing chains.[40] However, we restrict the choice to two competitors' chains: Albert Heijn and COOP. This choice is based on a number of considerations.

First, available information on chains' strategy and the economic literature suggest that it might be appropriate to include in the analyses an explanatory variable attempting to capture "chain-specific effects." Consequently, we restrict the number of chains in order to ensure that a sufficient number of stores is available for each chain.

Second, we want to include in our selection both a national competitor and a local competitor, to exploit any differences in their responses to a change in competition.

Third, we adjust our selection in order to take into account data availability issues. In particular, some supermarket chains – especially discounters like Aldi and Lidl – denied access to store level data. In addition, the data provider warned us about (i) missing data for some supermarket chains; and (ii) limited availability of data on private label goods in 2009 and 2010.

Our selection also attempts to ensure a widespread coverage of the Dutch territory as well as a balanced representation of merging parties and of the subset of competitors selected, across areas of overlap and areas of non-overlap. Moreover, we do not select stores from the largest cities. The main reason we excluded the largest cities from our selection is related to the difficulties of matching them with appropriate control regions. Data completeness proved to be an additional problem as supply level data are incomplete for most of the largest cities.

Concerning the kind of stores, the ACM defines a single 'product' market encompassing all supermarket formulas, including regular supermarkets, hypermarkets, and discounters. The difference between the various formulas is determined mainly by the shop size.[41] The assortment size can be a further element of differentiation among stores. Hypermarkets typically have the broadest assortment (20,000 SKUs is a common figure

[40] Among the stores of the merging parties, we wanted to have stores from the acquirer Jumbo and the target C1000. Moreover, we also tried to have stores that were re-brandend during the sample period –i.e., adopted the Jumbo insignia – as well as stores that were not re-branded.

[41] In a recent study, the European Commission adopted the following definition: i) supermarkets: stores whose size is between 400 and 2,499 square meters; ii) hypermarkets: stores whose size is equal to or greater than 2500 square meters; iii) discounters: all stores size.

Table 1.8: The sample of Stores

		Price		Variety	
		Overlap	Non-Overlap	Overlap	Non-Overlap
C1000	Rebranded to Jumbo	7	9	7	10
	Not rebranded	19	13	20	13
Jumbo	Jumbo	21	14	23	14
Competitors	Albert Heijn	14	15	14	15
	Coop	3	3	5	3

for food products). Supermarkets typically sell between 5,000 and 10,000 different food SKUs. Finally, discounters have the narrowest assortment, typically between 1,000 and 2,000 SKUs. In our study, we follow a different approach. For each supermarket chain, we limit our selection to regular formula only, in order to focus on the stores that are the closest substitutes.

Our final selection includes over 171 different stores representing the merging parties' chains and two competitors (Albert Heijn and Coop). For this list of stores, we asked for data on turnover, volume, promotional turnover, promotional share, and variety for a selection of products, as described in the data section. Note that we have a slightly different sample for the price and variety specifications. Table 1.8 reports the sample of stores used in our regressions.

1.10.3 List of SKUs

The following table presents a list of the selected SKUs per products' category used in the price analysis. In the cells we report the number of stores for which we have information on that particular product.

Table 1.9: Selected SKUs per Product Category – Price Analysis

		PRODUCTS	CHAINS				
Category			C1000	Jumbo	SdB	Coop	AH
Cleaners	A-brand	Ajax	61	66	37	10	50
		CITRONELLA			37		
		WITTE REUS	61	66		10	50
	Private label	Albert heijn					50
		C1000	61				
		JUMBO		66			
		MARKANT				10	
		O'LACY		66			
		PERFEKT					
		SUPER			37		
Coffee	A-brand	Douwe egberts			37	10	50
		KANIS & GUNNINK	61	66	37	10	50
		VAN NELLE SUPRA	61	66			
	Private label	C1000	61				
		HOOGVLIET					
		JUMBO		66			
		MARKANT				10	
		PERLA					50
		SUPER DE BOER			37		
Cola	A-brand	Coca cola	61	66	37	10	50
		PEPSI	61	66	37	10	50
	Private label	Albert heijn					50
		C1000	61				
		JUMBO		66			
		MARKANT				10	
		O'LACY		66			
		PERFEKT					
		SUPER			37		
Diapers	A-brand	Huggies super dry		66			50
		HUGGIES SUPER FLEX		66			
		PAMPERS BABY DRY		66	37	10	50
		PAMPERS NEW BABY	61				
	Private label	Albert heijn					50
		BUMBLIES				10	

		C1000	61				
		JUMBO		66			
		SUPER			37		
		SUPER DE BOER			37		
Fresh Milk	A-brand	Arla biologisch					50
		BIO PLUS				10	
		CAMPINA	61	66	37		50
		FRIESCHE VLAG	61	66	37	10	
		VECOZUIVEL					
	Private label	Albert heijn					50
		JUMBO		66			
		MELKAN		66		10	
		SUPER			37		
		ZUIVEL	61				
Frikandels	A-brand	Beckers	61	66	37	10	50
		MORA	61		37	10	50
		VAN RIJSINGEN		66			
	Private label	Albert heijn					50
		C1000	61				
		EUROSHOPPER					50
		JUMBO		66			
		MARKANT				10	
		O'LACY		66			
		PERFEKT					
		SUPER			37		
Mayonaise	A-brand	Calve			37		
		REMIA	61	66	37	10	50
		ZAANSE MAYONAISE	61	66		10	50
	Private label	Albert heijn					50
		C1000	61				
		JUMBO		66			
		MARKANT				10	
		O'LACY		66			
		PERFEKT					
		SUPER DE BOER			37		
Olive Oil	A-brand	Bertolli	61	66	37	10	50
		BIO PLUS		66	37	10	
		BIORGANIC					
		MONINI	61				50
	Private label	C1000	61				
		EUROSHOPPER					50
		JUMBO		66			
		MARKANT				10	
		O'LACY'S		66			
		PERFEKT					

		SUPER DE BOER			37		
Sanitary Napkins	A-brand	Always ultra	61			10	
		ALWAYS ULTRA NORMAAL	61			10	
		KOTEX MAXI SUPER		66	37		50
		LIBRESSE INVISIBLE	61	66	37	10	50
	Private label	Albert heijn					50
		C1000	61				
		JUMBO		66			
		NEWWAY		66		10	
		SUPER			37		
Shampoo	A-brand	Guhl	61	66	37		50
		NEUTRAL				10	
		SYOSS SHINE BOOST					
Toiletpaper	A-brand	Edet soft	61	66	37	10	50
		PAGE KUSSENZACHT		66	37	10	50
		PAGE ZACHT EN STERK	61				
	Private label	Albert heijn					50
		C1000	61				
		JUMBO		66			
		MARKANT				10	
		PERFEKT					
		SUPER DE BOER			37		

1.10.4 Local Variation

As explained in Section 1.5.2, in this Appendix we more carefully analyze the geographic extent of price and assortment variability. First, we graphically analyze the price and assortment distributions for different supermarket chains of each SKUs at different points in time by means of boxplots. Second, we compute a coefficient of variation for each SKU and each month. For prices, we first compute the standard deviation of price from SKU's average price of that month. We then divide the price standard deviation of each SKU by the average price of that SKU in order to obtain a measure of the price dispersion independent of the price level. In a similar way, we compute the coefficient of variation for variety. Below, we present a selection of the discussed graphs. Figures 1.5 to 1.9 show the geographic price variability of five SKUs, while figures 1.10 to 1.13 show geographic variability in stores' assortment for four selected categories.

For each SKU (category), the first graph (boxplot) shows the price (variety) dispersion in May 2010, May 2011, May 2012, and May 2013. These graphs allows comparing the price (variety) dispersion of Jumbo with:

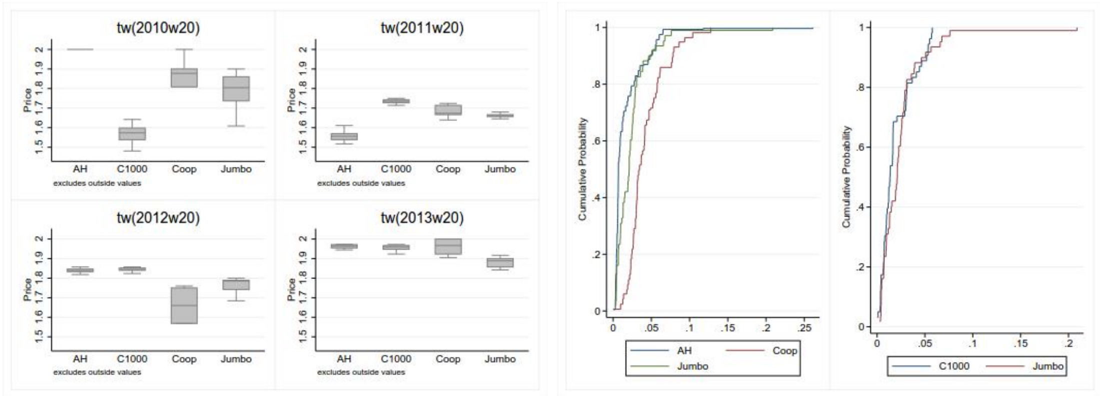
- price (variety) dispersion of the same SKU (category) sold by two competitors: the market leader (Albert Heijn) and a smaller player (Coop). Both reportedly have adopted a national pricing strategy.

- price (variety) dispersion of the same SKU (category) sold by C1000. The data in the graph refer to those C1000 stores that did not change their insignia to the Jumbo's Insignia during the period under study, even after the merger.

The second graph shows the cumulative distribution function of the coefficient of variation for prices (figures 1.5 to 1.9) and variety (figures 1.10 to 1.13) respectively. The coefficient of variation for price (variety) of each SKU (category), for each point in time and for each chain, is computed as the ratio between the price (variety) standard deviation and the average price (variety), and then plotted in a single graph, irrespective of the moment of their measurement. The cumulative distribution function of the coefficient of variation shows the cumulative probability that the coefficient of variation is below a given threshold. If the distribution concentrates around zero, the coefficient of variation over the period of analysis for a given chain and SKU (category) is likely to be low; hence the conclusion is that the chain sets national prices (assortment), i.e. there is no variation across stores. A more evenly distribution, instead, shows that the coefficient of variation is higher than zero. In the latter case, we would expect local prices (variety). The inclusion of the cumulative distribution function of different chains in the same graph allows across-chains comparisons. Chains whose curve is close to the vertical axis, are expected to set national prices (have national assortment) with higher probability than the other chains:

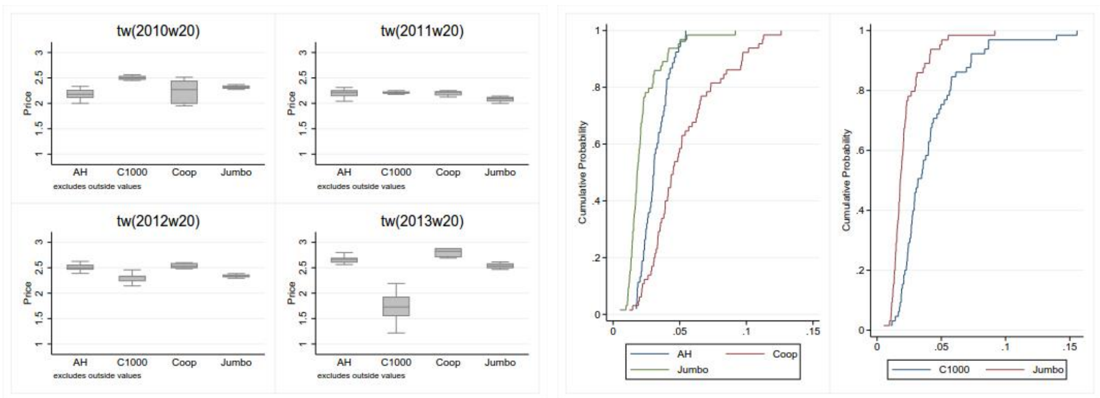
indeed, for that chain, the probability that the variation coefficient is around zero is higher. In the first panel, Jumbo is compared to its competitors Albert Heijn and Coop; in the second panel, Jumbo is compared to the target chain in the acquisition of C1000.

Figure 1.5: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for Ajax (cleaner brand)



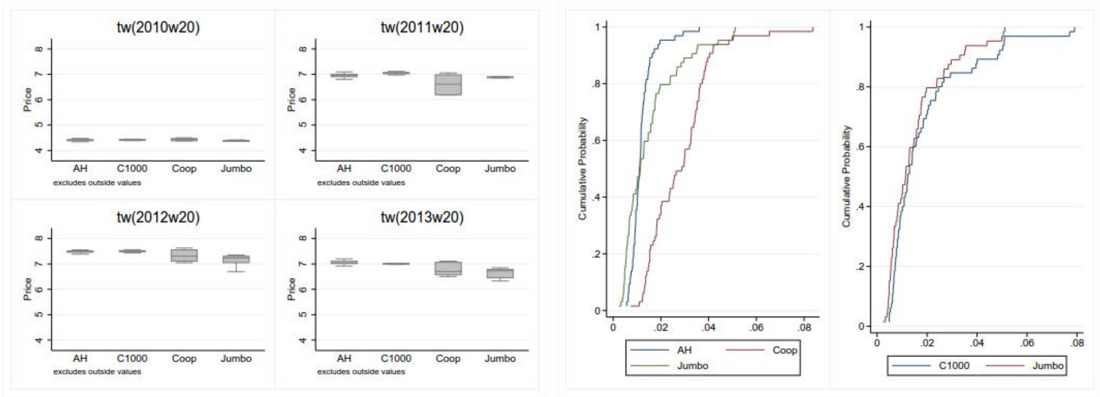
Source: our elaboration on IRI data.

Figure 1.6: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for REMIA (a mayonnaise brand)



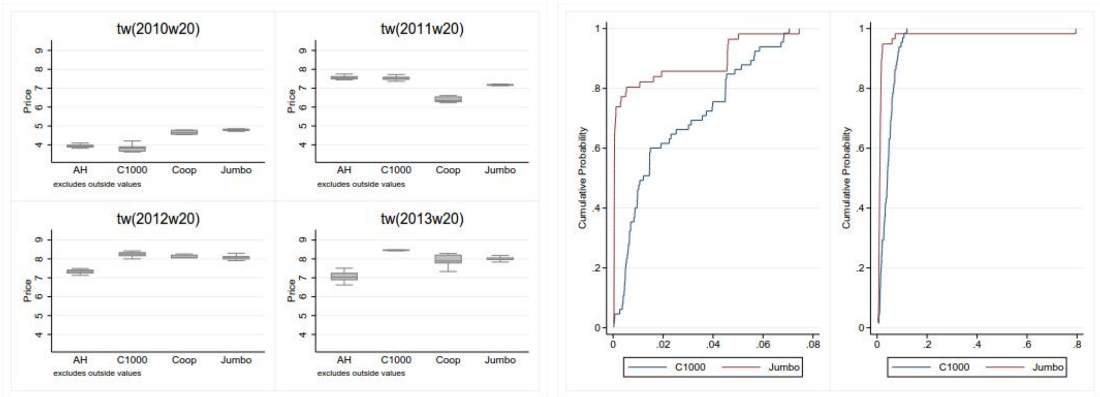
Source: Our elaboration on IRI data.

Figure 1.7: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for Kanis & Gunnink (coffee brand)



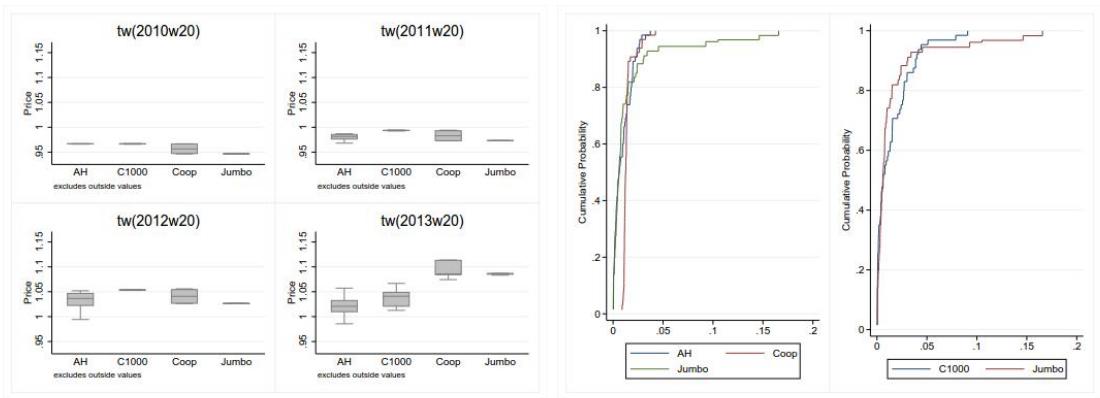
Source: Our elaboration on IRI data.

Figure 1.8: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for private label coffee brands



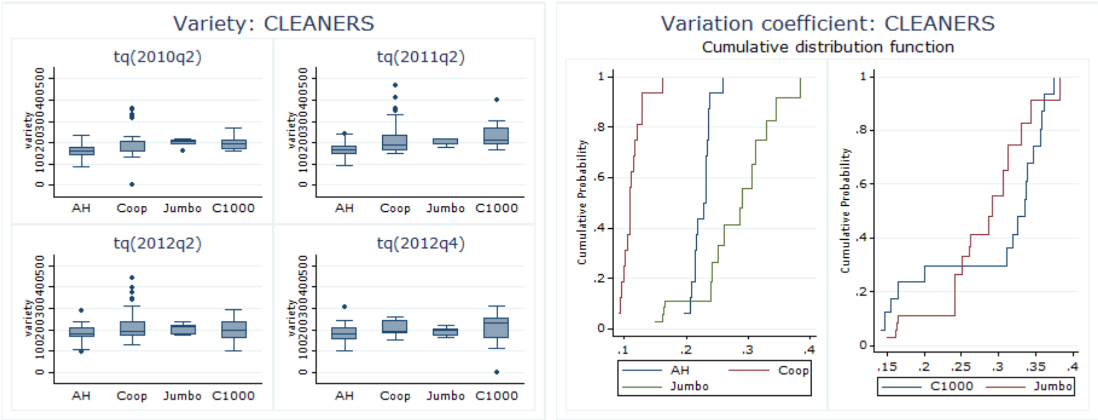
Source: Our elaboration on IRI data.

Figure 1.9: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for Coca cola (brand)



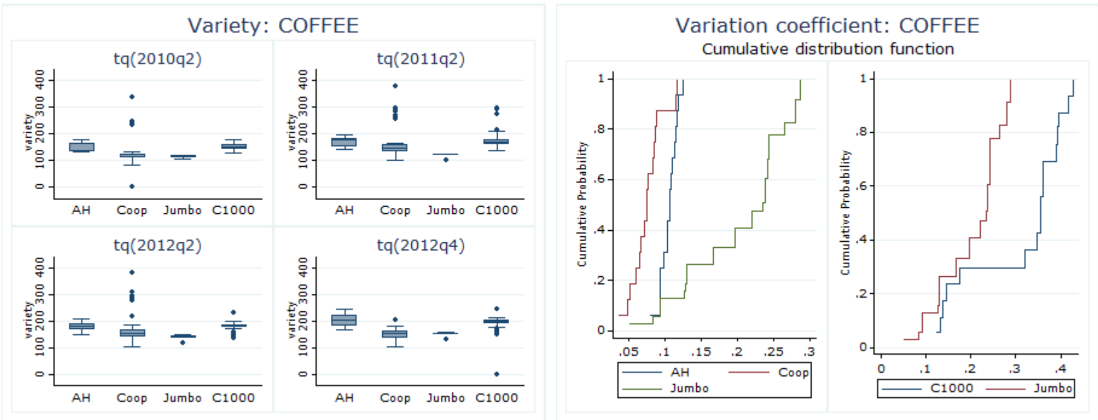
Source: Our elaboration on IRI data.

Figure 1.10: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for the category cleaners)



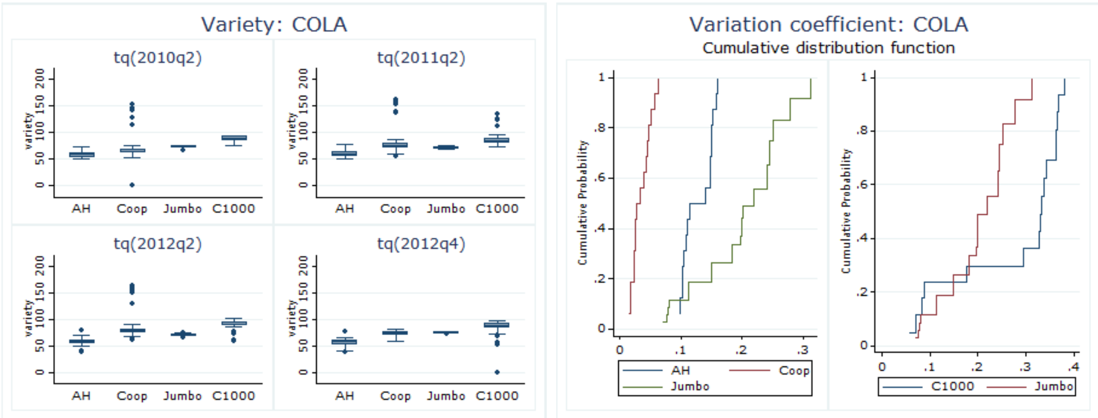
Source: our elaboration on IRI data.

Figure 1.11: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for the category coffee



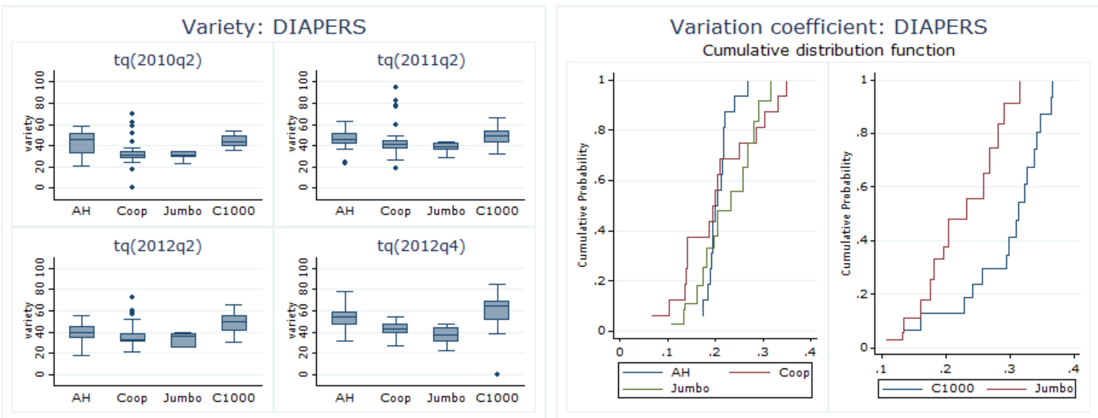
Source: Our elaboration on IRI data.

Figure 1.12: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for the category cola



Source: Our elaboration on IRI data.

Figure 1.13: Box-plot (first panel) and cumulative distribution function of the coefficient of variation (second panel) for the category diapers

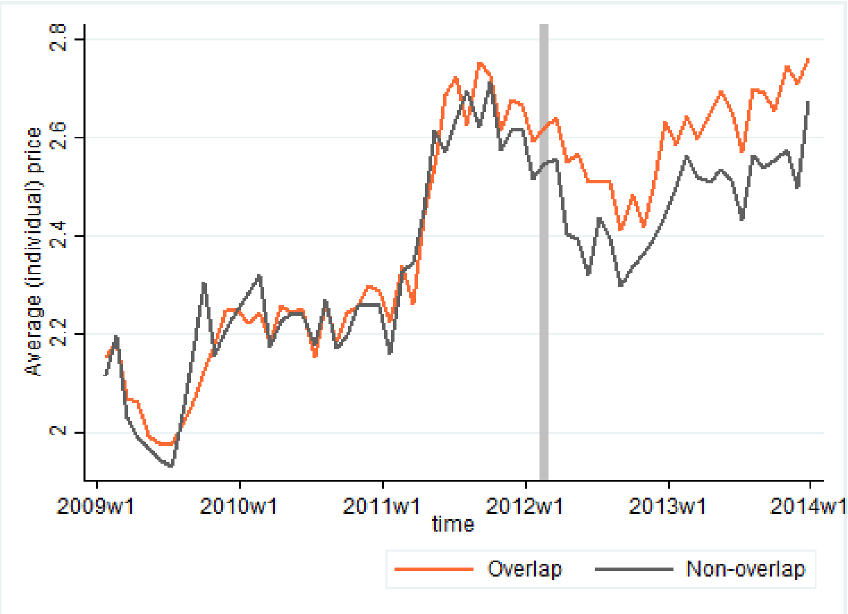


Source: Our elaboration on IRI data.

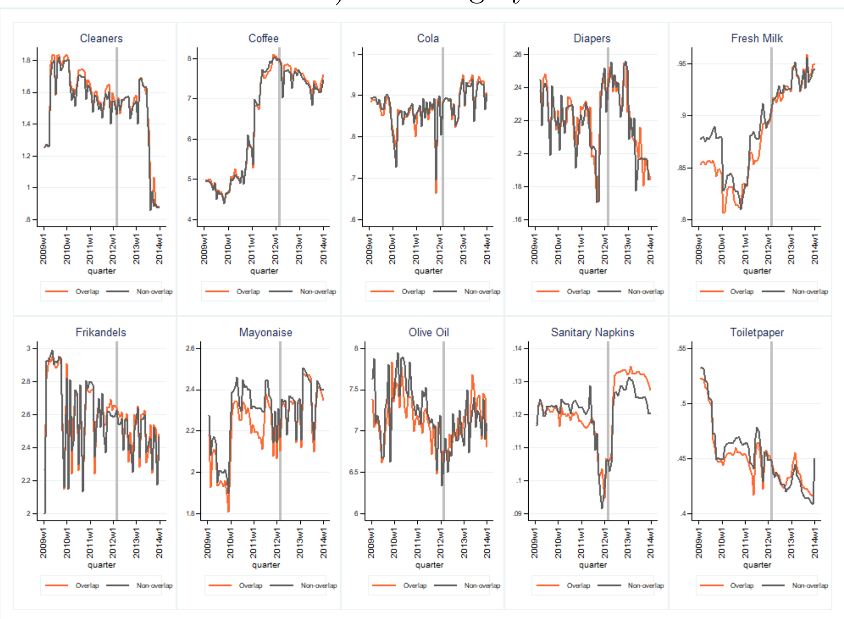
1.10.5 Additional Figures on the Common Trends

Figure 1.14: Trends for individual SKU prices in treated and control areas – Jumbo

a) Across all categories



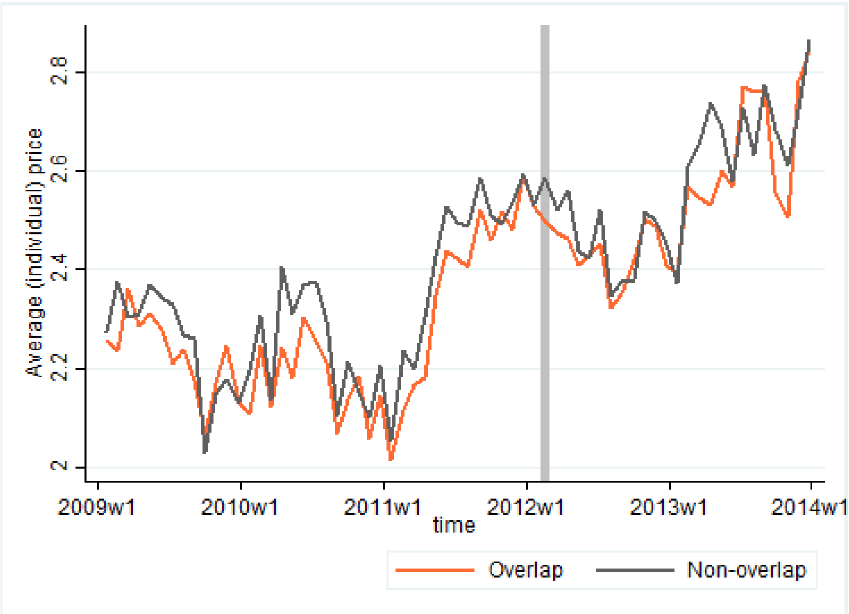
b) Per category



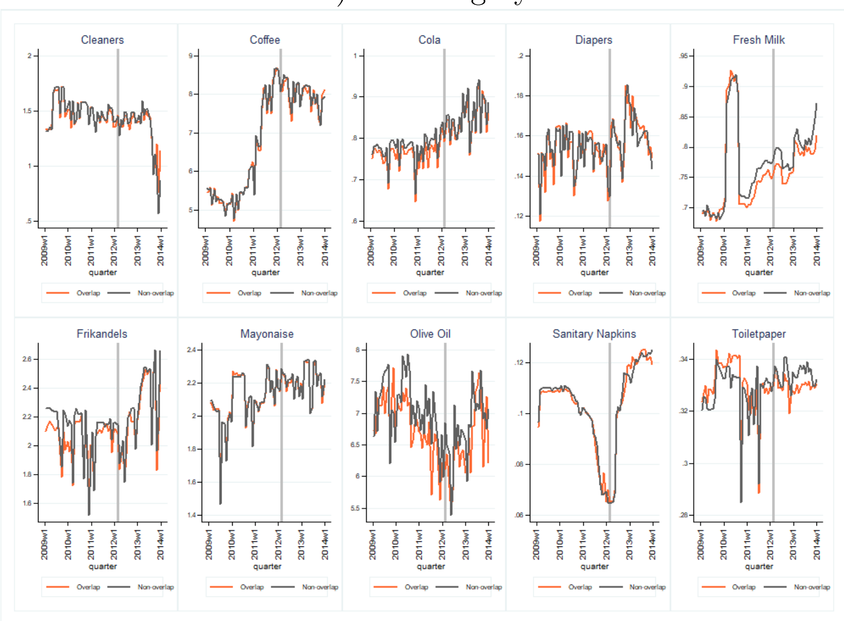
Source: Our elaboration on IRI data

Figure 1.15: Trends for individual SKU prices in treated and control areas – C1000

a) Across all categories



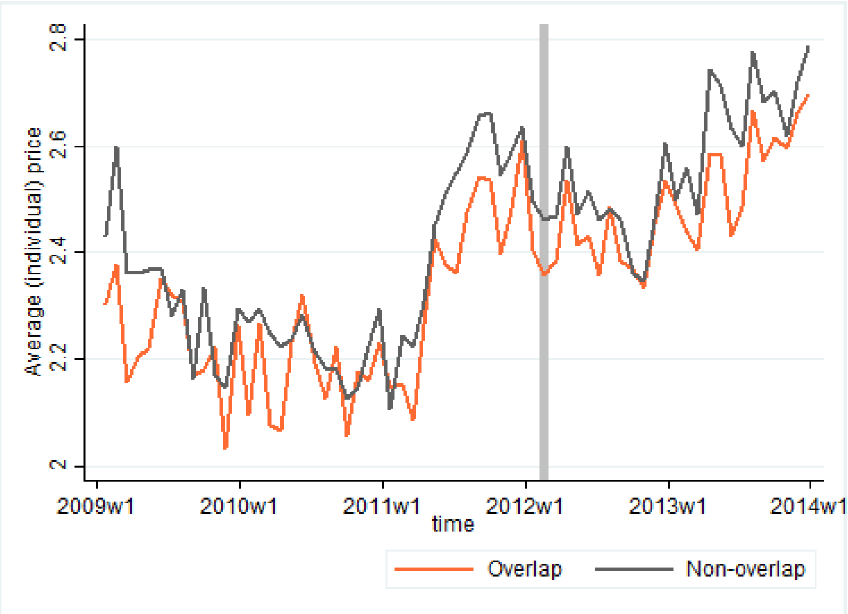
b) Per category



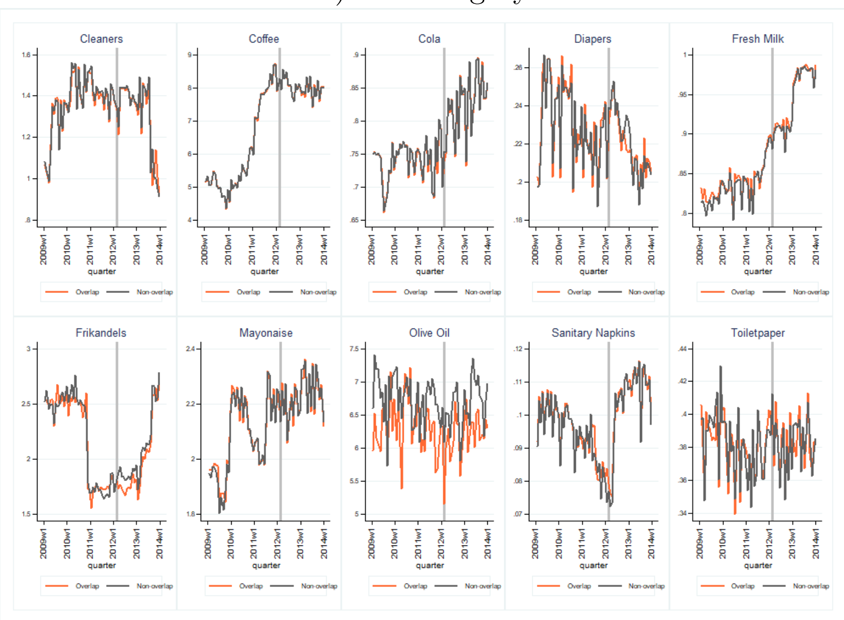
Source: Our elaboration on IRI data

Figure 1.16: Trends for individual SKU prices in treated and control areas – AH & Coop

a) Across all categories



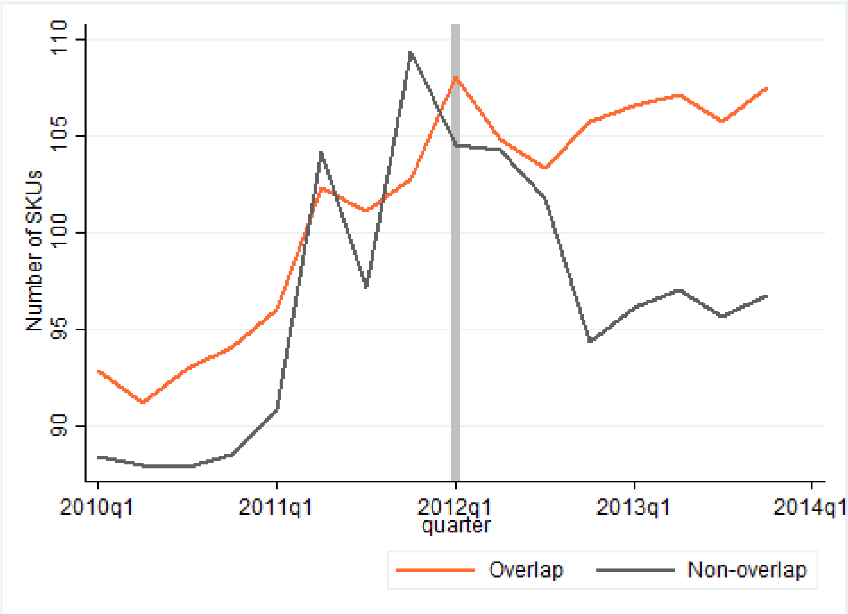
b) Per category



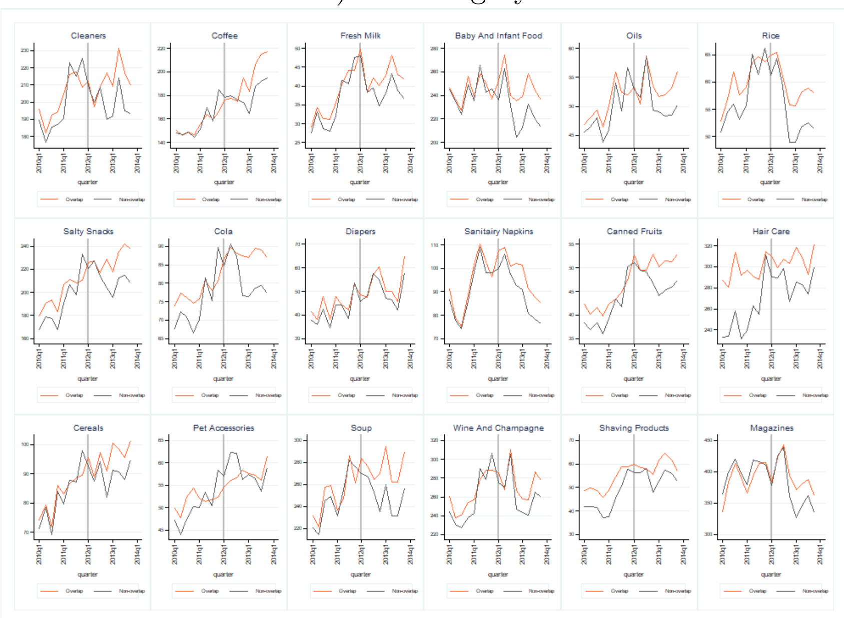
Source: Our elaboration on IRI data

Figure 1.17: Trends for variety in treated and control areas – Jumbo

a) Across all categories



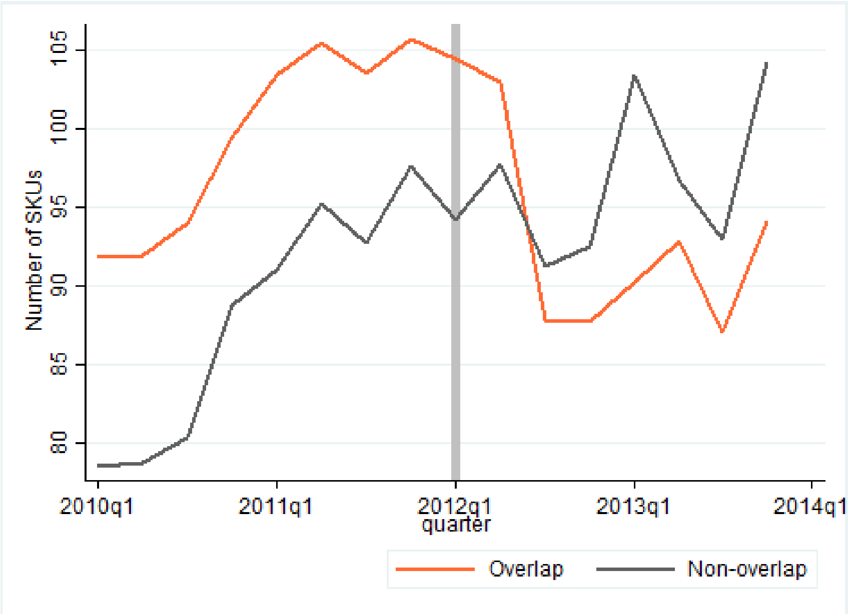
b) Per category



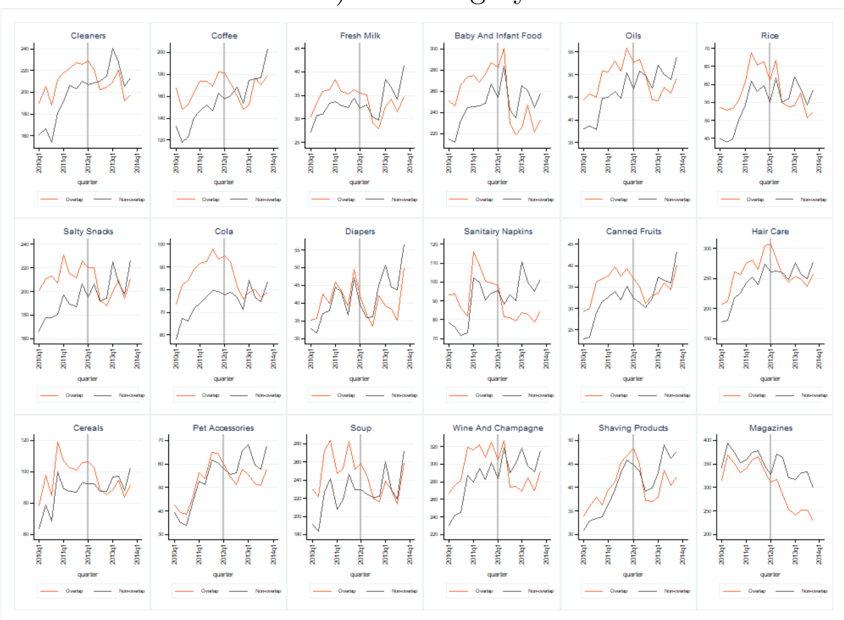
Source: Our elaboration on IRI data

Figure 1.18: Trends for variety in treated and control areas – C1000

a) Across all categories



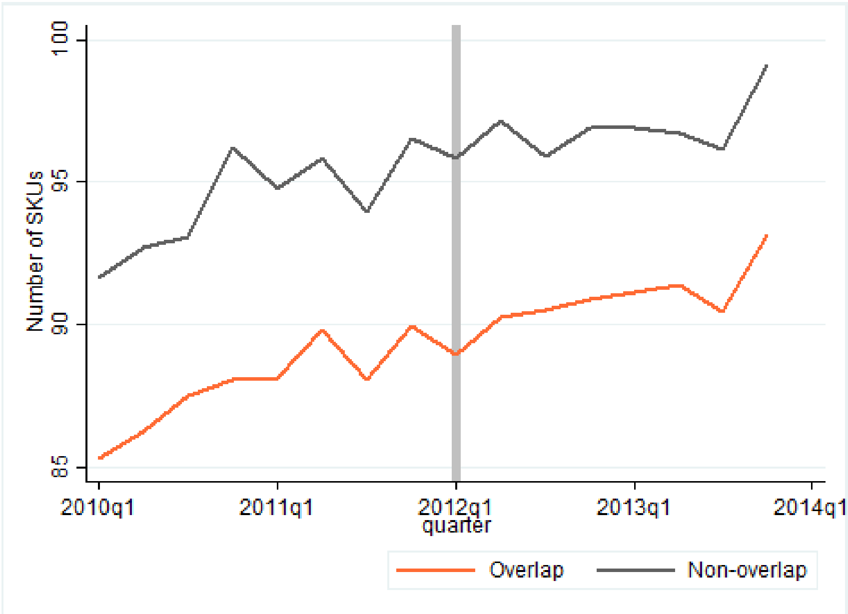
b) Per category



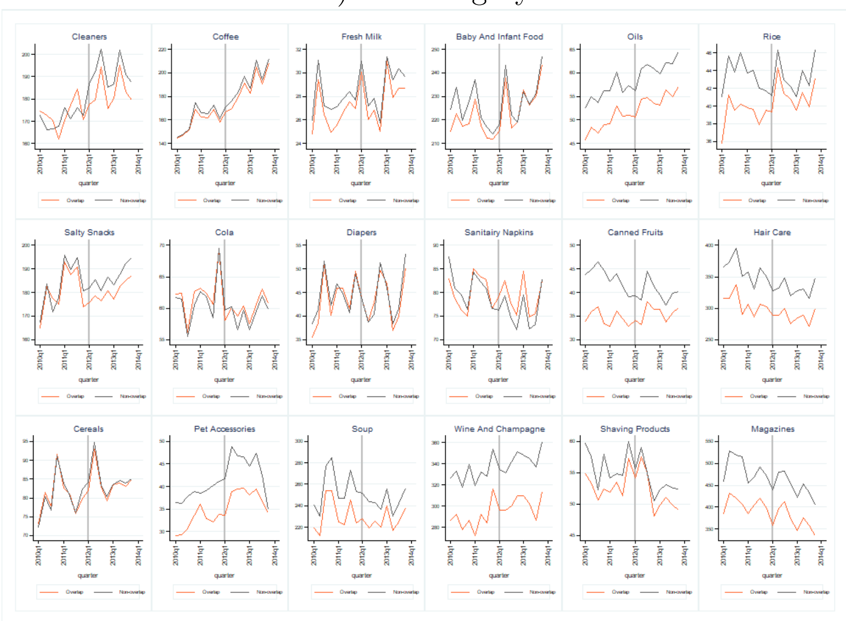
Source: Our elaboration on IRI data

Figure 1.19: Trends for variety in treated and control areas – AH & Coop

a) Across all categories



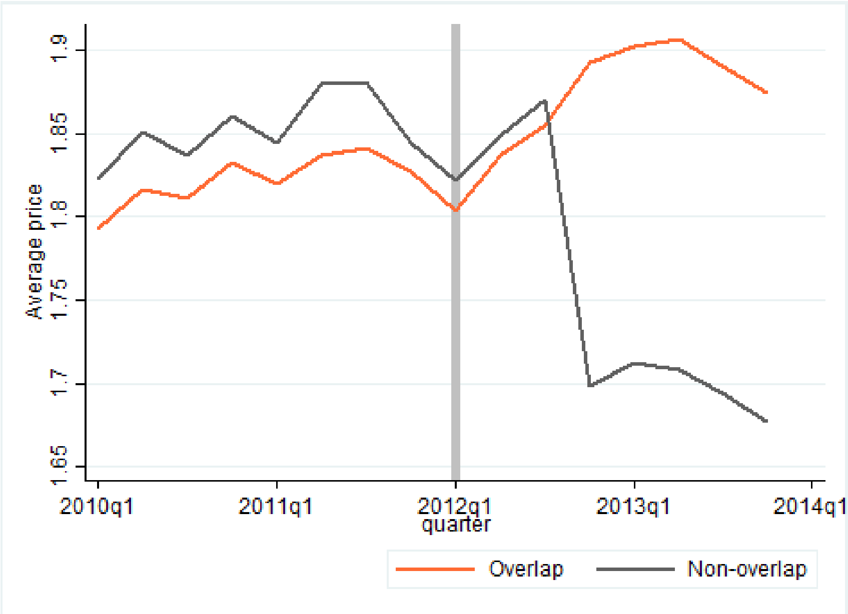
b) Per category



Source: Our elaboration on IRI data

Figure 1.20: Trends for average category prices in treated and control areas – Jumbo

a) Across all categories

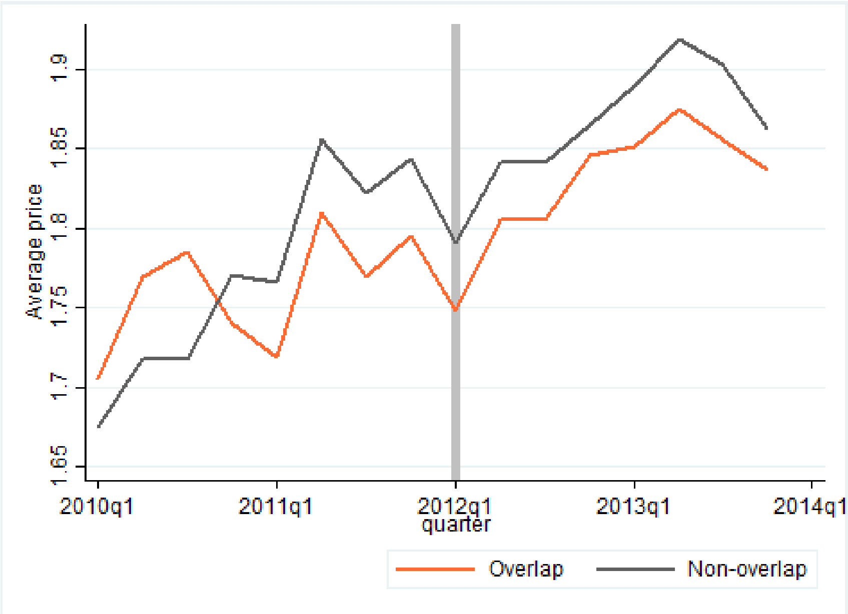


b) Per category

Source: Our elaboration on IRI data

Figure 1.21: Trends for average category prices in treated and control areas – C1000

a) Across all categories

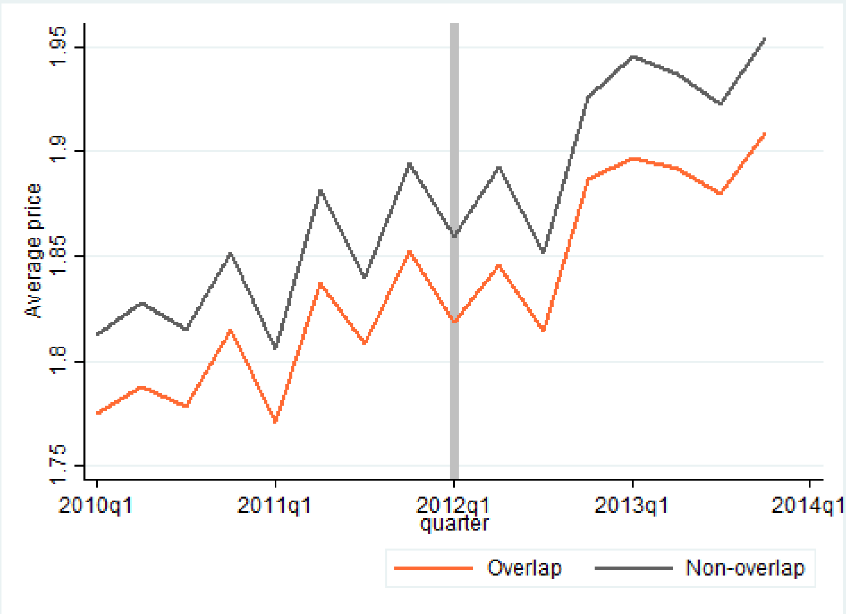


b) Per category

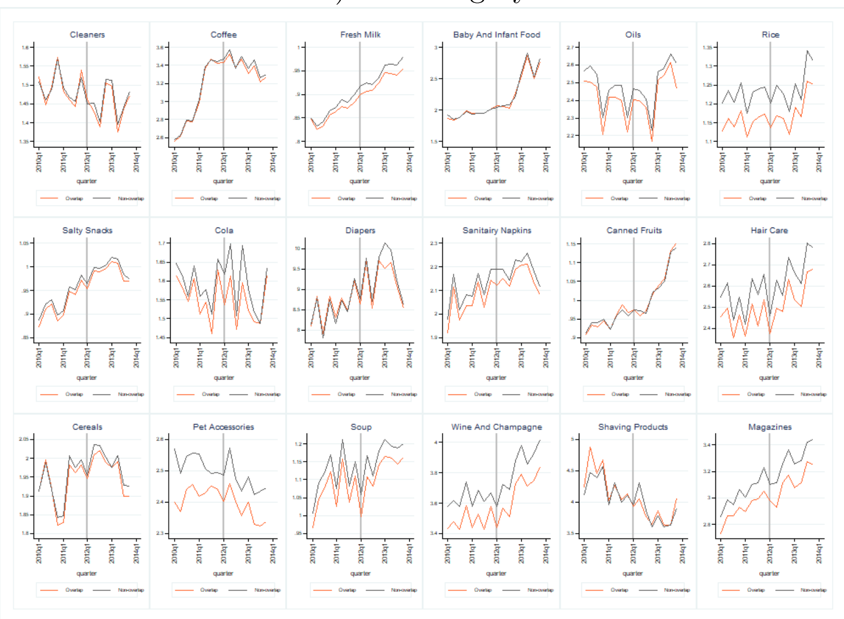
Source: Our elaboration on IRI data

Figure 1.22: Trends for average category prices in treated and control areas – AH & Coop

a) Across all categories



b) Per category



Source: Our elaboration on IRI data

1.10.6 Theoretical model: Additional results and Proofs

Given the modeling assumptions described in Section 6, we can derive the stores' demand and profit functions. Let us start with the demand stemming from v-consumers. We can define $n+1$ indifference points, denoted by w_j, with $j = 0, ..., n$, that partition the set $[0, 1]$ in $n+2$ subsets such that the v-consumer with characteristic w_j is indifferent between buying from store j and store $j+1$. We interpret w_0 as the consumer who is indifferent between shopping at store 1 and not buying at all; similarly w_n identifies the consumer who is indifferent between shopping at store n and not buying. These indifference points are implicitly defined by the following conditions:

$$u(v_{j+1}, w_j) - u(v_j, w_j) = \Delta_j, \tag{1.2}$$

where $\Delta_j = p_{j+1} - p_j$, $u(v_0, w_0) = 0$, $\Delta_0 = p_1$, $u(v_{n+1}, w_n) = 0$ and $\Delta_n = -p_n$. The implicit solutions of equations (1.2) are denoted by $w_j(v_{j+1}, v_j)$. Their relevant characterization is given in the following Lemma.

Lemma 1.10.1 *For any $j = 1, ..., n-1$, $w_j(v_{j+1}, v_j)$ is decreasing in v_{j+1} and increasing in v_j.*

Proof 1.1 *Lemma 1 is proved formally by the sign of the following derivatives:*

$$\frac{\partial w_j(v_{j+1}, v_j)}{\partial v_{j+1}} = -\frac{\frac{\partial u_j(v_{j+1}, w_j)}{\partial v_{j+1}}}{\frac{\partial u_j(v_{j+1}, w_j)}{\partial w_j} - \frac{\partial u_j(v_j, w_j)}{\partial w_j}} < 0$$

as $\frac{\partial u_j(v_{j+1}, w_j)}{\partial v_{j+1}} > 0$ and $\frac{\partial u_j(v_j, w_j)}{\partial w_j} - \frac{\partial u_j(v_{j+1}, w_j)}{\partial w_j} < 0$ by definition (see the meaning of w_i); similarly

$$\frac{\partial w_j(v_{j+1}, v_j)}{\partial v_j} = -\frac{-\frac{\partial u_j(v_j, w_j)}{\partial v_{j+1}}}{\frac{\partial u_j(v_{j+1}, w_j)}{\partial w_j} - \frac{\partial u_j(v_j, w_j)}{\partial w_j}} > 0$$

The results can also be explained intuitively as follows. Let w_j be the consumer indifferent between j and $j+1$, suppose that store $j+1$ increases variety (i.e. v_{j+1} increases), consumer w_j is no longer indifferent between j and $j+1$; she now prefers buying from $j+1$ as the monetary saving she obtains if she buys from j (i.e. Δ_j) does not suffice to offset the increased utility she gets by shopping at $j+1$. Hence, the new indifferent consumer is the one with a less intense preference for variety; this explains why $w_j(v_{j+1}, v_j)$ is decreasing in v_{j+1}. Now suppose that store j increases variety (i.e. v_j increases). Again consumer w_j is no longer indifferent between j and $j+1$; she prefers buying at j because the higher utility she gets if he shops at $j+1$ is no longer sufficient to compensate for the extra-price he has to pay. The new indifferent consumer is the one with a more intense *preference for variety; this explains why $w_j(v_{j+1}, v_j)$ is increasing in v_j.*

All consumers with $w_i > w_j(v_{j+1}, v_j)$ prefer buying from store $j+1$, while all those with $w_i < w_j(v_{j+1}, v_j)$ prefer buying from store j. Hence, demand for store $j = 1, ..., n$ stemming from v-consumers is:

$$q_{vj}(v) = \alpha [G(w_j) - G(w_{j-1})].$$

We assume that all v-consumers are served and therefore that $G(w_n) = 1$ and that $G(w_0) = 0$.

Let us now turn to h-consumers. Again, we have to partition the set of h-consumers in $n+2$ sub-sets. To do so, we have to identify $n+1$ indifference points h_j $(j = 0, ..., n)$ such that a consumer located at $h_j \in [0, 1]$ is indifferent between shopping at j and $j+1$. h_0 and h_n have the same interpretation as the one given for v-consumers. These indifferent consumers are identified by the following conditions:

$$b(h_j) - t(d(h_j, v_j)) - p_j = b(h_j) - t(d(h_j, v_{j+1})) - p_{j+1}$$

that can be written as:

$$t(d(h_j, v_j)) - t(d(h_j, v_{j+1})) = \Delta_j \tag{1.3}$$

Equations (1.3) implicitly define the indifferent consumers, denoted as $h_j(v_j, v_{j+1})$.

Lemma 1.10.2 *For any $j = 1, ..., n-1$, $h_j(v_j, v_{j+1})$ is increasing both in v_j and in v_{j+1}.*

Proof 1.2 *It is apparent that $h_j(v_j, v_{j+1}) \geq v_j$. Indeed, Δ_j is positive, as we assumed that $p_{j+1} > p_j$, and the expression $t(d(h_j, v_j)) - t(d(h_j, v_{j+1}))$ would be negative if $h_j(v_j, v_{j+1}) < v_j$, as $d(h_j, v_{j+1}) > d(h_j, v_j)$ and $t(\cdot)$ is an increasing function in $d(\cdot)$. Hence condition (1.3) cannot hold if $h_j(v_j, v_{j+1}) < v_j$. Given this and the assumption that $h_j(v_j, v_{j+1}) < v_{j+1}$, Lemma 2 is formally proved by the sign of the following derivatives:*

$$\frac{\partial h_j(v_{j+1}, v_j)}{\partial v_j} = -\frac{-\frac{\partial t}{\partial d}\frac{\partial d(h_j, v_j)}{\partial v_j}}{\frac{\partial t}{\partial d}\frac{\partial d(h_j, v_{j+1})}{\partial h_j} - \frac{\partial t}{\partial d}\frac{\partial d(h_j, v_j)}{\partial h_j}} > 0$$

as $\frac{\partial t}{\partial d} > 0$, $\frac{\partial d(h_j, v_j)}{\partial v_j} < 0$, $\frac{\partial d(h_j, v_{j+1})}{\partial h_j} < 0$ and $\frac{\partial d(h_j, v_j)}{\partial h_j} > 0$; similarly

$$\frac{\partial h_j(v_{j+1}, v_j)}{\partial v_{j+1}} = -\frac{\frac{\partial t}{\partial d}\frac{\partial d(h_j, v_{j+1})}{\partial v_{j+1}}}{\frac{\partial t}{\partial d}\frac{\partial d(h_j, v_{j+1})}{\partial h_j} - \frac{\partial t}{\partial d}\frac{\partial d(h_j, v_j)}{\partial h_j}} > 0$$

as $\frac{\partial d(h_j, v_{j+1})}{\partial v_{j+1}} > 0$. *Again Lemma 2 can be intuitively explained. Let* h_j *be the consumer indifferent between* j *and* $j+1$, *suppose that store* $j+1$ *increases variety (i.e.* v_{j+1} *increases), consumer* h_j *is now more distant from store* $j+1$ *and is no longer indifferent between* j *and* $j+1$; *she now prefers buying from* j. *Hence, the new indifferent consumer is closer to the location of* $j+1$ *and, therefore,* $h_j(v_{j+1}, v_j)$ *increases. Suppose that store* j *offers a higher level of variety (i.e.* v_j *increases). Now consumer* h_j *is closer to store* j *and is no longer indifferent between* j *and* $j+1$; *she prefers buying at* j. *In this case the new indifferent consumer is also closer to* $j+1$; *which explains why* $h_j(v_{j+1}, v_j)$ *is increasing in* v_j.

All consumers with $v_h > h_j(v_{j+1}, v_j)$ prefer buying from store $j+1$, and all those with $v_h < h_j(v_{j+1}, v_j)$ prefer buying from store j. Hence, demand for store $j = 1, ..., n$ stemming from h-consumers is:

$$q_{hj}(v) = (1-\alpha)\left[H(h_j) - H(h_{j-1})\right].$$

Again, we assume that all h-consumers are served and, therefore, that $H(h_n) = 1$, and that $H(h_0) = 0$.

The profit function of store $j = 1, ..., n$ is:

$$\pi_j(v) = p_j\left(q_{vj}(v) + q_{hj}(v)\right) - c(v_j).$$

Now suppose that stores j $(j = 1, .., n-k)$ and $j+k$ merge. Before proving the propositions stated in section 6, we prove that a merger between "distant competitors" (i.e. when $k \geq 2$) does not affect variety.

Proposition 1.2 *A merger between two distant competitors does not affect the level of variety offered in the market.*

Proof 1.3 *Post-merger the new entity maximizes the following profit function:*

$$\pi_m(v) = p_j q_j(v) + p_{j+k} q_{j+k}(v) - c(v_j) - c(v_{j+k})$$

The FOCs of this maximization problem are:

$$\frac{\partial \pi_m(v)}{\partial v_j} = p_j \frac{\partial q_j(v)}{\partial v_j} - \frac{\partial c(v_j)}{\partial v_j} + \frac{\partial q_{j+k}}{\partial v_j} = 0; \tag{1.4}$$

$$\frac{\partial \pi_m(v)}{\partial v_{j+k}} = p_{j+k} \frac{\partial q_{j+k}(v)}{\partial v_{j+k}} - \frac{\partial c(v_{j+k})}{\partial v_{j+k}} + \frac{\partial q_j}{\partial v_{j+k}} = 0. \tag{1.5}$$

If $k \geq 2$, we have that

$$\frac{\partial q_{j+k}}{\partial v_j} = 0 \text{ and } \frac{\partial q_j}{\partial v_{j+k}} = 0.$$

Hence the v_j and v_{j+1} that solve the new entity's maximization problem are the same as the one that solve the maximization problem faced by the two stores pre-merger. Since the other store's maximization problem is not directly affected by the merger, it follows that the pre-merger equilibrium profile remains an equilibrium post-merger.

Intuitively, the consequence of the merger is to internalize the effect that the decision concerning variety has on the other merging party. Since the demand obtained by a store j depends only on the level of variety set in the same store and in the two closest stores, $j+1$ and $j-1$, a merger between two distant competitors does not alter the merging parties' incentives as the effects of a change in variety remain external effects.

We can now prove the proposition in the text that is reported here for the sake of exposition.

Proposition 1.3 *After a merger between two close competitors, the new entity decreases variety in the low-variety store. The new entity decreases variety in the high-variety store only if there are "many" v-consumers.*

Proof 1.4 *The new entity maximization problem and the FOCs are those described in the proof of Proposition E1. However, in this case $k = 1$. The low-variety store, j , has an incentive to decrease variety if the FOC (1.4) is negative at the pre-merger equilibrium profile. We know that, by definition, at the pre-merger equilibrium*

$$p_j \frac{\partial q_j (v)}{\partial v_j} - \frac{\partial c (v_j)}{\partial v_j} = 0.$$

Hence, the sign of the derivative depends on the sign of $\frac{\partial q_{j+1}}{\partial v_j}$, where we have replaced k with 1. Computing this derivative we get:

$$\frac{\partial q_{j+1}}{\partial v_j} = -\alpha \frac{\partial G}{\partial w_j} \frac{\partial w_j}{\partial v_j} - (1-\alpha) \frac{\partial H}{\partial h_j} \frac{\partial h_j}{\partial v_j}.$$

Both G and H are increasing function by definition. Moreover from Lemmas 1 and 2 we know that $\frac{\partial w_j}{\partial v_j} > 0$ and that $\frac{\partial h_j}{\partial v_j} > 0$. This proves that $\frac{\partial q_{j+1}}{\partial v_j} < 0$ and, therefore, that the low-variety store has an incentive to decrease variety post-merger. We can repeat the same reasoning for the high-variety store. In this case, the relevant FOC is (1.5) and the relevant sign is the sign of $\frac{\partial q_j}{\partial v_{j+1}}$. We have that:

$$\frac{\partial q_j}{\partial v_{j+1}} = \alpha \frac{\partial G}{\partial w_j} \frac{\partial w_j}{\partial v_{j+1}} + (1-\alpha) \frac{\partial H}{\partial h_j} \frac{\partial h_j}{\partial v_{j+1}}. \tag{1.6}$$

Again we know that G and H are increasing functions; however from Lemmas 1 and 2 we know that $\frac{\partial w_j}{\partial v_{j+1}} < 0$ and that $\frac{\partial h_j}{\partial v_{j+1}} > 0$. Hence the sign of (1.6) is not unambiguously determined. The post-merger choice on variety of the high-variety store depends on the relative strength of the two effects just identified. In any case, we can define a threshold value of α, denoted with α^*, such that:

$$\frac{\alpha^*}{1-\alpha^*} = \frac{\partial H}{\partial h_j}\frac{\partial h_j}{\partial v_{j+1}} / \frac{\partial G}{\partial w_j}\frac{\partial w_j}{\partial v_{j+1}}$$

and we say that there are "many" v-consumers if $\alpha > \alpha^*$. From all of the above it stems that if there are many v-consumers the sign of (1.6) is negative and the high-variety store will decrease variety after the merger. If $\alpha = \alpha^*$ the merger will have no impact on the variety offered in the high-variety store. Finally if there are few v-consumers (i.e. $\alpha < \alpha^*$) the high-variety store increases variety post-merger.

1.10.7 Additional Heterogenous Effects and Robustness Checks

Table 1.10: Heterogenous Effects of Rebranding

	(1) Price	(2) Variety	(1) Average Price
Post	-0.0857***	0.368	-0.0183
	(0.024)	(0.657)	(0.012)
Overlap	-0.00750	10.27***	0.0218*
	(0.018)	(1.183)	(0.011)
Overlap×Post	0.0103	-9.202***	-0.0535**
	(0.062)	(0.959)	(0.017)
Overlap×Post×No re-branding	-0.0180	-7.584***	0.0248
	(0.061)	(0.848)	(0.017)
Population	-0.000197	-0.153***	-0.000422*
	(0.000)	(0.021)	(0.000)
Average Income	0.000613	-0.718***	-0.00435
	(0.003)	(0.151)	(0.003)
Discounters Market Share	0.0162	-18.22***	0.0587
	(0.033)	(2.692)	(0.032)
HHI	-0.000119	-0.233***	0.000448
	(0.000)	(0.028)	(0.000)
Net Sales Floor	0.00000957	0.804***	0.0000163**
	(0.000)	(0.088)	(0.000)
House Value	0.0000528	0.0346***	0.000449***
	(0.000)	(0.006)	(0.000)
No-rebranded store	0.00230	6.543***	-0.0134
	(0.012)	(0.809)	(0.008)
Quarter	0.0351***	0.962***	0.0164***
	(0.003)	(0.153)	(0.001)
Constant	-5.329***	-34.58	-0.400
	(0.691)	(31.451)	(0.225)
Observations	48,362	90,484	77,605
R^2	0.9510	0.8347	0.8412

We only present regressions for C1000. Clustered-robust standard errors at the product/category-insignia level in parentheses depending on the outcome variable. We control for fixed effect at the product/category-insignia level (depending on the outcomes) as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.11: Interaction with high concentration: Price

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-0.104***	-0.0835**	-0.104***	-0.137***
	(0.016)	(0.026)	(0.030)	(0.028)
Overlap	-0.00728	-0.00599	-0.00739	-0.0124
	(0.011)	(0.017)	(0.022)	(0.020)
Overlap×Post	0.00482	-0.000989	0.0186	0.00822
	(0.029)	(0.050)	(0.042)	(0.050)
Overlap×Post× HHI > 4000	-0.0113	-0.0112	-0.0506	0.0203
	(0.038)	(0.069)	(0.055)	(0.088)
Population	-0.000184	-0.000193	-0.000102	-0.0000103
	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	0.00187	0.000535	0.00194	0.00308
	(0.002)	(0.003)	(0.004)	(0.002)
Discounters Market Share	0.0391	0.0168	0.0751	0.0879
	(0.022)	(0.029)	(0.082)	(0.047)
Net Sales Floor	0.00000364	0.00000890	-0.00000154	-0.00000107
	(0.000)	(0.000)	(0.000)	(0.000)
House Value	0.0000178	0.0000486	0.0000218	-0.0000102
	(0.000)	(0.000)	(0.000)	(0.000)
HHI > 4000	-0.00324	-0.00868	0.0428	-0.0184
	(0.031)	(0.049)	(0.050)	(0.064)
Quarter	0.0388***	0.0350***	0.0346***	0.0453***
	(0.002)	(0.003)	(0.004)	(0.004)
Constant	-6.145***	-5.313***	-5.371***	-7.469***
	(0.465)	(0.691)	(0.927)	(0.837)
Observations	122,213	48,362	30,279	43,572
R^2	0.9532	0.9510	0.9612	0.9514

Clustered-robust standard errors at the product-insignia level in parentheses. We control for fixed effect at the product-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.12: Interaction with high concentration: Variety

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-2.120***	2.720***	-6.962***	-1.339
	(0.536)	(0.756)	(1.058)	(0.769)
Overlap	3.359***	12.97***	0.337	-3.705***
	(0.548)	(1.399)	(0.381)	(0.862)
Overlap×Post	-2.299***	-15.82***	12.29***	1.152***
	(0.340)	(1.620)	(1.298)	(0.291)
Overlap×Post×HHI > 4000	-2.217***	2.836*	-10.76***	-6.580***
	(0.657)	(1.107)	(1.712)	(1.587)
Population	-0.0664***	-0.103***	0.0386**	-0.00327
	(0.010)	(0.016)	(0.013)	(0.015)
Average Income	0.409***	-0.640***	-0.996***	2.039***
	(0.095)	(0.141)	(0.183)	(0.248)
Net Sales Floor	0.384***	0.689***	0.0400*	0.139***
	(0.041)	(0.074)	(0.019)	(0.025)
House Value	0.0213***	0.0366***	0.0601***	-0.0223***
	(0.003)	(0.006)	(0.007)	(0.005)
Discounters Market Share	1.864	-10.39***	14.67***	15.85***
	(1.272)	(2.066)	(2.262)	(2.984)
HHI > 4000	-2.506***	-9.293***	4.104***	0.127
	(0.613)	(1.264)	(1.179)	(1.188)
Quarter	0.534***	0.985***	-0.159	0.317**
	(0.110)	(0.154)	(0.116)	(0.116)
Constant	55.19*	-48.85	214.3***	77.22**
	(23.009)	(31.908)	(23.060)	(26.036)
Observations	225667	90484	72056	63127
R^2	.8805652	.8333422	.9048633	.9417944

Clustered-robust standard errors at the category-insignia level in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.13: Interaction with high concentration: Average Price

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-0.0412***	-0.0137	-0.105***	-0.0182**
	(0.005)	(0.013)	(0.008)	(0.006)
Overlap	-0.00967*	0.0174	-0.00132	-0.0197**
	(0.005)	(0.011)	(0.007)	(0.007)
Overlap×Post	0.0307***	-0.0566***	0.198***	-0.0141
	(0.008)	(0.017)	(0.015)	(0.008)
Overlap×Post×HHI $>$ 4000	-0.0241	0.0742**	-0.219***	0.0344
	(0.013)	(0.026)	(0.021)	(0.020)
Population	-0.000423***	-0.000557**	0.000457*	-0.000390**
	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	0.00159	-0.00368	-0.0133***	0.0124***
	(0.001)	(0.003)	(0.002)	(0.002)
Discounters Market Share	0.0496**	0.0450	-0.0978***	0.147***
	(0.018)	(0.031)	(0.029)	(0.034)
Net Sales Floor	0.00000434	0.0000214***	-0.00000906**	-0.00000274
	(0.000)	(0.000)	(0.000)	(0.000)
House Value	0.000333***	0.000438***	0.000636***	0.000141*
	(0.000)	(0.000)	(0.000)	(0.000)
HHI $>$ 4000	0.0421***	-0.0240	0.173***	-0.0326
	(0.011)	(0.018)	(0.017)	(0.017)
Quarter	0.0102***	0.0167***	0.00229*	0.0103***
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.996***	-0.467*	2.904***	0.812***
	(0.108)	(0.220)	(0.226)	(0.149)
Observations	216060	77605	71960	51881
R^2	.8871619	.8412363	.8916562	.9499007

Clustered-robust standard errors at the category-insignia levell in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.14: Interaction with divestiture: Price

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-0.148***	-0.112***	-0.143***	-0.203***
	(0.019)	(0.029)	(0.038)	(0.035)
Overlap	-0.00678	-0.00723	-0.00463	-0.0127
	(0.009)	(0.014)	(0.020)	(0.016)
Overlap×Post	0.00329	0.00164	0.00641	0.0130
	(0.026)	(0.043)	(0.039)	(0.046)
Overlap×Post×Divestiture	0.00834	0.00551	0.0135	0.0345
	(0.038)	(0.054)	(0.053)	(0.100)
Population	-0.000164	-0.000213	-0.000195	-0.0000617
	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	0.00192	0.000366	0.00120	0.00301
	(0.001)	(0.003)	(0.004)	(0.002)
Discounters Market Share	0.0464*	0.00933	0.0647	0.0979**
	(0.020)	(0.029)	(0.080)	(0.037)
Net Sales Floor	0.00000351	0.00000815	-0.00000215	0.00000143
	(0.000)	(0.000)	(0.000)	(0.000)
House value	0.0000127	0.0000481	0.00000716	-0.0000292
	(0.000)	(0.000)	(0.000)	(0.000)
HHI	0.0000576	-0.000110	0.000148	-0.000190
	(0.000)	(0.000)	(0.000)	(0.001)
Divestiture	-0.00209	0.00202	-0.0156	-0.00801
	(0.014)	(0.019)	(0.027)	(0.031)
Quarter	0.0408***	0.0361***	0.0372***	0.0482***
	(0.003)	(0.004)	(0.005)	(0.005)
Constant	-6.529***	-5.501***	-5.855***	-8.021***
	(0.517)	(0.761)	(1.048)	(0.930)
Observations	109,908	43,645	27,217	39,046
R^2	0.9528	0.9512	0.9600	0.9510

Clustered-robust standard errors at the product-insignia level in parentheses. We control for fixed effect at the product-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.15: Interaction with divestiture: Variety

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-11.24***	-17.28***	-10.17***	-2.002
	(1.498)	(2.025)	(1.647)	(1.288)
overlap	3.438***	11.53***	1.820***	-4.090***
	(0.554)	(1.281)	(0.431)	(0.869)
Overlap×Post	-3.834***	-19.58***	13.86***	0.671*
	(0.447)	(1.925)	(1.407)	(0.314)
Overlap×Post×Divestiture	0.578	10.15***	-16.39***	-3.013***
	(0.297)	(1.217)	(1.709)	(0.478)
Population	-0.107***	-0.167***	0.0192	-0.0490**
	(0.013)	(0.022)	(0.015)	(0.015)
Average Income	0.0457	-1.804***	-1.466***	2.315***
	(0.090)	(0.245)	(0.208)	(0.266)
Net Sales Floor	0.415***	0.916***	-0.121***	0.110***
	(0.043)	(0.095)	(0.024)	(0.022)
House Value	0.0283***	0.0568***	0.0643***	-0.0236***
	(0.004)	(0.008)	(0.007)	(0.004)
Discounters Market Share	-6.851***	-25.91***	-1.795	12.44***
	(1.445)	(3.234)	(1.970)	(2.788)
HHI	-0.104***	-0.257***	0.00937	-0.192***
	(0.013)	(0.030)	(0.011)	(0.039)
Divestiture	-9.926***	-15.54***	-7.161***	-6.563***
	(0.965)	(1.721)	(0.874)	(1.111)
Quarter	1.337***	2.579***	0.244*	0.372*
	(0.171)	(0.289)	(0.113)	(0.145)
Constant	-100.3**	-336.7***	146.9***	67.12*
	(35.841)	(56.505)	(22.743)	(31.699)
Observations	182146	73503	58254	50389
R^2	.8770395	.8333096	.9005832	.9420009

Clustered-robust standard errors at the category-insignia levell in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.16: Interaction with divestiture: Average Price

	(1) Full sample	(2) C1000	(3) Jumbo	(4) Competitors
Post	-0.0464***	0.00577	-0.166***	0.0273***
	(0.008)	(0.014)	(0.016)	(0.007)
Overlap	-0.00378	0.0257*	0.00567	-0.0233***
	(0.004)	(0.010)	(0.008)	(0.006)
Overlap×Post	0.0579***	-0.0391*	0.264***	-0.0127
	(0.009)	(0.015)	(0.020)	(0.009)
Overlap×Post×Divestiture	-0.133***	-0.0276	-0.319***	-0.0389*
	(0.015)	(0.015)	(0.034)	(0.018)
Population	-0.000220*	-0.000629***	0.000794***	-0.000580***
	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	-0.000349	-0.00383	-0.0219***	0.0151***
	(0.001)	(0.003)	(0.003)	(0.002)
Discounters Market Share	0.0705***	0.0732*	-0.185***	0.119***
	(0.018)	(0.031)	(0.040)	(0.028)
Net Sales Floor	-0.00000218	0.0000157*	-0.0000207***	-0.00000465
	(0.000)	(0.000)	(0.000)	(0.000)
House Value	0.000369***	0.000445***	0.000676***	0.0000563
	(0.000)	(0.000)	(0.000)	(0.000)
HHI	0.00128***	0.000457	0.00208***	-0.000180
	(0.000)	(0.000)	(0.000)	(0.000)
Divestiture	0.0202**	0.0204	-0.00271	-0.00121
	(0.006)	(0.011)	(0.011)	(0.013)
Quarter	0.0116***	0.0149***	0.00878***	0.00676***
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.628***	-0.174	1.629***	1.414***
	(0.127)	(0.269)	(0.201)	(0.145)
Observations	174,278	62,979	58,174	53,125
R^2	0.8828	0.8439	0.8825	0.9461

Clustered-robust standard errors at the category-insignia levell in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.17: Robustness:Individual SKU Price

	Full sample		C1000		Jumbo		Competitors	
	3months	6months	3months	6months	3months	6months	3months	6months
Post merger	-0.0927***	-0.0345	-0.0515*	0.0487	-0.0935**	-0.0575	-0.148***	-0.122***
	(0.017)	(0.020)	(0.026)	(0.030)	(0.036)	(0.043)	(0.032)	(0.034)
overlap	-0.00678	-0.00643	-0.00530	-0.00505	-0.00739	-0.00333	-0.0135	-0.0141
	(0.011)	(0.011)	(0.017)	(0.017)	(0.023)	(0.023)	(0.020)	(0.019)
Overlap x Post	0.00256	0.00271	-0.00249	-0.000482	0.00750	0.00524	0.0136	0.0157
	(0.029)	(0.032)	(0.049)	(0.053)	(0.044)	(0.049)	(0.052)	(0.057)
Population	-0.000157	-0.000132	-0.000204	-0.000207	-0.000101	-0.0000865	-0.0000933	-0.0000467
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	0.00179	0.00163	0.0000282	0.000386	0.00118	0.000183	0.00333	0.00340
	(0.001)	(0.001)	(0.003)	(0.003)	(0.004)	(0.004)	(0.002)	(0.002)
Discounters market share	0.0444*	0.0475*	0.0132	0.0189	0.0762	0.0612	0.0810*	0.0993**
	(0.020)	(0.021)	(0.029)	(0.032)	(0.068)	(0.065)	(0.036)	(0.037)
HHI	0.0000500	0.0000921	-0.000137	-0.0000773	0.000225	0.000109	-0.000162	-0.0000549
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Net Sales Floor	0.00000475	0.00000632	0.0000105	0.0000142	-0.000000879	0.000000575	0.00000196	0.00000149
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
House value	0.0000187	0.0000166	0.0000610	0.0000510	0.0000241	0.0000164	-0.0000408	-0.0000401
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
quarter	0.0372***	0.0326***	0.0318***	0.0247***	0.0342***	0.0315***	0.0449***	0.0419***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	-5.800***	-4.864***	-4.627***	-3.216***	-5.234***	-4.754***	-7.378***	-6.735***
	(0.459)	(0.442)	(0.649)	(0.620)	(0.928)	(0.898)	(0.850)	(0.821)
Observations	182399	153658	73141	61854	58382	49297	50876	42507
R^2	.8805479	.8774614	.8400926	.8380834	.8983351	.894747	.9413618	.9408327

Clustered-robust standard errors at the product-insignia level in parentheses. We control for fixed effect at the product-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.18: Robustness:Variety

	Full sample		C1000		Jumbo		Competitors	
	3months	6months	3months	6months	3months	6months	3months	6months
Post merger	-7.035***	-13.13***	-7.950***	-12.36***	-9.855***	-24.30***	-1.861	-4.372
	(1.183)	(2.264)	(1.341)	(2.295)	(1.590)	(3.315)	(1.257)	(2.224)
Overlap	3.263***	3.351***	12.09***	12.48***	0.107	-0.356	-4.398***	-4.496***
	(0.568)	(0.585)	(1.345)	(1.388)	(0.410)	(0.424)	(0.902)	(0.898)
Overlap×Post	-4.449***	-4.254***	-20.03***	-20.79***	11.07***	13.54***	1.030**	0.824*
	(0.500)	(0.504)	(1.981)	(2.060)	(1.165)	(1.409)	(0.313)	(0.335)
Population	-0.0644***	-0.0676***	-0.130***	-0.140***	0.103***	0.126***	-0.00979	-0.00991
	(0.010)	(0.010)	(0.020)	(0.020)	(0.015)	(0.016)	(0.017)	(0.017)
Average Income	0.363***	0.372***	-1.043***	-1.005***	-1.133***	-1.357***	2.153***	2.185***
	(0.097)	(0.099)	(0.181)	(0.181)	(0.190)	(0.204)	(0.256)	(0.258)
Discounters market share	0.253	-0.154	-19.09***	-18.96***	20.05***	19.68***	16.54***	17.42***
	(1.243)	(1.270)	(2.715)	(2.692)	(2.507)	(2.547)	(2.788)	(2.756)
HHI	-0.0681***	-0.0633***	-0.222***	-0.230***	0.0985***	0.124***	-0.130***	-0.125**
	(0.010)	(0.010)	(0.027)	(0.028)	(0.014)	(0.016)	(0.038)	(0.037)
Net Sales Floor	0.399***	0.345***	0.866***	0.902***	-0.132***	-0.241***	0.145***	0.109***
	(0.042)	(0.039)	(0.092)	(0.096)	(0.022)	(0.028)	(0.025)	(0.024)
House value	0.0231***	0.0245***	0.0402***	0.0406***	0.0631***	0.0688***	-0.0172***	-0.0203***
	(0.004)	(0.004)	(0.006)	(0.006)	(0.007)	(0.008)	(0.004)	(0.004)
quarter	0.969***	1.453***	1.902***	2.312***	-0.0231	0.962***	0.337*	0.548**
	(0.148)	(0.224)	(0.229)	(0.313)	(0.121)	(0.186)	(0.141)	(0.208)
Constant	-28.38	-130.4**	-220.3***	-311.0***	188.3***	-2.831	75.34*	31.66
	(30.920)	(47.181)	(46.273)	(64.003)	(23.745)	(36.965)	(30.655)	(44.372)
Observations	182399	153658	73141	61854	58382	49297	50876	42507
R^2	.8805479	.8774614	.8400926	.8380834	.8983351	.894747	.9413618	.9408327

Clustered-robust standard errors at the category-insignia levell in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Table 1.19: Robustness:Average Category price

	Full sample		C1000		Jumbo		Competitors	
	3months	6months	3months	6months	3months	6months	3months	6months
Post merger	-0.0281***	-0.0172	0.0224	0.0402*	-0.115***	-0.163***	0.00372	0.0537***
	(0.007)	(0.009)	(0.015)	(0.018)	(0.011)	(0.019)	(0.006)	(0.010)
overlap	-0.00125	0.00637	0.0337**	0.0459***	-0.00359	0.00427	-0.0243***	-0.0242***
	(0.005)	(0.005)	(0.011)	(0.011)	(0.008)	(0.008)	(0.006)	(0.006)
Overlap x Post	0.0392***	0.0461***	-0.0462**	-0.0567***	0.202***	0.242***	-0.00943	-0.0123
	(0.008)	(0.009)	(0.015)	(0.017)	(0.016)	(0.020)	(0.009)	(0.009)
Population	-0.000148	-0.0000940	-0.000593**	-0.000694***	0.00151***	0.00190***	-0.000509***	-0.000501***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Average Income	0.000845	-0.000821	-0.00469	-0.00547*	-0.0184***	-0.0243***	0.0149***	0.0148***
	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Discounters market share	0.0830***	0.0806***	0.0697*	0.0719*	0.0132	-0.00391	0.126***	0.123***
	(0.018)	(0.018)	(0.032)	(0.032)	(0.029)	(0.030)	(0.028)	(0.028)
HHI	0.00133***	0.00149***	0.000446	0.000417	0.00296***	0.00331***	-0.000146	-0.000141
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Net Sales Floor	-0.00000203	-0.00000304	0.0000189**	0.0000244***	-0.0000222***	-0.0000273***	-0.00000235	-0.00000501
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
House value	0.000340***	0.000387***	0.000456***	0.000476***	0.000678***	0.000799***	0.0000751	0.0000722
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
quarter	0.00928***	0.00859***	0.0134***	0.0125***	0.00196*	0.00481***	0.00838***	0.00436***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	1.073***	1.170***	0.122	0.261	2.877***	2.293***	1.086***	1.843***
	(0.119)	(0.144)	(0.271)	(0.335)	(0.217)	(0.196)	(0.142)	(0.188)
Observations	182399	153658	73141	61854	58382	49297	50876	42507
R^2	.8805479	.8774614	.8400926	.8380834	.8983351	.894747	.9413618	.9408327

Clustered-robust standard errors at the category-insignia level in parentheses. We control for fixed effect at the category-insignia level as well as a time trend and quarterly seasonal dummies. The symbols ***, **, * denote significance level at the 1%, 5%, and 10% significance level, respectively.

Chapter 2

Anticompetitive conduct and investment incentives in the fixed telecoms markets

2.1 Introduction

Telecommunications is an infrastructure industry where the network is an essential input to provide telecoms services to consumers. In the last decade, investments in Next Generation Networks (henceforth "NGNs")[1] have been focal to policy makers attention: promoting fast and ultra-fast internet access for all European household is the target of the Digital Agenda prompted by the European Commission in 2010.[2]

Nowadays, fast, reliable and connected digital networks underpin every part of our business and private lives: few examples are video on demand applications, high definition television, cloud services. The deployment of ultrafast broadband networks that enable a massive increase in bandwidth has become a major issue for regulator and telecom companies.

Telecom markets are characterized by high structural barriers (high economies of scale, high sunk cost) that make investment and full-based facility entry hard to sustain. Following the market liberalization, regulatory policies have typically promoted the entry of alternative operators in the retail telecoms market by mandating access to the existing infrastructure of the incumbent (the former monopolist). This approach has been transposed in the academic literature as the ladder of investment approach ("LOI"): entrants should be progressively encouraged to make investment in network assets which are less and less easily replicable - thus climbing the so called "ladder of investment".

Regulatory tools may be detrimental for infrastructure investment. If the access prices to the legacy copper network are set too low, entrants might prefer relying on the incumbent's network and their incentives to invest in their own infrastructure may be hindered. The LOI requires the regulator to "burn up the rungs" on which the entrant is standing while placing higher rungs (i.e higher level of access) on the investment ladder to neutralize such effect. However, this poses a problem of regulatory credibility commitment and informational requirement: entrants must believe that mandatory access will be temporary and regulator should know when the entrant is ready to move to the higher level of access.

It turns out that setting attractive terms of access to the legacy network to promote short-run competition can hinder entrant firms to invest and also reduce the infrastructure owners' (incumbents) incentives to upgrade their network. Regulatory tools can not

[1]Next Generation Networks (NGNs) are very high bandwidth networks featuring an architecture able to integrate quad-play and high end services. NGNs can include VDSL (very-high-bit-rate digital subscriber line), cable, fiber.

[2]The Europe 2020 Strategy seeks to ensure that, by 2020, (i) all Europeans have access to internet speeds above 30 Mbps and (ii) 50 % or more of European households to subscribe to internet connections above 100 Mbps. See Communication from the Commission to the Europena Parliament, the Council, the European Economic and Social Committee and the Committee of the regions - A Digital Agenda for Europe, available at https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52010DC0245R(01)

only prevent investments in the existing technology, but also investment in a superior technology, thereby delaying the migration from old to new infrastructure technology.

Setting the adequate regulatory framework to foster investment is not an easy task. Regulators should indeed strike the balance betweeen, on one hand, encouraging investment and innovation, giving the investors the long term stability of revenues they seek when making large commitments to infrastructural renewal and, on the other hand, promoting price-orientated service competition and avoiding the assertion of monopoly privileges over these new infrastructure.

When revising the regulatory framework for the new telecommunication networks in 2007, the European Commission (henceforth "EC" or "Commission") has carefully considered whether pursuing a forbearance approach and remove regulatory commitments on the NGNs.[3]

At that time, the EC noted that although broadband penetration rate was increasing in Europe, fiber-to-the-home (FTTH)[4] networks were still very little developed. This was strongly in contrast with Japan and USA, where the take-up of fiber seemed to be driven by intense local competition with electricity utilities in Japan, and strong competition between cable and telephone companies in USA. Infrastructure based competition, rather than service or access-based competition, may have played a role.

The impact assessment explored three main policy options:

- option 1: separate the incumbent's wholesale and retail operation, by way of an accounting, and/or functional and/or structural separation of the infrastructure and service provision;
- option 2: no regulation, which implies removing or restrict sector-specific regulation (forbearance approach);
- option 3: maintain the current model of the framework.

The Commission considered that a modified option 3, where mandatory functional seperation is an exceptional measure available to the national regulator, was the most appropriate option.[5] As to option 2 (regulatory forbearance), the EC noted that the

[3]European Commission, 2007: Impact assessment accompanying the document to the Commission proposal for a Directive of the European Parliament and the Council amending European Parliament and Council Directives 2002/19/EC, 2002/20/EC and 202/21/EC. Available at https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2007:1472:FIN:EN:PDF

[4]Fiber-to-the-x indicates a broadband network using optical fiber to provide all or part of the local loop used for the last mile telecommunications. In case of fiber-to-the-home, fiber reaches the boundary of the living space.

[5]It should be stressed that the European regulatory framework requires national regulator to impose ex-ante remedies only on operators that are found to have significant market power. Starting from 2014, national regulators can identify additional markets susceptible of regulation through the application of

presence of competing alternative infrastructures was key, and in the absence of such infrastructure competition, regulation plays a vital role in setting the right conditions for accessing the incumbent's infrastructure and thereby creating service-based competition. The EC considered that option 2 carried a strong risk of disrupting the level playing field between market players without any clear indication that it would lead to more investment and innovation.

The Review of the Electronic Communications Regulatory Framework carried out in 2016 goes along the same lines. The 2016 Review, indeed, seeks to ensure a more legally certain approach to network access regulation, encourage the re-use of existing civil engineering for infrastructure deployment, the use of commercial agreements including co-investment and access agreement between telecoms operators.[6]

The conflict between regulation, competition and investment has been highly debated in the literature, and there is a wide theoretical literature that investigates the relationship between access pricing and investment in telecoms market. This chapter aims at contributing to the existing literature by illustrating a theoretical model where high access price (to the limit of being excessive from the regulator's point of view) to the legacy copper network spur both entrants' and the incumbent's investment in a superior broadband technology (the fiber).

The discussion is motivated by the investment strategies pursued by the alternative operators in the Slovak fixed telecoms market, following the incumbent's refusal to supply access to its legacy copper network. This chapter is structured as follows. Section 2.2 provides the factual background on the abuse of dominance in the Slovak market. Section 2.3 presents a review of the most relevant literature, focusing on the most recent contributions. Section 2.4 describes the setting of the strategic investment game, while Section 2.5 presents the obtained findings. Section 2.6 and Section 2.7 discuss, respectively, the access price would have been set by the regulator and the conditions under which the incumbent would react to the alternative operators' investment by investing itself. Section 2.8 concludes.

2.2 The abuse of dominant position in the Slovak market

Slovak Telekom (ST) is the fixed incumbent operator of the Slovak market, and started offering broadband services in 2003. In 2004, Slovakia entered the European Union and

the so-called "three criteria test" contained in Article 2 of the EC Recommendation of 9 October 2014 on Relevant Markets Susceptible to Ex-Ante Regulation.

[6]See https://ec.europa.eu/digital-single-market/en/news/review-electronic-communications-regulatory-framework-executive-summaries

adopted the European Directives on national regulation. In 2005, the Slovak telecom regulator, designated ST as holding significant market power in the fixed broadband market and mandated the operator to provide wholesale access to its copper network and to publish a Reference Unbundling Offer (RUO) establishing the conditions under which alternative operators could gain access to its unbundled local loops.[7]

In 2014, the EC fined ST for abusive conduct in the period from August 2005 (date of launch of the first reference unbundling offer) to at least the end of 2010. According to the EC, ST refused to properly supply access to its LLU (e.g. witholding relevant information on the physical site of their local loop unbundling) and engaged in margin squeeze practice (by charging excessively wholesale pricing that would have impeded an equally efficient competitor to enter the market).

Since alternative operators could not get access to the local loop of ST's copper network, they had to look for alternative solutions to provide fixed broadband services:

- Orange Slovensko (hencefort "Orange" or "OSK"), active in the Slovak mobile market since 1997, entered the fixed market by deploying its own fiber network around 2006 and 2007 in urban areas;

- UPC Slovakia, the main cable operator of the country, started offering triple-play services (TV, broaband and voice) in 2006 over its cable networks;

- Slovanet, SWAN and Benestra started acquiring in 2007 smaller and local players, that were using different access technologies (WIMAX, cable, fiber).

Moreover, the evidence collected shows that, after the launch of fibre service by Orange, Slovak Telekom has also announced a similar intent: offering fiber services under the T-Com brand.

The evidence from the Slovak market shows that, by setting excessively high access price to its copper network, the incumbent has provided entrants with incentives to invest in fiber network. The model developed in this chapter sheds light on which are the mechanisms that make this outcome possible.

2.3 Literature review

Existing theoretical studies on the relationship beween access regulation and investment in the broadband market mainly fall into three categories:

[7]The local loop unbundling (LLU) is a regulatory regime that requires the incumbent telephone companies to unbundle the last-mile copper loop to the entrant carriers.

- papers investigating the impact of access pricing on the incumbent's investment in the quality of the existing technology;
- papers investigating the impact of access pricing on the timing of the entrant's investment in the existing technology;
- papers investigating the impact of access pricing on both the incumbent's and the entrant's incentives to invest in a superior technology.

The first and second strand of the literature examines the impact of mandatory local loop unbundling[8] on firms' incentives to invest in the existing technology. The "ladder of investment theory", originally developed by [Cave and Vogelsang, 2003], posits that allowing the entrant to lease some network elements that are difficult to replicate (such as the last-mile copper loop) at the initial stage of competition may encourage them to invest in their own facilities some time later. This argument has been fiercely criticized.

First, many papers proves that mandatory unbundling adversely affects incumbent's incentives to invest into the upgrades and maintenance of existing facilities. [Gayle and Weisman, 2007] show that decreasing - rather than increasing - the unbundling access price can discourage investment in process innovation. [Foros, 2004] examines the interplay between a vertically integrated firm and an independent competitor in the retail market for broadband services. The latter leases access to the network of the vertical integrated firm. The paper shows that, if the two firms do not differ too much with respect to their ability to offer value-added services when the input quality is improved, access price regulation reduces incumbent's incentives to invest. If the vertical integrated firm's ability to offer value added services is much higher than that of the rival, and there is access price regulation, the vertical integrated firm will overinvest to drive the rival out of the market. [Kotakorpi, 2006] shows that when the incumbent's investment generates spillovers to rivals' demand, the incumbent will invest less than the social optimum. When access price is regulated, the problem is exacerbated as the incumbent is not allowed to make profits on access provision. [Vareda, 2010] shows that an increase in access price gives the incumbent higher incentives to invest in quality upgrades, but it discourages cost-reducing investments.[9] The effect of an increase in access price on the aggregate investment will depend on the weight of each type of investment.

Access regulation may also affect the entrant's investment incentives. [Bourreau and Dogan, 2006] shows that mandatory unbundling delays facility-based entry. The paper

[8]See footnote 7.

[9]Quality upgrades allow to increase bandwidth and the number of potential services, by relying on the installation of new fiber optic cables. Cost reducing investments allow to reduce the cost per user, by relying on more sofisticated network equipment. The quality upgrading investment is modelled as a shift in both the incumbent's and entrant's demand function. The cost reducing investment, instead, reduces only the incumbent's costs and it is likely to reduce the rival's number of subscribers.

also argues that sunset clauses - i.e. clauses specifying ex-ante a period of time after which the incumbent's network will be no longer regulated - are not effective: in a unregulated environment, when the threat of facility-based entry becomes likely, the incumbent will prefer charging attractive access prices to its network, therefore further delaying entrant's investment. The author suggests that the appropriate policy for regulators is to commit to ban unbundled access when facility-based entry becomes feasible. [Avenali et al., 2010] show instead that an access price that rises over time is critical to foster alternative operators' investment.

This chapter mainly contributes to the third strand of the literature, which examines the relationship between access regulation and investment incentives in a superior technology. The most recent contributions to this strand are listed below.

[Bourreau et al., 2012] analyse the investment decision of both an incumbent and an entrant. They develop a sequential investment game in which the incumbent moves first. At the beginning of the game, both firms rely on the incumbent's old generation network. The entrant pays an access price, which is exogenous and set by the regulator. The original feature of the model is that firms are assumed to invest in a continuum of areas, and investment costs vary across areas. The paper shows that high access price increases entrant's investment, while the effect on the incumbent's investment may be ambiguous. The latter is due to the presence of two opposite effects: the "retail-level migration effect" and the "wholesale-revenues effect". When the access price to the old generation network is low, the price of the retail services based on the old generation network is low, and the incumbent will need to set relatively low prices for the retail services based on the new generation network, as to attract consumers. This reduces the profitability of investing in the new generation network. The wholesale-revenue effect works in the opposite direction. When the access price to the old generation network is low, the opportunity cost of investing in the new generation network is low since the foregone wholesale revenues will be low. This increases the profitability of investing in the new generation network.

[Inderst and Peitz, 2012] develop a strategic investment game in which both the incumbent and the entrant will simultaneously make their investment decisions given the decision of their respective competitor. There is no duplication of investments: investment costs relative to demand are assumed too high to make network expansion profitable for more than one of the two firms. Investment costs are symmetric, the access price to the incumbent's network is exogenously set by the regulator. The authors show that, when access to the new technology is not mandated, a higher access price for the old technology leads to stronger investment's incentives for the entrants and weaker investment's incentives for the incumbent.[10]

[Brito et al., 2012] analyse the incentives of an incumbent and an entrant to invest and to give access to a new technology. They develop a two stage game: in stage 1, both firms decide whether to invest, if only one firm invests, it makes an access price offer to the rival; in stage 2, if one of the firms did not invest, it chooses which technology to use, if any. The entrant and the incumbent have the same investment costs, the access price to the old technology of the incumbent is exogenous. The authors show that if the investment cost is low, there is a unique equilibrium where both firms invest. If the investment cost is high, either there is a unique equilibrium when the entrant alone invests, or two equilibria coexist: in one the incumbent alone invests, and in the other the entrant alone invests. The case where the entrant alone invests occurs for a larger set of parameter values. This occurs because the incumbent pays a lower access price when it asks for access to the new technology since, differently than the entrant, it has an outside option of using its own old technology at a zero access price.

The original feature of this chapter is that access price is endogenous and set by the incumbent. The purpose of the model is indeed to explain the mechanism through which an abuse of dominant position can affect investment incentives. The abuse of dominance is transposed into the model by allowing the incumbent to arbitrarily set the access price to its own (old) technology. This chapter also differs from the reviewed literature by taking the following approach: (i) both the incumbent and the entrant simultaneously make their investment decision in the new technology, (ii) there is asymmetric information on investment costs, (iii) investment can be duplicated and finally (iv) access to the new technology is not granted.

2.4 The setting

There are two firms, an incumbent (firm I) and an entrant (firm E), competing in the retail telecoms market to provide broadband services. At the beginning of the game, the incumbent relies on its legacy copper network (the old generation network, OGN) to provide retail services. The entrant may instead decide to lease access to the incumbent's copper network at the unit price $a \geq 0$, or to invest in a superior infrastructure (the next generation network, NGN). The access price a is set by the incumbent.

[10] This applies both in case of drastic and non-drastic innovation. In the latter case, however, the authors assume that the incumbent is subject to access regulation only when it does not invest. When it invests, it will act as a monopolist.

2.4.1 Demand for broadband services

Similarly to [Bourreau et al., 2012], this model adopts the competitive setting of quantity competition with quality differentiation from [Katz and Shapiro, 1985]. The indirect utility function of a consumer of type τ is $U = \tau + s_j - p_j$, where s_j and p_j denote the quality and price of firm j, with $j = i, e$. Consumers' type is uniformly distributed over $(0, 1]$. Firms set quantities, and all the other marginal costs and wholesale costs are normalized to zero.[11] The quality of the OGN is denoted by s^o, and the quality of the NGN by s^n. Therefore, firms set $s_j = s^o$ or s^n, for $j = i, e$. Since the NGN allows to provide premium broadband services, $s^n > s^o$.

In the Katz and Shapiro setting, if both the incumbent and the entrant are active in equilibrium, their quality adjusted prices are the same, $p_i - s_i = p_e - s_e = \hat{p}$. The marginal consumer has valuation $\tau = \hat{p}$, and hence, for the uniform distribution assumption, the total demand is given by $Q = q_i + q_e = 1 - \hat{p}$.

2.4.2 Timing and strategies

The strategic investment game has two stages which unfold as follows. In stage 1, the incumbent decides the level of the access price a. In stage 2, the entrant and the incumbent simultaneously make their investment decisions given the decision of their respective competitor. The incumbent's investment strategy may be:

- relying on its copper network and providing quality s^o; or
- investing in the NGN (the fiber network), paying the investment cost I and providing quality s^n.

The entrant's strategies may instead be:

- leasing access to the incumbent's copper network, providing quality s^o, and paying the access price a; or
- investing in the NGN, paying the investment cost I and providing quality s^n; or
- staying out of the market.

2.4.3 Profits

The incumbent's profits are equal to $\Pi_i = p_i q_i + a q_e$, whereas the entrant's profit are equal to $\Pi_e = (p_e - a) q_e$ with $a = 0$ if the entrant employs the NGN. Profits after deduction of

[11] This is an innocent assumption as long as the demand is assumed to be linear.

investment cost are given as $\Pi_j^{k,l} - I$, where $k, l = O, N$ refer to the network technology of the incumbent and the entrant, respectively. Investment costs are assumed to be constant across different geographical areas (the fixed of cost of rolling out the fiber network does not depend on the consumers' location).

The investing firm will not grant its competitors access to the new technology.

The equilibrium gross profits in each possible configuration are presented below:

1. Service-based competition within the copper network - both firms employ the incumbent's copper network:

$$\Pi_i^{o,o}(a) = \frac{(1+s^o)^2 + 5a(1-a) + 5as^o}{9}$$
$$\Pi_e^{o,o}(a) = \frac{(1+s^o-2a)^2}{9}$$

2. Infrastructure-based competition between the copper and the fiber network:

   - the incumbent uses its copper network, while the entrant employs its own fiber network:

$$\Pi_i^{o,n} = \frac{(1+2s^o-s^n)^2}{9}$$
$$\Pi_e^{o,n} = \frac{(1+2s^n-s^o)^2}{9}$$

   - the incumbent employs the fiber network while the entrant relies on access to the incumbent's copper network:

$$\Pi_i^{n,o}(a) = \frac{(1+2s^n-s^o)^2 + 5a(1-a) + a(s^n+4s^o)}{9}$$
$$\Pi_e^{n,o}(a) = \frac{(1+2s^o-s^n-2a)^2}{9}$$

3. Infrastructure-based competition between the fiber networks (both firms employ their own fiber network):

$$\Pi_i^{n,n} = \frac{(1+s^n)^2}{9}$$
$$\Pi_e^{n,n} = \frac{(1+s^n)^2}{9}$$

4. The entrant stays out of the market and the incumbent is monopolist:

- the incumbent uses its copper network:

$$\Pi_i^o = \frac{(1+s^o)^2}{4}$$

- the incumbent employs the fiber network:

$$\Pi_i^n = \frac{(1+s^n)^2}{4}$$

As in [Bourreau et al., 2012], when the entrant relies on the incumbent's network, its profits decrease with the access price. Conversely, the incumbent's profits increase with the access price up to a certain level. Indeed, when the access price is excessively high, increasing it further may reduce the entrant's demand and, in turn, wholesale revenues and thereby decreasing the incumbent's profits. The thresholds on the access price correspond to the monopoly access prices.[12]

2.5 The equilibrium

In this section we solve the equilibrium by backward induction. s^o is normalized to zero, so that s^n measures the technology gap. The innovation is not drastic: the gap between the old and new technology is not excessively high. This applies as long as $0 < s^n < 1+2s^o$ so that $\Pi_i^{o,n} > 0$.

2.5.1 Stage 2: investment decision

The stage 2 of the game can be depicted in a normal form. The value of a will depend on the choice of the incumbent in stage 1.

Table 2.1: The investment decision

i/e	s^o	s^n	NE
s^o	$\Pi_i^{o,o}(a)$;$\Pi_e^{o,o}(a)$	$\Pi_i^{o,n}$; $\Pi_e^{o,n} - I$	$\Pi_i^o(a)$;0
s^n	$\Pi_i^{n,o} - I$;$\Pi_e^{n,o}(a)$	$\Pi_i^{n,n} - I$; $\Pi_e^{n,n} - I$	Π_i^n;0

[12]The thresholds are as follows:

$\frac{\partial \Pi_i^{o,o}}{\partial a} \geq 0$ if $a \leq \frac{(1+s^o)}{2}$; $\frac{\partial \Pi_i^{n,o}}{\partial a} \geq 0$ if $a \leq \frac{(5+s^n+4s^o)}{10}$

$\Pi_e^{o,o}(a) \geq 0$ and $\Pi_e^{n,o}(a) \geq 0$ for any value of a and s^n. We assume that entry costs are zero, and in case $\Pi_e^{o,o}(a) = 0$ and $\Pi_e^{n,o}(a) = 0$, the entrant will prefer to enter rather than not to enter the market. The strategy NE is hence a dominated strategy for the entrant.

The incumbent will decide to invest in the new technology when the extra-profits it gains when investing are such that it covers the investment costs:

- suppose the entrant invests: the incumbent will invest only if $\Pi_i^{n,n} - \Pi_i^{o,n} \geq I$. It will invest for $I \leqslant \frac{4}{9}s^n$; *[A]*
- suppose the entrant does not invest: the incumbent will invest only if $\Pi_i^{n,o} - \Pi_i^{o,o}(a) \geq I$. It will hence invest for $I \leqslant \frac{s^n(4s^n+4+a)}{9}$. *[C]*

As for the incumbent, the entrant will decide to invest in the new technology if the extra-profits cover the investment costs:

- suppose the incumbent invests: the entrant will invest only if $\Pi_e^{n,n} - \Pi_e^{n,o}(a) \geq I$. It will invest for $I \leqslant \frac{(4s^n+4a)(1-a)}{9}$; *[B]*
- suppose the incumbent does not invest: the entrant will invest only if $\Pi_e^{o,n} - \Pi_e^{o,o}(a) \geq I$. It will invest for $I \leqslant \frac{4s^n(s^n+1)-4a(a-1)}{9}$. *[D]*

2.5.2 Stage 1: setting a

Table 2.2 recaps the equilibrium strategies of the incumbent and the entrant for the relevant values of I.[13]

[13] Please note that *[A]* $<$ *[B]* relies on $a \leqslant 1 - s^n$.

$0 < I \leqslant \frac{4}{9}s^n$	$\frac{4}{9}s^n < I \leqslant \frac{(4s^n+4a)(1-a)}{9}$	$\frac{(4s^n+4a)(1-a)}{9} < I \leqslant \frac{s^n(4s^n+4+a)}{9}$	$\frac{s^n(4s^n+4+a)}{9} < I \leqslant \frac{4s^n(s^n+1)-4a(a-1)}{9}$	$I > \frac{4s^n(s^n+1)-4a(a-1)}{9}$
$0 < I \leqslant [A]$	$[A] < I \leqslant [B]$	$[B] < I \leqslant [C]$	$[C] < I \leqslant [D]$	$I > [D]$
$\Pi_i^{nn} - I, \Pi_e^{nn} - I$	$\Pi_i^{on}, \Pi_e^{on} - I$	$\Pi_i^{on}, \Pi_e^{on} - I$ $\Pi_i^{no} - I, \Pi_e^{no}$	$\Pi_i^{on}, \Pi_e^{on} - I$	Π_i^{oo}, Π_e^{oo}

Table 2.2: The investment decision

Assumption 1 *There is asymmetric information on the investment costs: the incumbent does not know the fixed cost the entrant will have to bear to deploy the fiber infrastructure.*

In the following I assume that the incumbent's investment costs are $I_i \geq \frac{4s^n}{9}$. This is an innocent assumption considering that both the threshold *[A]* and the profits for $0 < I \leqslant$ *[A]* do not depend on the level of access price. It is plausible to assume that the entrant's investment costs are at least equal to the incumbent's investment costs: the incumbent can use the copper ducts to lay the fiber cables and this provides him with a cost advantage. Henceforth I focus on the equilibria that may arise when the investment costs are above *[A]*.

Depending on the level of access price a set by the incumbent, the investments' costs and the quality gap s^n, three possible equilibria may arise:

- the entrant invests alone;
- the incumbent invests alone;
- neither the entrant nor the incumbent invests.

As in [Brito et al., 2012], the case where the entrant alone invests occurs for a larger set of parameter values than the case where the incumbent alone invests. The incremental profits the entrant will obtain when it invests and the incumbent does not invest, or when it invests and the incumbent also invests are higher than the incremental profits will get the incumbent in the opposite situations. Indeed, when not investing, the entrant will have always to pay an access price to rely on the incumbent's copper network.[14]

The objective of this model is to investigate the underlying causes of the outcome observed for the Slovak market. To this end, in what follows, I will ignore the equilibrium whereby only the incumbent can invest (which may realize when entrants' and incumbent's investment costs are above *[B]* and below *[C]*).

The entrant may hence decide to invest or not. The incumbent will never invest. The entrant's decision of investing will depend on its investment costs and the thresholds' value. The thresholds' value depends on a and s^n. The incumbent does not know the entrants' investment costs and will hence set a as to maximize:

$$E(\Pi_i) = (1 - Prob(E\ invests)) \cdot \Pi_i^{oo}(a) + (Prob(E\ invests)) \cdot \Pi_i^{on} \tag{2.1}$$

where

[14]Differently from [Brito et al., 2012], the investing firm will not grant access to its network. This is a plausible assumption: in the Slovak context, for instance, the alternative operators have invested in fiber to react to the anticompetitive conduct pursued by the incumbent. In this setting, it is reasonable to assume that, after investing in fiber, the alternative operator will decide to not provide the incumbent with access to its superior network.

$$\frac{\partial E(\Pi_i)}{\partial a} = (1 - Prob(E\ invests)) \cdot \frac{\partial \Pi_i^{oo}(a)}{\partial a} + \frac{\partial Prob(E\ invests)}{\partial a} \cdot (\Pi_i^{on} - \Pi_i^{oo}(a)) \quad (2.2)$$

The incumbent faces a **trade-off** between increasing a to increase its profits and decreasing a to reduce the probability that the entrant invests:

- the profits $\Pi_i^{oo}(a)$ are increasing in a (as long as $a < \frac{1}{2}$);
- the probability that the entrant invests in the new technology is increasing in the level of access price to the old technology;
- the incumbent will be better off if the entrant does not invest: $\Pi_i^{on} - \Pi_i^{oo}(a) < 0$;

Suppose that the entrant's investment costs are uniformly distributed: $I_e \sim U(\frac{4s^n}{9}; \bar{i})$. Equation 2.1 can be hence written as follows:

$$\begin{aligned} E(\Pi_i) = Prob\Big(\frac{4s^n}{9} < I \leqslant \frac{4s^n(s^n+1) - 4a(a-1)}{9}\Big) \cdot \frac{(1-s^n)^2}{9} + \\ + Prob\Big(I > \frac{4s^n(s^n+1) - 4a(a-1)}{9}\Big) \cdot \frac{1+5a(1-a)}{9} \end{aligned} \quad (2.3)$$

Equation 2.2 will then become:

$$\begin{aligned} \frac{\partial E(\Pi_i)}{\partial a} = \frac{\bar{i} - 4s^n(s^n+1) + 4a(a-1)}{9\bar{i} - 4s^n} \cdot \frac{5-10a}{9} + \\ + \frac{8a-4}{9\bar{i} - 4s^n} \cdot \Big(\frac{5a - 5a^2 - s^{n2} + 2s^n}{9}\Big) = 0 \end{aligned} \quad (2.4)$$

For some combination of s^n and $\bar{i}$[15], the optimal solution will be:

$$\hat{a} = \underset{a}{\operatorname{argmax}}\, E(\Pi_i(a)) = \frac{1}{2} - \frac{1}{20}\sqrt{10}\sqrt{28s^n - 45\bar{i} + 16s^{n2} + 10}. \quad (2.5)$$

This is below $a = \frac{1}{2}$, that is the level of access price that maximizes $\Pi_i^{oo}(a)$. Moreover, this level of access price decreases in s_n and increases in $\bar{i}$: the higher will be the quality of the new technology (s^n), the higher will be the incentive of the incumbent to reduce

[15]See Appendix 2.9.

the access price to discourage the entrant's investment; the higher will be the cost of the investment ($\bar{i}$), the lower will be such incentive.

In equilibrium, the incumbent will set the level of access price as to reduce the thresholds below which the entrant will invest. Would that be enough to discourage the entrant from investing? The entrant's investment costs may turn out to be lower than the incumbent was expecting, and the entrant may still decide to invest. Indeed, in case the entrant's investment costs result to be lower than $\frac{4s^n(s^n+1)-4\hat{a}(\hat{a}-1)}{9}$, the entrant will invest. In the Slovak market, the deployment of the fiber network has been driven by the alternative operator Orange Slovensko (OSK). OSK is part of the global Orange group, which is among the largest provider of broadband services in Europe. The know-how and financial support of the Orange group could have enabled OSK to deploy fiber infrastructure in the Slovak market.

The findings above are summarized in **Proposition 2.1**.

Proposition 2.1 *In equilibrium, (i) in case there is incomplete information on the entrant's investment costs and (ii) the incumbent has not convenience to invest, the incumbent will face a trade-off between increasing the access price to increase its wholesale revenues, and decreasing the access price to dissuade the entrant from investing in a new technology.*

Proof 2.1 *See Appendix 2.9.*

The equilibrium level of access price does not maximize the incumbents' wholesale revenues, as to reduce the probability the entrant will invest. However, this may still be higher than the fair terms would have been set by a regulator.

2.6 Social welfare and access price

The key question is understanding whether the level of access price set by the incumbent is higher than the level the regulator would set to maximize social welfare. The Slovak evidence shows that the incumbent has set an excessive access price, thereby abusing its dominant position.[16]

Social welfare is the sum of consumer and producer surplus. In this setting, we assumed there are two firms: the incumbent and the entrant. The regulator may assign a positive weight, θ, to the incumbent's profits, to protect its incentives to invest. Social welfare would then be equal to:

[16] Please consider that, according to the EC, ST's abuse of dominance consisted of both (i) a margin squeeze practice (in the form of excessive wholesale price) and (ii) a refusal to properly supply access to its LLU.

$$W = CS + \theta \Pi_i^{k,l} + \Pi_e^{k,l}$$

where $k, l = O, N$ refer to the network technology of the incumbent and the entrant, respectively.

Both consumer and producer surplus depend on the equilibrium will arise in the market. As before, I will focus on two possible equilibria: the entrant will invest alone, or neither the incumbent nor the entrant will invest. In case the entrant will invest alone, the entrant profits will be $\Pi_e^{o,n}$ while the incumbent profits will be $\Pi_i^{o,n}$. Profits will not depend on the access price, as the entrant will be relying on its own fiber network. The social welfare will be:

$$W(a)_{inv} = \frac{(2 + s^n - a)^2}{18} + \theta \frac{(1 - s^n)^2}{9} + \frac{(1 + 2s^n)^2}{9} \tag{2.6}$$

The regulator will set the level of access price that maximizes the social welfare:

$$\frac{\partial W(a)_{inv}}{\partial a} = \frac{a - s^n - 2}{9} = 0 \tag{2.7}$$

This is a convex function, and given $a \geq 0$, it is maximized for $a^*_{inv} = 0$.

In case neither the entrant nor the incumbent will invest, both the firms will rely on the legacy copper network, and the entrant will pay to the incumbent the access price. The social welfare will be:

$$W(a)_{noinv} = \frac{(2 - a)^2}{18} + \theta \frac{1 + 5a(1 - a)}{9} + \frac{(1 - 2a)^2}{9} \tag{2.8}$$

The regulator will set the level of access price that maximizes the social welfare:

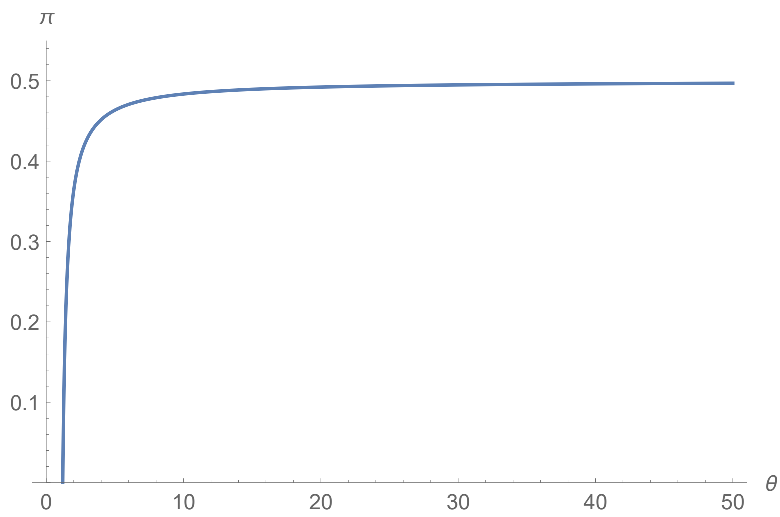
$$\frac{\partial W(a)_{noinv}}{\partial a} = \frac{18a - 12 - 10\theta - 20a\theta}{18} = 0 \tag{2.9}$$

Equation 2.9 is solved for:

$$a^*_{noinv} = \underset{a}{\operatorname{argmax}}\, W(a)_{noinv} = \frac{6 - 5\theta}{9 - 10\theta}$$

For $\theta \to \infty$, $a^*_{noinv} = \frac{1}{2}$. When the weight assigned to the incumbent's profits is infinitely high, the level of access price that maximize the social welfare is equal to the level that maximize the incumbent's profits.

Figure 2.1: The level of access price when both firms rely on copper



The equilibria that will arise will depend on whether the entrant's investment costs are above or below the thresholds identified in Table 2.2. The regulator does not know the entrant's investment costs, and will maximize the following:

$$E(W(a)) = Prob\Big(\frac{4s^n}{9} < I \leqslant \frac{4s^n(s^n+1) - 4a(a-1)}{9}\Big) \cdot W(a)_{inv} + \\ + Prob\Big(I > \frac{4s^n(s^n+1) - 4a(a-1)}{9}\Big) \cdot W(a)_{noinv}$$

which corresponds to the following

$$E(W(a)) = \frac{\frac{4s^n(s^n+1)-4a(a-1)}{9} - \frac{4s^n}{9}}{\bar{i} - \frac{4s^n}{9}} \cdot \Big(\frac{(2+s^n-a)^2}{18} + \theta\frac{(1-s^n)^2}{9} + \frac{(1+2s^n)^2}{9}\Big) + \\ + \frac{\bar{i} - \frac{4s^n(s^n+1)-4a(a-1)}{9}}{\bar{i} - \frac{4s^n}{9}} \cdot \Big(\frac{(2-a)^2}{18} + \theta\frac{1+5a(1-a)}{9} + \frac{(1-2a)^2}{9}\Big) \quad (2.10)$$

The solution to Equation 2.10 is the level of access price that maximizes social welfare, a^*.[17]

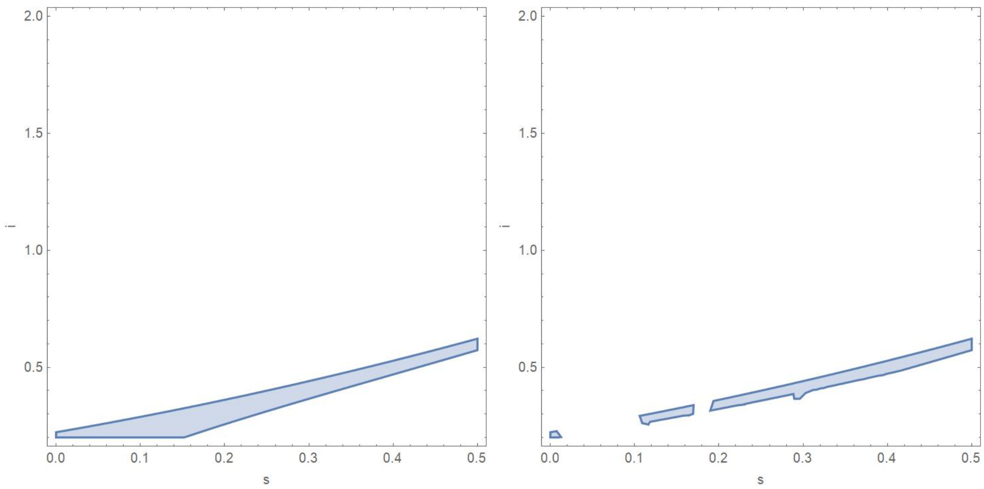
Proposition 2.2 *For some combination of s^n, $\bar{i}$, and θ, the level of access price set by the regulator, a^*, is lower than the level of access price set by the incumbent, $\hat{a}$.*

[17] See Appendix 2.9.

Figure 2.2 shows the range of values of $\bar{i}$ and s^n that makes the level of access price set by the incumbent higher than the level the regulator would set. The range will depend on the values of θ, that is the weight the regulator assigns to the incumbent's profits. When $\theta = 1$ (Figure 2.2a), the incumbent sets an excessively high access price for low values of s^n. When the quality of fiber is lower, the incumbent is less threatened by the entrant's investment, and will set an high access price. At the same time, the regulator has less incentives to stimulate the entrant's investment, and will not be tempted to increase the access price. The higher is θ, the narrower is the range of values that makes $\hat{a} \geq a^*$ (Figure 2.2b).

Figure 2.2

(a) Inequality range, $\theta = 1$ (b) Inequality range, $\theta = 15$



2.7 The incumbent's reaction

Right after OSK started investing in fiber, the Slovak incumbent announced that "extending optical networks to households is not to end in Slovakia with investments of Orange".[18]

Within four years of this announcement, ST has reached and surpassed the number of OSK's fiber subscribers (see Figure 2.3).

[18]See ST's annual report, 2007: Extending optical networks to households is not to end in Slovakia with investments of Orange. On the very first day of the commercial launch of that operator's service Doma, based on fibre-optics network brought right to the client's home, a similar intent was announced by Slovak Telekom, offering services for households under the T-Com brand. The largest fixed line operator wants to invest by year-end SKK 1 bn in a network covering close to 200 thousand households. Orange, currently covering some 110 thousand potential clients, wants to achieve a similar presence by then. In the following year, Slovak Telekom anticipates investing approximately SKK 1 bn more into optics. Orange has not yet revealed its next year's plans but the Company's investment will probably be around the same level.

Figure 2.3: Fiber services - subscribers by operator

There might be some uncertainty on the costs of the deployment of a new technology. The decision of the entrant to invest may have made the incumbent realize that the roll-out of the fiber infrastructure is less expensive than expected. Furthermore, the entrant's investment may have generated some positive spillovers:

- the incumbent may directly benefit from the investment efforts made by the entrant by obtaining savings in its administrative and contractual costs. The entrant, indeed, may have already went through the administrative process of obtaining the necessary authorizations, or investigated the feasibility of the investment in the territory[19];
- an earlier investment in fiber may indirectly benefit the incumbent by reducing the uncertainity on the demand-side and, in turn, the investment risk. The initial supply of fiber-based services may have positively affected a wide range of sector including TV-media, healthcare, education, whose ability to enhance their services is increased by the availability of ultra-fast broadband Internet access. This may have enhanced the demand for fiber services and also increased consumers' willingness to pay.[20]

Given the setting of the model, the incumbent will invest if the entrant invests when:

$$\Pi_i^{n,n} - I_i \geq \Pi_i^{o,n}$$

which implies:

$$I_i \leq \frac{4s^n}{9}$$

[19] Similar assumptions are in [Bourreau et al., 2012]

[20] Another source of positive investment spillovers is related to infrastructure sharing. In this model, however, I assume the entrant is not cooperating with the incumbent after the investment. This is plausible given that the entrant's investment is modelled as a reaction to the abuse of dominance position of the incumbent.

In the above, I assume that $I_i \geq \frac{4s^n}{9}$. In the case in which, after the entrant's investment, the incumbent realizes that its cost of rolling-out the fiber is lower than expected ($\frac{4s^n}{9}$) or benefited from some positive spillovers, it will decide to react to the entrant's investment by investing itself.

2.8 Conclusions

The relationship between regulation, competition and investment keeps on being a topic of hot debate in the field of competition policy. In the telecommunications markets, regulatory tools have historically been considered key to promote competition at the retail level. Entry in telecoms markets requires large and irreversible investments in infrastructure. Based on the "ladder of investment" theory, regulators have prompted entry by allowing alternative operators to lease access to the incumbent's network. Entrants could have hence invested in their own network gradually, as their customer base increased. While encouraging entry in the short run, access regulation can hinder both the entrant's and incumbent's incentives to invest.

Numerous studies show that mandating access to the incumbent's network may delay entrants' investment in the existing network, or discourage incumbents from upgrading their networks. This chapter contributes to the relatively small literature strand that investigates the relationship between access pricing and firm's incentives to invest in a superior technology, thereby migrating from an old to a new technology. This chapter aims at investigating the underlying causes of the outcome observed in the Slovak market. The European Commission has fined the Slovak incumbent for having abused its dominant position by refusing to properly supply access to its copper network and charging excessively high wholesale price. In response to the abuse, alternative operators have started developing their own network thereby leading the deployment of the fiber infrastructure in Slovakia.

I adapted the model in [Bourreau et al., 2012] to make both access price and investment as endogenous choices. In the model, the entrant decides whether relying on the incumbent's copper network or investing in a (superior) fiber network, while the incumbent decides (i) whether investing or not and (ii) the level of access price on the copper network. The access price and the entrant's decision to invest are interrelated: a higher access price to the copper network may spur entrant's investment in fiber. The model also assumes asymmetric information on the investment costs: the incumbent does not know the entrant's costs to deploy the fiber infrastructure.

Results show that, for intermediate values of investments costs, the incumbent will set an access price higher than the fair price would have been set by the regulator, and the entrant invests alone in the fiber network. This chapter also shows that, when the entrant's investment generates some positive spillovers or reduces the incumbent's uncertainity on its own investment's costs, the incumbent reacts to the entrant's investment by investing itself.

Conclusions are far from obvious. The findings of this chapter may suggest that deregulating access to the incumbent's network can spur the modernization of the telecoms' infrastructure. However, results also point towards a duplication of infrastructure and investment costs. Moreover, the Slovak evidence shows that alternative operators have delimited their investment effort to the urban and densely populated areas, where costs are expected to be lower. In the rural and mostly remote areas, incentives to invest are lower, and the incumbent would benefit from the monopoly privilege ensured by the high access price on the copper network. The ultimate impact of the Slovak infringement on consumers' welfare is hard to assess and deserves further research.

2.9 Appendix

2.9.1 The optimal access price set by the incumbent

In stage 2 of the strategic investment game, the incumbent sets a to maximize $E(\Pi_i)$ and to solve equation 2.4:

$$\frac{\partial E(\Pi_i)}{\partial a} = \frac{\bar{i} - 4s^n(s^n+1) + 4a(a-1)}{9\bar{i} - 4s^n} \cdot \frac{5-10a}{9} + \\ + \frac{8a-4}{9\bar{i}-4s^n} \cdot \left(\frac{5a - 5a^2 - s^{n2} + 2s^n}{9}\right) = 0 \quad (2.11)$$

Equation 2.4 is solved for:

- $a_1 = \frac{1}{2}$
- $a_2 = \frac{1}{2} + \frac{1}{20}\sqrt{10}\sqrt{28s^n - 45\bar{i} + 16s^{n2} + 10}$
- $a_3 = \frac{1}{2} - \frac{1}{20}\sqrt{10}\sqrt{28s^n - 45\bar{i} + 16s^{n2} + 10}$

When the access price is $a = a_2$, it increases with s^n - the technology gap - and decreases with $\bar{i}$ - the higher support of the uniform distribution of I_e. This implies that the higher is the quality of the new technology, the higher is the access price and the higher is the probability that the entrant invests. Furthermore, the wider is the support, the higher is the investment cost and the lower will be the access price. Such comparative statistics do not sound reasonable: the incumbent should indeed decrease the access price (and in turn the probability the entrant will invest) when the quality of the new technology is high, and instead increase the same when the investment costs are high (and hence the probability the entrant will invest is less likely). Henceforth, a_2 is excluded.

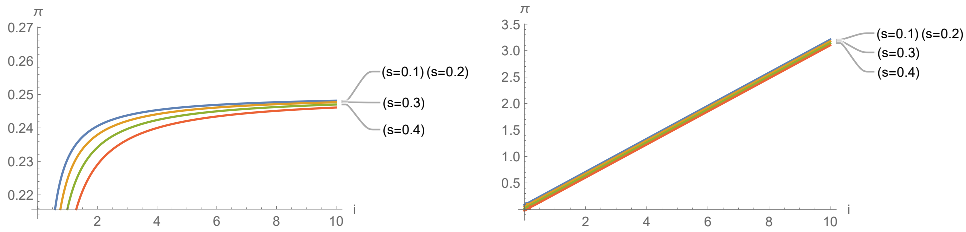
Figure 2.4a and 2.4b shows the incumbents' expected profits for $a = a_1$ (left hand side) and $a = a_3$ (right hand side), for some values of s^n and $\bar{i}$.

For any positive value of $\bar{i}$, expected profits decrease in s^n.[21] This is reasonable: the higher is the quality of the superior technology, the higher may be the demand that will migrate to the entrant in case it will invest.

[21] Please consider that the assumption that $a \leqslant 1 - s^n$ and $a \leq \frac{1}{2}$ is such that $s^n \leq \frac{1}{2}$.

Figure 2.4

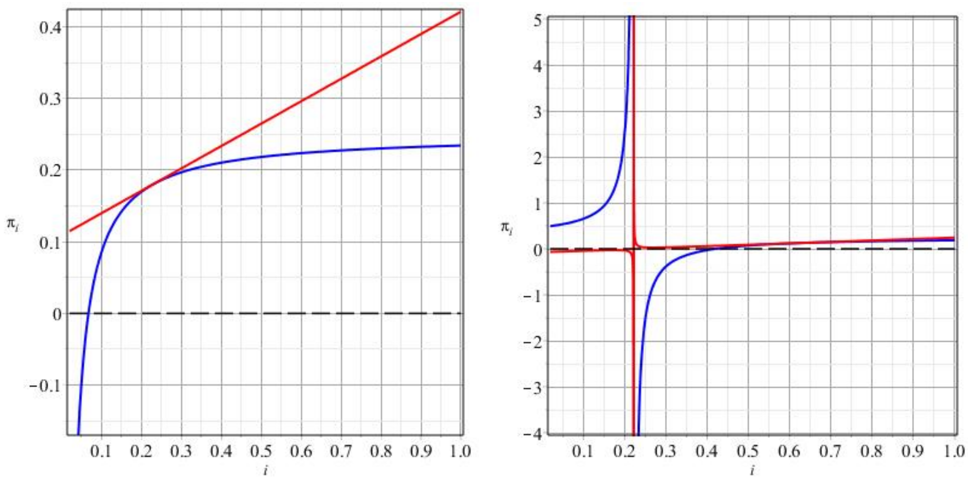
(a) Incumbent's expected profits, $E(\Pi_i(a_1))$ (b) Incumbent's expected profits, $E(\Pi_i(a_3))$



While it is straightforward that $E(\Pi_i(a_1)) \leq E(\Pi_i(a_3))$ for positive and high values of $\bar{i}$ and regardless of s^n, the relationship is less clear for the lowest positive values of $\bar{i}$. Figure 2.5 shows the incumbent's expected profits for the lowest positive values of $\bar{i}$. For $\bar{i}$ at least above 0.2, incumbent's expected profits are higher when the access price is set equal to a_3 (red line). This seems to be robust $\forall\ s^n \in [0, \frac{1}{2}]$.

Figure 2.5: Incumbent's expected profits

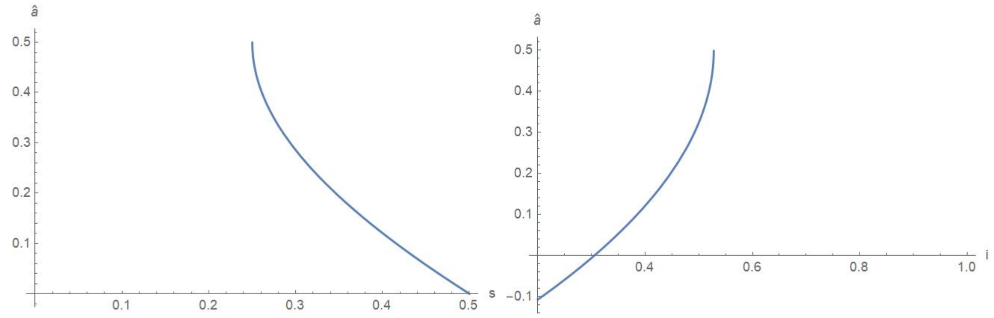
(a) Incumbent's expected profits, $s = 0.01$ (b) Incumbent's expected profits, $s = 0.5$



For $\bar{i} \in [0.2, \infty]$ and $\forall\ s^n \in [0, \frac{1}{2}]$, the incumbent will set $\hat{a} = a_3$, as this maximizes its profits. Figure 2.6 shows how this varies with s^n (Figure 2.6a) and $\bar{i}$ (Figure 2.6b).

Figure 2.6: The access price set by the incumbent

(a) $\hat{a}$, $i = 0.4$ (b) $\hat{a}$, $s^n = 0.4$



2.9.2 The optimal access price set by the regulator

When setting the level of access price to the incumbent's network, the regulator maximizes Equation 2.10:

$$E(W(a)) = \frac{\frac{4s^n(s^n+1)-4a(a-1)}{9} - \frac{4s^n}{9}}{\bar{i} - \frac{4s^n}{9}} \cdot \left(\frac{(2+s^n-a)^2}{18} + \theta\frac{(1-s^n)^2}{9} + \frac{(1+2s^n)^2}{9}\right) + \\ + \frac{\bar{i} - \frac{4s^n(s^n+1)-4a(a-1)}{9}}{\bar{i} - \frac{4s^n}{9}} \cdot \left(\frac{(2-a)^2}{18} + \theta\frac{1+5a(1-a)}{9} + \frac{(1-2a)^2}{9}\right) \quad (2.12)$$

Equation 2.10 is solved for $a = a^*$.[22]

Figure 2.7 and 2.8 show, respectively, how the access price a^* varies wth s^n and $\bar{i}$ for $\theta = 1$ and $\theta > 1$.

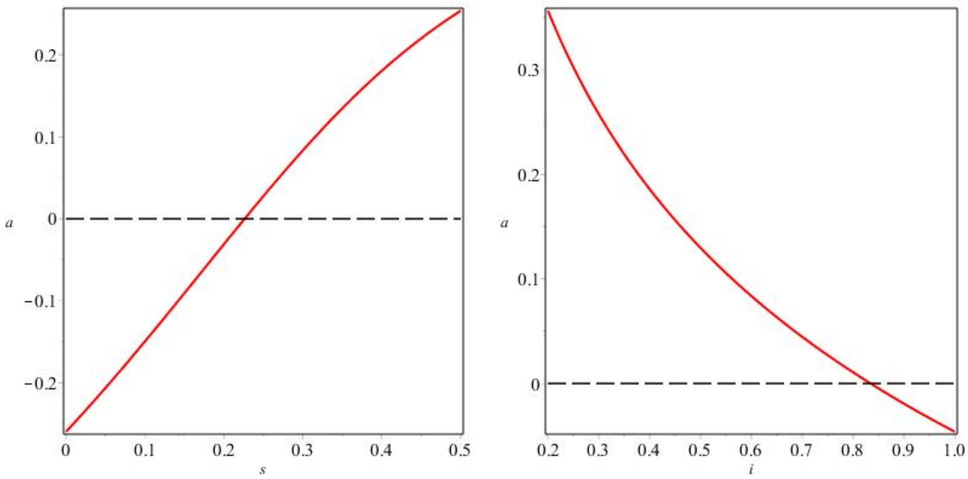
When $\theta = 1$, the regulator assigns equal weight to the profits of the entrant and the incumbent, and the consumer surplus. In this case, the level of access price set by the regulator decreases with $\bar{i}$ and increases with s^n. Holding constant the cost of investment, when the quality of the fiber is high, the regulator encourages investment in fiber by making it difficult access to the incumbent's network (Figure 2.7a). Holding constant the quality of the fiber, when the costs of deploying fiber are expected to be high, the regulator encourages entry by allowing access to the incumbent's network at a lower price (Figure 2.7b).

When $\theta > 1$, the regulator assigns a positive weight to the profits of the incumbent to protect its incentives to invest. In this case, the level of access price set by the regulator increases with $\bar{i}$ and decreases with s^n. This is the same comparative statics that applies to $\hat{a}$. Holding constant the cost of investment, when the quality of the fiber is high, the regulator discourages investment in a superior technology by making access to the

[22]This equation has three roots, but two of them are imaginary.

Figure 2.7: The access price set by the regulator, $\theta = 1$

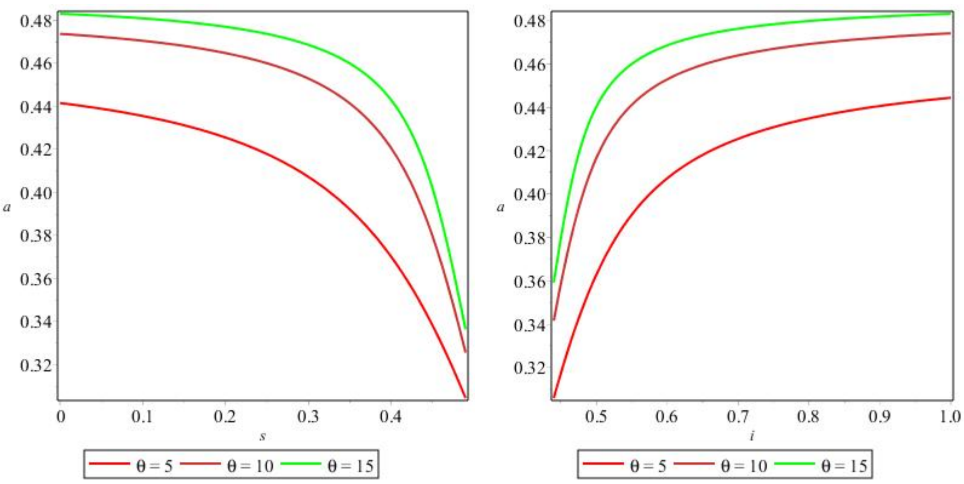
(a) a^{*}, $\bar{i} = 0.6$ (b) a^{*}, $s = 0.3$



incumbent's network less expensive (Figure 2.8a). The higher is θ, the higher will the be the level of access price for a given level of s^n: however, the values of the access prices converge for high values of s^n. Holding constant the quality of the fiber, when the costs of deploying fiber are expected to be high, the regulator sets an higher access price to increase the incumbent's profits (Figure 2.8b). The higher is θ, the higher is the level of access price for a given $\bar{i}$.

Figure 2.8: The access price set by the regulator, $\theta > 1$

(a) a^{*}, $\bar{i} = 0.6$ (b) a^{*}, $s = 0.3$



Chapter 3

Abuse of dominance in the fixed telecom markets and its effects

3.1 Introduction

In Europe, fixed telecoms markets generally present high entry barriers and sunk costs. Telecom is a relatively capital-intensive industry and fixed telecoms markets are also characterised by the strong presence of former national monopolists (incumbents), who rolled out their (metallic) infrastructure over significant time periods protected by exclusive rights.

Since the liberalization of telecoms markets, competition and regulatory authorities have often intervened to ensure a fair competition process and guarantee the entry of alternative operators. The European (EU) regulatory framework (Regulation 2887/2000) considers that it would not be economically viable for new entrants to duplicate the incumbent's metallic local access infrastructure within a reasonable time, and it establishes that national operators with significant market power (SMP) are obliged to provide access to their network infrastructure. Regulation mandates unbundled access[1] to the metallic local loops of national operators with SMP at transparent, non-discriminatory and fair terms.

Over the last decades, the European Commission (EC) has opened 5 proceedings against dominant operators in the fixed telecom markets for having refused to supply access to their networks or squeezed their competitors' margins in the retail markets (by setting excessively high wholesale price or charging retail prices below costs). These conducts were considered to have exclusionary effects in the retail market for fixed telecoms services, by preventing the entry or hindering the growth of alternative operators. Table 3.1 shows the timeline of the 5 infringement decisions taken by the EC to fine foreclosure conducts by incumbent operators in fixed telecoms markets.

Table 3.1: Infringement decisions adopted by the EC in fixed telecoms markets

EC decision	Year of decision	Period of infringement
Wanadooo (French incumbent)	2003	2001-2002
Deutsche Telekom (German incumbent)	2003	1998-2001
Telefonica (Spanish incumbent)	2007	2001-2006
Telekomunikacja Polska (Polish incumbent)	2011	2005-2009
Slovak Telekom (Slovak incumbent)	2014	2005-2010

Slovak Telekom is the most recent case investigated by the EC.[2] Slovak Telecom (ST) is the incumbent operator in Slovakia and owns the only nationwide fixed copper access

[1]The local loop unbundling (ULL) is a regulatory regime that requires the incumbent telephone companies to unbundle the last-mile copper loop to the entrant carries. The last-mile loop connects the network termination point at the subscriber's premises to the cabinet or equivalent facility in the fixed public telephone network.

[2]The decision has been adopted in October 2014 - EC Case AT 39523.

network. The EC identified both a refusal to supply and a margin squeeze conduct. The assessment indeed revealed that ST withheld relevant network information necessary for the unbundling of local loops, unjustifiably reduced the scope of its regulatory obligation to unbundle and applied excessively high wholesale prices which made it unfeasible for alternative operators to replicate the retail broadband services offered by ST. The assessment of this case has created a legal precedent according to which the indispensability of the access product does not need to be shown if the incumbent has a legal obligation to grant network access.[3]

Mandating access to the incumbent's network is commonly regarded as a pro-competitive measure that enables alternative operators to enter the retail market and ultimately to invest. The underlying principle is that entrants lease some network elements that are particularly difficult to replicate at the initial stage of competition, and invest in their own facilities some time later when they have reached a critical mass of consumers (this is also known as the "ladder of investment" approach). There is however a wide theoretical and empirical literature that questions the validity of this approach: mandatory access may indeed distort both the incumbents and the entrants' incentives to either upgrade their networks or invest in a superior technology. Once entrants enjoy profits from serving consumers based on the wholesale access product provided by the incumbent, their incentives to invest in their own infrastructure may be hindered, especially if access prices are set too low.

Existing studies show that local loop unbundling does not stimulate the adoption of broadband technologies ([Bouckaert et al., 2010], [Distaso et al., 2006]) and does not encourage entrants to invest in their own infrastructure ([Wallsten and Hausladen, 2009], [Bacache-Beauvallet et al., 2014], [Briglauer et al., 2015]). Furthermore, the most recent empirical literature shows that the number of entrants' unbundled lines are negatively correlated with the number of entrants' fiber lines. Nowadays, the deployment of ultra-fast broadband networks, the Next-Generation Access networks, has become a major issue for regulator and telecom companies. Fiber networks are the ultimate technology to increase bandwidth and deliver fast broadband connections. This chapter aims at contributing to the existing literature by investigating the investment strategies pursued by fixed telecom operators in the Slovak broadband market, following the refusal of the incumbent to properly and fairly provide access to its metallic infrastructure. This chapter aims at empirically demonstrating that, by hindering access to its metallic network infrastructure,

[3]This has also been confirmed by the General Court (GC) on 13 December 2018: the GC held that since the relevant regulatory framework acknowledged the indispensability of ST's local loop for alternative operators, the Commission was no longer required to independently establish indispensability. While the General Court largely upheld the Commission's decision, it reduced the fines imposed on the basis that the Commission failed to establish that ST's margin squeeze practices resulted in exclusionary effects before 1 January 2006.

ST's anticompetitive conduct has triggered alternative operators' incentive to invest in their own and superior fiber infrastructure.

The original feature of this chapter is that it exploits the abuse of dominance by the Slovak incumbent to demonstrate that banning, rather than mandating, access to the incumbent's copper network may cause entrants to invest. During the period 2005-2010, Slovak Telekom has withheld from alternative operators network information that were necessary for the unbundling of local loops and applied excessive wholesale prices to get access to its local loops. A firm's decision to invest in a new infrastructure generally depends on (i) the profits it expects to gain by investing in a new technology and (ii) the profits it expects to gain by purchasing access to the incumbent's network. The higher is the access price set by the incumbent, the higher will be the incremental profits from investing, and in turn, the higher will be the incentive to invest. This is also shown in Chapter 2 of this thesis, which demonstrates that, in case of asymmetric information on the costs of deploying fiber, and for intermediate values of investment costs, the incumbent will set an excessively high access price and the entrant will decide to invest in a superior technology.

The identification strategy of this chapter exploits heterogeneity in fiber coverage in the European Union through a *Difference in Differences* ("DiD") approach. European countries where the incumbent has not engaged into an anticompetitive conduct are used to evaluate what would have been the evolution of entrants' investment in fiber in Slovakia in the absence of the abuse. In line with most of the existing related literature, this chapter investigates investment dynamics by relying on penetration metrics. The availability of fiber connections (i.e. fiber coverage), which would have been an exact measure of the investment made in fiber technologies, is proxied by the number of subscribers to fiber services (i.e. fiber penetration). This however should not impede the identification of the effects on investment: since fiber deployment was very limited in Europe before 2005, a positive variation in the penetration of fiber services need necessarily to be attributed to an increase in the number of newly available fiber connections. Results show that, by hindering access to its network, the Slovak incumbent has triggered alternative operators to invest in fiber network.

This chapter is structured as follows. Section 3.2 presents the related empirical literature on access regulation and broadband adoption and investment. Section 3.3 discusses the level of fiber coverage in Slovakia, right after the end of ST's abuse, compared to the rest of Europe. Section 3.4 provides the factual background and shortly describes the Slovak market structure. Section 3.5 discusses the data and identification strategy, and Section 3.6 analyzes the effect of the abuse on the investment in fiber in Slovakia. Section 3.7 concludes.

3.2 Related literature

The existing empirical literature has centered on the relationship between regulation and broadband technologies adoption. Regulatory policies shape the mode of competition between broadband internet access providers. [Bouckaert et al., 2010] distinguishes between three main forms of competition:

- inter-platform competition: which is not dependent on access regulation, but instead results from rivalry between multiple infrastructures in a country (e.g. DSL and cable network);
- facilities based intra-platform competition, which mainly depends on mandatory access through local loop unbundling: alternative operators lease unbundled local loop elements and have to invest in their own equipment;
- service based intra-platform competition, which depends on mandatory access through bitstream access: alternative operators merely resell the incumbent's retail services.

Most of the existing literature have dealt with the relationship between different modes of competition, as implied by regulation, and the overall penetration of broadband technologies. The ultimate aim is investigating whether mandatory access encourages broadband penetration, and in that case, which type of access should be imposed. While resale service (which gives rise to service-based intra-platform competition) allows entrants to merely resell the incumbent's service, ULL (which instead gives rise to facilities based intra-platform competition) requires the entrants to invest in their own equipment and, at the same time, gives them the opportunity to differentiate their service from that of the incumbent, for instance by offering higher speed connections.

Based on a panel data set for 20 OECD countries over the period 2003-2008, [Bouckaert et al., 2010] finds that inter-platform competition positively affects broadband penetration, while service based competition has a significant and negative impact on penetration. ULL have no significant impact. Broadband penetration is measured as percentage of households subscribed to any broadband technology (DSL, cable, fiber).[4] Similar findings are obtained by [Distaso et al., 2006], who develop both a theoretical and econometric model, demonstrating that while inter-platform competition drives broadband adoption, intra-platform competition for the DSL services does not play a significant role.

Employing a very detailed data set covering the whole of the United Kingdom, [Valletti and Verboven, 2015] finds that ULL has a positive effects on total broadband penetration in the early years, and such effect disappears as the market reaches maturity. However,

[4] The authors relies on a dataset provided by Analysys Mason, similar to the one that informs the analysis of this chapter.

they also estimate that local areas experiencing ULL entry have a considerably higher average broadband speed than those that have not experienced such entry.
[Crandall et al., 2013] reviewed the major empirical studies conducted between 2003 and 2011 which test for the effects of unbundling on either broadband penetration or, in a few cases, broadband availability. Overall, the author concluded that these studies do not support the hypothesis that unbundling increases broadband penetration.[5]

In addition to these studies, there is also a large body of empirical research on the effects of ULL on investment. According to the review conducted by [Cambini and Jiang, 2009], most of the evidence shows that local loop unbundling discourages both incumbent and entrants from investing in infrastructure. This is the branch of the related literature much closer to the analysis presented in this chapter, and I present below the most recent contributions. In most of the cases, investment in fiber is measured through fiber penetration, that is the number of subscribers to fiber services. Differently from the papers cited above, these studies focus on the effects of ULL on the penetration of a specific, and superior, broadband technology.
[Wallsten and Hausladen, 2009] look at the correlation between the use of unbundled local loops and the rollout of fiber broadband connections, based on biannual dataset of 27 EU countries from 2002-2007. Results shows that the number of broadband lines per capita provided over unbundled local loops is negatively correlated with broadband connections over fiber. The most likely explanation for the negative results of local loop unbundling on investment in fiber is that firms with the ability to invest in their own equipment are more likely to choose to use local loops instead of building new platforms if the option is available to them.
[Bacache-Beauvallet et al., 2014] use an annual dataset of 15 European countries from 2002 to 2010 and test the validity of the "ladder of investment, (LOI)" regulatory approach. The idea of the LOI is that, by setting low access prices, the regulator encourages service based-entry in the short term. Then, once entrants have gained a sufficient customer base, they can climb up the ladder of investment and invest in their own facility. This basically implies that service-based intra-platform competition could serve as a stepping stone for facilities-based intra-platform competition which, in turn, can encourage inter-platform competition. The paper develops an econometric model in which the number of broadband lines that belong to new entrants and are deployed using a new access technology (e.g. fiber) is the dependent variable, and the number of bitstream access or unbundled lines that are used by new entrants in previous periods is the main explanatory variable. They find that operators that use unbundled local loops do not ascend the ladder of investment

[5]Few papers argue in favour of the positive effect of unbundling on broadband penetration and availability, see [Willig, 2019] and [Ford and Spiwak, 2004].

and build their own infrastructure. Their empirical results are consistent with the ladder of investment hypothesis only when considering the migration from bitstream access lines to unbundled lines.

Based on a sample of EU27 countries over the period 2005-2014, [Briglauer et al., 2015] investigate the relationship between ULL prices and the new broadband technologies adoption and coverage. This is one of the very few papers that examines the effects of a change in the prices to access the old technology on the new technology adoption. Results show that a 1% increase in the regulated price to access the DSL network increases the penetration and coverage of FTTx technologies by respectively 0.45% and 0.47%.

This chapter aims at contributing to the existent empirical literature by examining the impact of an abuse of dominance in the DSL segment, which impedes entrants to get access to the incumbent's network, on investment in fiber networks. While the existing literature exploits heterogeneity in ULL prices or in the number of unbundled lines across European countries and over a time-span to identify the causal relationship between unbundling and investment in fiber, this chapter offers an ex-post evaluation exercise where the effects of access regulation on investment are evaluated after an infringement of such regulatory obligations. Finally, this chapter exploits a rich and disaggregated dataset providing quarterly data on the number of subscribers to each broadband technology and operator in almost all EU27 countries, over the period 2003-2010.

3.3 Heterogeneity of fiber coverage in Europe in 2011

In March 2010, the EC launched the Europe 2020 strategy which includes the "Digital Agenda for Europe", aimed at harnessing the full potential of the Information Communication Technologies (ICT). As part of the Agenda, Member States had to provide their citizens with basic broadband coverage by 2013 and broadband speeds of at least 30 Megabits per second (Mbps) by 2020. According to the study carried out by Point-topic for the EC[6], by the end of 2011, almost 95.7% of households - over 200 million - in the European Union had access to at least a basic level of fixed broadband services. These were based on fixed line technologies capable of providing at least 2 Mpbps downstream, and mainly including DSL, WiMAX[7] and Standard Cable[8]. The DSL technology is provided through the conventional telephone lines and relies on the legacy copper network

[6] Broadband coverage in Europe in 2011 - Mapping progress towards the coverage objectives of the Digital Agenda. A study prepared for the European Commission DG Communications Networks, Content & Technology. Available at https://ec.europa.eu/digital-single-market/en/news/study-broadband-coverage-2011

[7] WiMAX is a wireless service based on IEEE standards.

[8] This is broadband delivered over a fixed TV network using coaxial cable according to the earlier cable broadband standard such as DOCSIS 1 or 2.

previously owned by the State. Over 50% of EU households - 105 million - also had Next Generation Access (hereinafter, "NGA") services available to them, capable of delivering at least 30 Mbps, and that are mainly based on the VDSL[9], fiber to the premises (FTTP)[10] and Docsis 3 Cable[11] technologies. In particular, FTTP is the "ultimate technology" for delivering super fast broadband directly into people's homes and businesses. This is based on fiber optic cables, rather than copper cables, connected all the way from the exchange to the premises. The Point-topic study shows however that FTTP is, on average, available to just 12% of homes. Most notably, the picture is fragmented when looking at each Member State.

Figure 3.1 shows the FTTP coverage in European Member States in 2011, that is right after the end of the ST's abuse in Slovakia. FTTP coverage is measured as the percentage of homes within a country which have access to FTTP. Having access means being able to subscribe to the FTTP without requiring significant additional investment.[12]
Based on a partitional clustering method[13], countries have been grouped in 5 clusters, depending on their FTTP coverage. Slovakia, together with Lithuania and Latvia (cluster 1), have the greatest FTTP coverage, thereby leading the investment in FTTP technologies. In general, Eastern European Countries have the greatest coverage: most of them are indeed above the European average of 11.6%. Among the Western European Countries, the five Nordic countries - Denmark, Finland, Iceland, Norway and Sweden - have achieved well above average fiber coverage. Portugal, France and Luxembourg are also well above the average.

[9]This a "very-high-speed" version of DSL capable of delivering 25Mbps or more over conventional telephone lines.

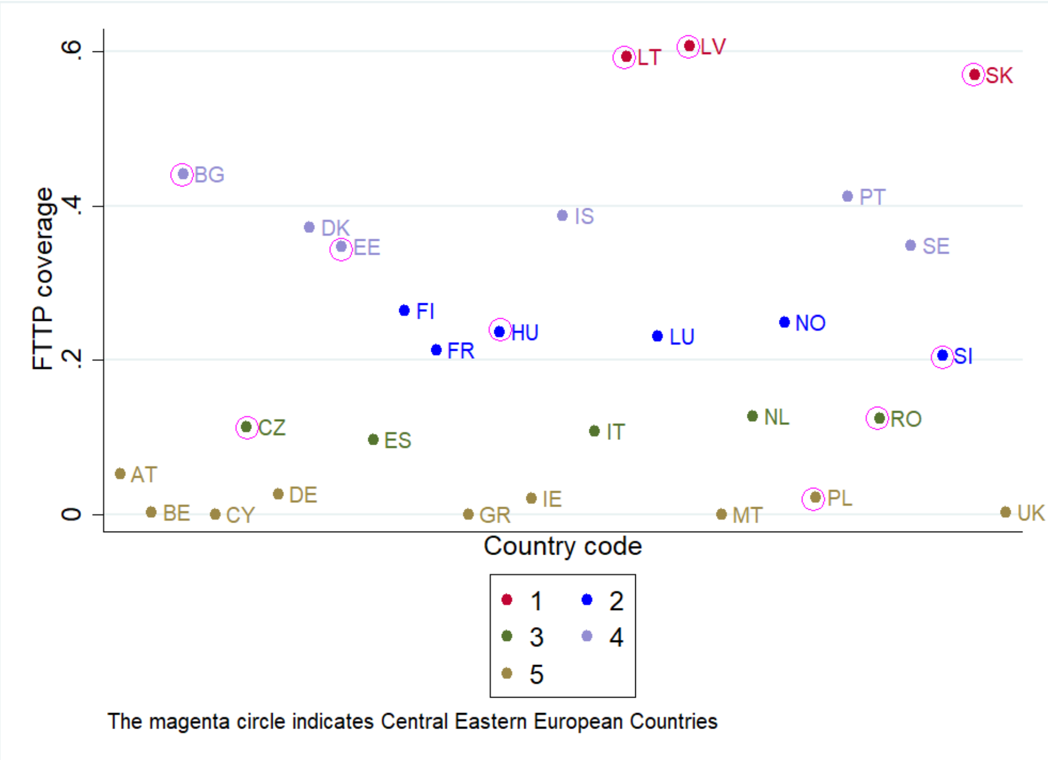
[10]There are several configurations of fiber network infrastructure which are mainly arranged into two groups: FTTP/FTTH/FTTB (Fiber laid all the way to the premises/home/building) and FTTC/N (fiber laid to the cabinet/node, with copper wires completing the connection).

[11]This is broadband delivered over a fixed TV network using coaxial cable according to the DOCSIS 3 standard, providing download speeds of 30 Mbps and above.

[12]Please note that this means that a home that is covered by a FTTP line has not necessarily activated that line and subscribed to the fiber services.

[13]Partitional clustering is opposite to hierarchical clustering and requires data to be assigned into k-clusters by minimizing the distance between two points. Figure 3.1 is based on k-*means* clustering, which starts with a user defined number of clusters, k. The objective function is given by the Euclidean distance between a data point and the cluster center (see [Saxena and al., 2017]). I have iteratively imputed higher number of clusters and selected the optimal number of clusters based on the highest value of the Calinski and Harabasz (1974) pseudo-F.

Figure 3.1: FTTP coverage in Europe - 2011



Most of the very low-coverage countries (cluster 5) rely on alternative NGA technologies such as Docsis 3 Cable and VDSL. In 2011, the development of fiber infrastructure in Europe was hence very heterogeneous. There are several factors explaining why Central Eastern European (CEE) countries have taken the lead:

1. the immediate need is greatest since copper networks are less developed; this is particularly true for local areas which rely on local cable-TV networks or fixed wireless access technologies;

2. a large proportion of housing consists of several flats (typically 40) per block, and this makes economically attractive to run optical fiber to a single block. In many Eastern countries, indeed, infrastructure has been deployed locally and using non-standard architecture and deployment techniques;

3. lower costs to deploy the fiber network, which is often done aerially and, in any case, relies on lower labour costs;

4. late launch of DSL services[14];

[14]For instance, in Romania the incumbent Romtelecom was relatively late and launched DSL services in 2005. Partly as a consequence, alternative carriers entered the broadband market either using existing infrastructure (e.g. cable operators) or new infrastructure (e.g. fibre-based Internet Service Providers or ISPs – the so-called 'neighbourhood networks'). See http://www.itu.int/ITU-D/treg/broadband/BB_MDG_Romania_BBCOM.pdf

5. late entry in the EU and late launch of wholesale services on the incumbent's network. Most of the CEE countries have entered the EU in 2004, with the exception of Romania and Bulgaria in 2007, and Croatia in 2013. The late entry in the EU delayed the adoption of the EC Regulation, and in particular the adoption of EC Regulation 2887/2000 on local loop unbundling, which has been applied to Member States since 2001, and required operators holding significant market power on the fixed public telephone network to give access to their unbundled local loops. Even after the entry in the EU, some incumbent operators refused to supply access to the local loops of their copper network calling for the intervention of the EC, who fined them for abuse of dominance and imposed them to provide access. This has occurred in Slovakia, Polonia and Slovenia.

In the absence of a proper copper network, and in light of the favourable investment conditions, telecoms operators launched FTTP networks quite early in CEE countries. With the exception of the Estonia, where the incumbent Elion has driven the investment in fiber[15], small regional operators and alternative operators have been the leader of the FTTP investment in CEE countries. In Latvia, Lithuania, Slovakia and Slovenia, the investment by alternative and regional operators have almost immediately been followed by the incumbent investment.

In the Nordic countries, instead, and in particular in Sweden and Denmark, the deployment of fiber has been driven by municipal organizations and electricity utilities.[16] Sweden is characterised by the early deployment of point to point FTTH, led primarily by independent municipal organizations such as Stokab. Stokab has been formed in 1994 and financed by the City of Stockholm. By the end of 2011, 90% of all Stockholm's households and nearly 100% of all companies had FTTH connections with speeds of up to 1 Gigabit-per-second.[17] In Denmark, instead, the deployment of fiber network has been mainly driven by utilities company. The primary FTTH network is the point-to-point network developed by DONG Energy ("DONG"). The second and third largest fixed telecom operators, who have also heavily contributed to the fiber deployment, are Waoo! - established as a product and marketing house for the fiber access networks of 15 of the Denmark's largest energy companies - and Syd Energi - which is the telecoms arms of an electricity company (previously part of Waoo!).[18]

[15] Small regional operators have also invested, supported by the Estonian Wideband Infrastructure Project ("EstWin") funded by the Government.

[16] In Finland, two of the three incumbents, Elisa and Finnet, have heavily invested in FTTB and VDSL technologies.

[17] Please see https://www.ftthcouncil.eu/documents/CaseStudies/STOKAB.pdf.

[18] Based on [Godlovitch et al., 2015], available at http://prodstoragehoeringspo.blob.core.windows.net/8564694b-f758-4823-b400-ec2c2b9a6c6f/Bilag%20-%20Analysis%20of%20market%20structures%20in%20the%20Danish%20broadband%20markets%20-%20august%202014%20-%20WIK.pdf

In the remaining well-performing Western Countries, the FTTP investment drivers have been various. In Portugal, the strong presence of cable has spurred the incumbent's investment in FTTH since 2008. In France, the alternative operator, Iliad, leveraged on its DSL base to invest in fiber.[19] Iliad is indeed considered as one of the few cases where access seekers have been able to reach the final rung of the "ladder of investment"[20] (as per [Cave and Vogelsang, 2003]).

This chapter empirically investigates whether Slovakia would have attained the same level of fiber coverage in the absence of the anticompetitive conduct engaged by ST, that impeded alternative operators to rely on ST's copper infrastructure. In particular, this chapter examines whether, and to what extent, ST's conduct has triggered alternative operators' investment in fiber.

3.4 The Slovak fixed telecom market and the abuse

Slovak Telecom (ST) is the largest telecom operator in the Slovak Republic: it owns and operates the fixed copper network originally built using public resources, which covers the entire territory of the Slovak Republic. ST provides a wide range of narrowband and broadband data services, and starting from April 2007, also launched ultra-broadband services over its fiber network.

Following the entry in the EU in May 2004, in line with European regulatory framework, the Telecommunication Office of the Slovak Republic ("TUSR") designated ST as an operator with significant market power (SMP) in the wholesale market for access to the unbundled local loop ("ULL") in March 2005. The EC regulation requires operators holding SMP in the fixed telecoms market to give access to ULL and to publish a Reference Unbundling Offer ("RUO"). ST published its first RUO in August 2005. The RUO specified the contractual and technical conditions under which ST was willing to give wholesale broadband (e.g. bitstream) and physical (e.g. ULL) access to its network.[21] The access procedure defined in the first RUO, however, was such that the network information provided by ST regarding its ULL was insufficient or unclear, given late in the

[19]In 2006, Iliad joined the Paris Digital City initiative, marking the start of the fibre deployment in Paris. To reduce investment costs, the company has relied for its early fibre deployments on access to the Paris sewer system. Since the September 2008 ruling by the French Regulation Authority that imposed duct access, Iliad makes use of the civil infrastructure of Orange. To further reduce roll-out costs, the operator made use of aerial solutions and of facilities belonging to the municipalities.

[20]Other examples are NetCologne, M-net, Wilhelm.Tel and EWE-Tel among others in Germany, Metroweb in Italia, Statsnet in Sweden

[21]The TUSR does not prescribe the content of the RUO in detail, but it just requires that the RUO guarantees non-discrimination, transparency and fair access to network elements and to the related information.

process and onerous.[22] ST was basically hindering access to its local loops.

In contrast with the situation at European Union level, in Slovakia, ULL was non-existent until December 2009, when the first 3 local loops were unbundled by GTS Slovakia.[23]

The sluggish opening up of ST's physical network infrastructure has triggered many regulatory and legal disputes. The TUSR repeatedly fined ST for refusing to provide wholesale access to its network and ST has changed the RUO terms nine times over the period 2005-2010. In the meantime, the EC Commission initiated ex-officio a case against ST. Following requests for information and an unannounced inspection at ST's premises in January 2009, the EC opened formal proceedings against ST in April 2009. In October 2014, the Commission established that ST (and its parent company Deutsche Telekom) has committed a single and continuous infringement of Article 102 of the Treaty of the Functioning of the European Union ("TFEU"), which lasted from 12 August 2005 (that is the date when the first RUO was published) until 31 December 2010. According to the Commission, the infringement consisted of the following practices[24]:

- withholding from alternative operators ('AOs') network information necessary for the unbundling of local loops;
- reducing the scope of its obligations regarding unbundled local loops;
- setting unfair terms and conditions in its Reference Unbundling Offer regarding collocation, qualification, forecasting, repairs and bank guarantees;
- applying unfair tariffs which did not allow an equally efficient competitor to rely on wholesale access to ST's unbundled local loops to replicate the retail broadband services offered by ST without incurring a loss.

While the EC identified anticompetitive conduct from ST's provision of ULL, the EC ascertained availability of both national and regional wholesale broadband access ("WBA") at competitive conditions. Although WBA still allows AOs to provide retail services based on DSL connections, WBA and ULL should not be however considered substitute wholesale products. Compared to ULL, WBA does not allow an AO to influence most of the technical and quality parameters of the network connection, which relies on the incumbent backbone and active operating equipment. According to the ladder of investment approach, WBA is the first rung of the ladder.

[22]ST was omitting crucial information on the location of the physical access site and on the availability of local loops in specific part of the network. Alternative operators willing to access ST's network would have obtained such information only on request, subject on access fee, and after having signed a confidentiality agreement and provided a bank guarantee.

[23]European Commission, Case AT. 39523, § 387

[24]EC decision, Case AT. 39523, Article 1.

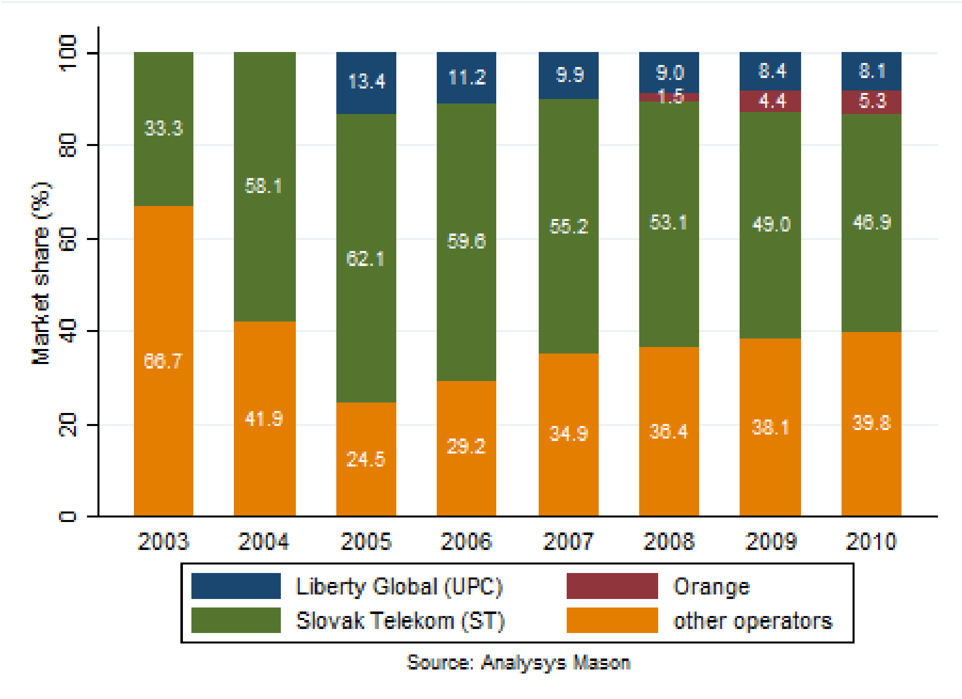
The final amount of the fine imposed on Slovak Telekom and on Deutsche Telekom, for which they were jointly and severally liable, was EUR 38 million.

Figure 3.2 shows the market share of fixed telecom operators in Slovakia (as a percentage of total number of subscribers to broadband services provided over fixed technologies) over the period 2003-2010. Following the liberalisation of the Slovak telecommunication sector in 1998 and the launch of retail broadband services in June 2003, a variety of players entered the Slovak retail broadband market. The cable operator, UPC Broadband Slovakia, is the second largest operator in Slovakia and provides broadband and ultra-broadband services over its cable network. The other fixed players operating at national level are mainly SWAN, Slovanet and GTS Slovakia. Both SWAN and Slovanet provided retail services over a limited fiber infrastructure. GTS Slovakia mainly serves business customers and it was the first operator capable of concluding an agreement with ST over-unbundled access to the local loop before 2011. Over the period 2006-2009, SWAN and GTS Slovakia acquired many small fixed national players, making the number of Slovak players decreasing from 14 to 5. In 2006, the fixed national operator Orange Slovensko (hereinafter, Orange or OSK), belonging to the French Telecom group Orange, entered the Slovak market and rolled out its own FTTH (fiber to the home) infrastructure, mainly in densely populated area.[25]

At that time, Slovakia was also characterised by a large number of regional players mainly providing fiber services at local level (e.g. Satro, Antik, Imafex).

[25] European Commission, Case AT. 39523 - Slovak Telekom

Figure 3.2: Market share of fixed telecom operator - Slovakia



In 2006, ST served almost 60% of fixed broadband subscribers, through mainly DSL technologies, while UPC and other operators have respectively a market share of 11.2% and 29.2% and serve their customer mainly based on cable and fiber technologies. Orange attained an appreciable market share in 2008. Interestingly, ST's market share decreased over the period 2006-2010, to the benefit of other operators and Orange.

At the end of its investigation, the EC concluded that ST's conduct, consisting of refusal to supply access and margin squeeze, was likely to foreclose AOs from the key xDSL segment of retail mass-market for broadband service. Investing in their own infrastructure deployment was the only possibility left to AOs on the retail mass market for broadband services offered at a fixed location. According to the market analysis carried out by the TUSR, by the end of 2011, Slovanet provided fiber services in 6 cities, SWAN in 10 cities, Antik in 7 cities, Orange in 17 cities, and other operators only locally, mostly in parts of larger cities or newly built housing estates. Slovanet declared that investing into fiber was the only practicables means of continuing its business.[26] Orange sought ULL access to ST's network and finally decided, in 2006, to roll out its own fiber network. The operator indeed declared that "given the market situation and given that the outcome of the regulation was difficult to foresee [they] have decided to invest in [their] own infrastructure based on FTTH".[27] Orange explained that it built this network in some densely populated areas where a reasonable payback of the investment could be expected.

[26]EC Decision, Case AT. 39523, § 1090.
[27]EC Decision, Case AT. 39523, § 424.

Orange started to build its fiber network in 2006. The coverage of Orange's fiber network in terms of households amounted to over 300,000 households at the end of 2009. ST followed shortly with its fiber network roll out targeting the most densely populated areas, and reached 315,000 households at the end of 2009. ST's roll out significantly overlapped with OSK's roll out, since both operators have focused on deploying fiber in larger cities and densely populated areas. ST's investment might have been triggered by the competitive pressure exerted by OSK: right after OSK started investing in fiber, the Slovak incumbent announced that "extending optical networks to households is not to end in Slovakia with investments of Orange".[28] On the other hand, ST's fiber roll-out appeared inevitable given the technical limitations of the copper network and the increasing demand of customers for high speed access.

3.5 Data and Identification

The empirical analysis seeks to identify the effects of ST's anticompetitive conduct on the decision of AOs to invest in a new and superior technology, the fiber. Additionally, it also assesses the effects of the abuse of dominance on total investment in fiber in Slovakia. Over the period 2005-2010, ST has refused to supply access to the local loops of its copper network to AOs. The objective of the analysis is demonstrating that such anticompetitive conduct has left the AOs with no other choice than investing in fiber to enter the retail telecom markets. The investigation of the causal effects of the refusal to supply access on investment in fiber has to start with the examination of the determinants of firms' investment decisions.

Assume firm j is an alternative operator in a market. In line with the EU telecommunications regulatory framework, firm j may decide whether entering the retail market by (i) relying on the incumbent's legacy network O (as old technology) and paying a wholesale access price a, or (ii) investing in a next generation infrastructure N. It is profitable for firm j to invest if the additional gross profit it earns by investing in a next generation infrastructure is higher than the investment cost I:

$$\Pi_j^N - \Pi_j^O(a) \geq I$$

[28]See ST's annual report, 2007: Extending optical networks to households is not to end in Slovakia with investments of Orange. On the very first day of the commercial launch of that operator's service Doma, based on fibre-optics network brought right to the client's home, a similar intent was announced by Slovak Telekom, offering services for households under the T-Com brand. The largest fixed line operator wants to invest by year-end SKK 1 bn in a network covering close to 200 thousand households. Orange, currently covering some 110 thousand potential clients, wants to achieve a similar presence by then. In the following year, Slovak Telekom anticipates investing approximately SKK 1 bn more into optics. Orange has not yet revealed its next year's plans but the Company's investment will probably be around the same level.

When the alternative operator relies on the old network to provide its services, its profits $\Pi_j^O(a)$ decrease with the access price a. This assumption is rather standard and implies that the entrant faces a make-or-buy decision according to the level of the access charge[29]: as long as the access charge to the old network increases, since its profit would decrease, it might decide to invest in its own next generation infrastructure. In the equation above, this implies that as long as the access price a increases, the profitability of investment increases. The ultimate decision will also depends on the cost of investment I.

By setting excessively high access price, thereby hindering access to its network, ST has triggered AOs' incentives to investment. For intermediate values of I, the AOs may indeed find convenient investing in fiber.[30].

The identification strategy exploits cross-country variation in fiber investment within the European Union through a *Difference in Differences* ("DiD") methodology.

3.5.1 Econometric model

The DiD methodology has been widely applied in the economic literature on program evaluation for the estimation of treatment effects (see [Imbens and Wooldrige, 2009], [Abadie and Cattaneo, 2017]). It is also widely used in the field of ex-post evaluation of competition policy decision, and in particular, for the estimation of merger effects. (see [Ashenfelter and Hosken, 2008], [Ashenfelter et al., 2013a], [Aguzzoni et al., 2016a].)

The DiD methodology entails comparing the evolution of the outcome variable in the unit(s) affected by the treatment (i.e. treated units) with the evolution of the same variable in the unit(s) that was instead not affected (i.e. control units), before and after the treatment. The variation over time in the outcome variable in the control units is used to establish what would have occurred in the treated units in the absence of the treatment. In line with the above, the effects of the abuse on fiber investment can be obtained by comparing the variation of fiber investment in Slovakia and in the other European Countries, before and after the abuse.

More formally, this can be implemented through the following equation:

$$y_{ijt} = \alpha + \beta abuse_t + \gamma treated_j + \delta abuse_t \times treated_j + \mu X_{jt} + \lambda_t + \rho_j + \epsilon_{jt} \tag{3.1}$$

where y_{ijt} measures the fiber investment in country j at time t by all the alternative operators i[31], X_{jt} indicates a vector of time-varying observable factors at country level, λ_t

[29] See [Bourreau and Dogan, 2006].

[30] Chapter 2 of this thesis presents a theoretical model that outlines the mechanisms that make this outcome possible.

[31] When investigating the effect of the abuse on total investment and the investment made by the incumbent, y_{ijt} measures, respectively, the fiber investment in country j by all telecoms operator and by

and ρ_j are respectively time and country fixed effects helping to control for unobservable factors at time and country level, ϵ_{jt} is the error term.

In a standard DiD fashion, $abuse_t$ is a dummy variable that takes value one over the period of the abuse (2005q4-2010q4) and zero otherwise; $treated_j$ is a dummy variable that takes value one when the country is Slovakia, and zero otherwise. The interaction term $abuse_t \times treated_j$ takes value one when the fiber investment is measured in Slovakia and over the abuse period, and zero otherwise. Its coefficient measures the causal effect of the abuse, and it will be equal to:

$$\delta = (E[Y_{ijt}/t = abuse; j = treated - E[Y_{ijt}/t = noabuse; j = treated]) - \\ (E[Y_{ijt}/t = abuse; j = control] - E[Y_{ijt}/t = noabuse; j = control])$$

The causal effect will be indeed equal to the additional variation in fiber investment occurred in Slovakia, compared to the control countries, before and after the abuse. By taking the difference in the variation of the outcome variable between the treated and the control countries, the DiD methodology allows to control for any unobserved time-varying factors which may affect the outcome variable and confound the estimation of the effect.

Identification in the DiD methodology relies on the common-trend assumption: in absence of the treatment, the average outcome for the treated countries and the average outcome for non treated countries would have experienced the same variation over time. This makes the selection of the control countries a crucial step to reach a clear identification of the causal effects of the abuse on fiber investment. The set of the selected control countries, indeed, should be able to reproduce the counterfactual trajectory of the fiber investment in Slovakia.

3.5.2 Control group

The control group consists of alternative operators from a sub-set of European Countries.[32] I have limited the candidate countries to European countries as they share a common framework in terms of access regulation and may be subject to common macro-economics shocks.

The control group has to be not affected by a similar treatment or structural changes in the period of analysis. I have hence excluded Poland, Slovenia and Spain, where the telecom incumbents also infringed Article 102 of the TFEU by abusing their dominant

the national incumbent

[32]When investigating the effects of the abuse on total investment and on the investment made by the incumbent, the control group consists of, respectively, all the national telecom operators and the national incumbents from a subset of European Countries.

positions in the wholesale market for access to physical network infrastructure.[33]
Slovakia is an Eastern European country and, as most of the CEE countries, entered the EU in 2004, thereby adopting the EU framework on access regulation quite lately. This reinforced the position of the incumbent operator especially in the DSL market. As in many Eastern Countries, following the liberalization of the telecoms markets, many small AOs (e.g. Antik, Slovanet) entered the retail market by deploying a limited, but own, telecom infrastructure. These small AOs relied on different technologies, ranging from WIMAX, cable to fiber. At the same time, many utilities companies (e.g. Energotel) exploited their infrastructure to deploy limited fiber networks. In light of the above similarities, I have further restricted the control group to the European countries located in the Central-East Europe.[34] As a robustness check, I am also considering two alternative control groups:

- all European countries, with the exception of Poland, Slovenia and Spain;
- all European countries in which alternative operators have made an early investment in fiber. I have considered all the countries where (i) there has been an investment in fiber by AOs before 2005q2 and (ii) the AOs' investment has occurred before the incumbent's. This includes both CEE and WE countries[35] and it aims at capturing countries where demand and costs conditions are favourable to early investment in fiber.

In spite of a careful selection of the control countries, the common trend assumption still need to be assessed. I have empirically evaluated the plausibility of this assumption by using a twofold strategy, similarly to [Ashenfelter et al., 2013a]. First, I have estimated the difference between the outcome variable in the treated and control countries, for each quarter in the pre-abuse period. I have then estimated whether such differences are jointly

[33]With the decision COMP 39.525, the EC established that Telekomunikacja Polska, the Polish incumbent, refused to properly provide access to its network from August 2005 to October 2009. With the decision COMP 38.784 the EC fined Telefonica, the Spanish incumbent, for having foreclosed equally efficient competition by squeezing their margins in the market for wholesale broadband access from September 2001 to December 2006. Finally, Telekom Slovenije, the Slovenian incumbent, has been instead fined by the Slovenian Competition Protection Agency for having abused its dominant position the wholesale markets for broadband bit-stream access and for access to physical network infrastructure over the period 2005-2014 (see https://webgate.ec.europa.eu/multisite/ecn-brief/en/content/telekom-slovenije-abuses-its-dominant-position-refusing-access-network). See also Table 3.1.

[34]The CEE included in the control group are: Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Romania.

[35]This control group includes Estonia, Hungary, Latvia, Lithuania, Romania, Sweden, Denmark and Italy. In Italy, investment has been driven by small private investors in the Northern Italy and the alternative operator Fastweb starting to deploy its fiber network in 2005. See Section 3.3 for Sweden and Denmark.

equal to zero. This has been implemented by estimating the following equation:

$$y_{ijt} = \alpha + \sum_q \beta_q quarter_q + \gamma treated_j + \sum_q \delta_q quarter_q \times treated_j + \mu X_{jt} + \rho_j + \epsilon_{jt} \tag{3.2}$$

Rejecting the null hypothesis that the coefficients δ_q are jointly equal to zero implies rejecting the common trend assumption. Secondly, I have examined whether the fiber investment in the treated and control countries trend similarly in the period before the abuse. This has been done by estimating the following equation:

$$y_{ijt} = \alpha + \beta trend + \gamma treated_j + \delta trend \times treated_j + \mu X_{jt} + \rho_j + \epsilon_{jt} \tag{3.3}$$

Rejecting the null hypothesis that the coefficient δ is equal to zero implies rejecting the common trend assumption.[36]

3.5.3 Data

The dataset that informs the analysis of this chapter is a panel of 22 EU countries over the period 2003q4-2010q4.

In line with most of the existing related literature, the investment made by national fixed telecom operators in fiber has been proxied by the penetration of fiber services provided by such operators. For each country, I have obtained quarterly data on the percentage of fixed subscribers (over total population) to fiber services offered by each telecom operators.[37] Data systematically cover all the European Countries with the exception of Cyprus, Malta and Luxembourg, and have been provided by Analysys Mason.

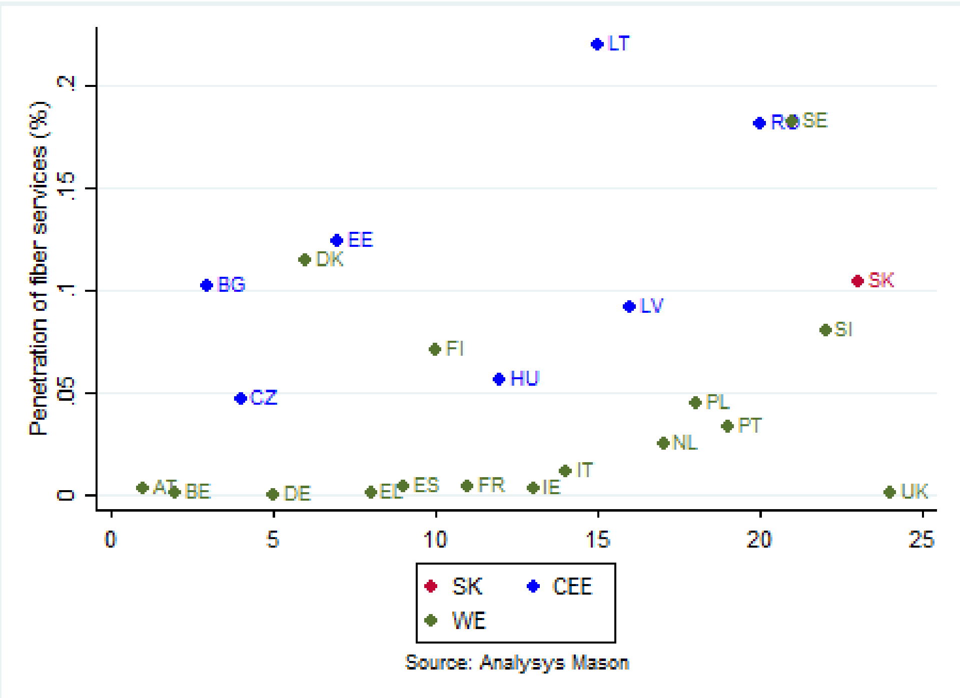
Data on fiber coverage, rather than fiber penetration, would have been a much proper measure of investment. Coverage measures indeed the availability of fiber connections, without necessarily implying that such connections have been activated by a subscriber. Penetration reflects, instead, both the availability and the demand of fiber connections. Unfortunately, coverage data were available only starting from 2011 (and were not disaggregated at operator level). Relying on data on penetration should not impede to identify the causal effects of the abuse on investment. Before 2005, DSL was the main broadband technology in Europe and the deployment of alternative broadband technologies, including fiber, was quite limited. The variation in the penetration of fiber services before and after 2005 has to be necessarily related with a variation in the availability of fiber connections,

[36] This is similar to [Muralidharan and Prakash, 2013].

[37] I have grouped national and small alternative operators by taking the sum of their subscribers, and divided them by the national population for each quarter.

that is a variation in fiber investment. By using data on penetration, however, the causal effect of the abuse on investment may be underestimated. Fiber connections are generally used to provide high-quality services (e.g. Triple-play) that tend to be more expensive and to face less demand (especially at their early stages). The evidence collected by the EC at the time of the investigation of ST shows indeed that "although Orange's fiber network covered 300,000 households in 2009, Orange had only 38,000 fiber subscribers (accounting for only 12.6% of the total capacity)"[38]. Figure 3.3 shows the fiber penetration (rather than coverage) in Slovakia and the other European countries in the last quarter of 2010 (the latest data available). Differently from Figure 3.1, Slovakia is no longer taking the lead: the countries with the highest fiber penetration are instead Sweden, Lithuania and Romania.[39]

Figure 3.3: FTTP penetration in Europe - 2010q4



Data on penetration could hence underestimate the investment made by national operators. Table 3.2 shows some descriptive statistics for the main outcome variable of this analysis in Slovakia and the three proposed control groups.

The penetration of fiber services experienced a huge increase both in Slovakia and in the remaining European Countries: the percentage of subscribers to fiber services increased by 2.07 percentage points in Slovakia, while it increased by 0.82 percentage points

[38]EC decision, Case AT 39523, § 1102

[39]While the percentage of households covered by fiber connection is almost 60% in Slovakia, only 10% of them are subscribed to such services.

Table 3.2: Outcome variable: penetration of fiber services offered by AOs

	pre-abuse				abuse			
group	mean	stdev	min	max	mean	stdev	min	max
Treated (SK)	.25	.14	.13	.52	1.76	.87	.63	3.00
Control (CEE)	.14	.26	0	1.03	1.45	1.66	0	6.53
Control (AO)	.53	.78	0	2.95	2.28	2.00	.04	7.03
Control (ALL)	.20	.54	0	2.95	1.02	1.65	0	7.03

in all the candidate control countries (last row of Table 3.2). Fiber penetration during the abuse period in Slovakia was almost twice the penetration in the remaining European countries, but also lower than the penetration in the Central Eastern European countries, and in the countries where alternative operators have made an early investment in fiber. I have also collected a set of country-specific control variables which may explain change in the demand or supply of fiber services.

GDP per capita and the penetration of mobile services may affect the demand of fixed broadband services based on fiber technologies. GDP per capita may be indeed interpreted as a proxy of income, while the demand of mobile (voice) services may capture the population propensity for telecom services. Population dispersion and population density may instead affect the fiber investment's costs.[40] There are large economies of density when deploying a new infrastructure: the establishment of a network in densely populated areas allows to share the ducting for the connection loops of multiple premises and reduces investment costs. While population density measures the average number of people per squared km, population dispersion indicates how individuals are spread throughout the territory. In spite of very high (average) density, population can be concentrated in a single portion of the territory, e.g. rural or mountainous areas, where costs are expected to be higher and investment less viable. In this dataset, population dispersion measures the percentage of population living in rural areas.

Finally, I have also collected time-invariant variables and in particular:

- year of entry in the EU: WE Countries have entered the EU between 1985-1995, while CEE countries joined the EU between 2004-2013. Late entry indicates late adoption of the EU framework of access regulation on DSL network, thereby increasing the countries' need of finding a viable alternative by investing in their own infrastructure;

[40] As in [Bacache-Beauvallet et al., 2014], due to the lack of appropriate date, I cannot directly control for the cost of fiber. However this should not give rise to an omitted variable problem. The cost of fiber deployment depends on the cost of fiber equipment and the costs of fiber infrastructure. The cost of fiber equipment is roughly the same in all EU countries, and therefore is captured through the time fixed effects. The cost of fiber infrastructure is instead controlled for through population density and dispersion.

- amount of State aid received to deploy NGA technologies in the period 2003-2010. National investment could have been indeed facilitated by public subsidies.[41]

Table 3.3 recaps the set of control variables, their definition, source and provide some basic statistics.

Table 3.3: Control variables

variable	description	mean	max	min	sd
population dispersion	Share of national population in rural regions. Annual data from Eurostat.	26.6	60.9	.62	16.64
population density	Population per km2. Annual data from Eurostat.	130.8	503.1	17.1	113.4
GDP per capita	Gross domestic product (current US $) divided by midyear population. Annual data from World Bank national accounts data.	30,261.3	69,330.7	2,698.6	17,133.9

[41]In CEE countries, only Lithuania has received public subsidies for NGA infrastructure deployment in the analysed period. I have hence only included this control variables when performing the analysis with the two alternative control groups, where the number of countries receiving NGA aid is higher, thereby allowing for statistical inference of the aid effect on penetration.

Table 3.3: Control variables

variable	description	mean	max	min	sd
mobile penetration	Mobile cellular subscription (per 100 people). It excludes subscriptions via data cards or USB modems and subscriptions to public mobile data services. Annual data from International Telecommunication Union	116.4	172.2	32.4	20.9
aid	Sum of the aid amount (EUR - million) received over the period 2003-2010 to develop NGA infrastructure[42]	.46	1	0	.50

3.6 Results

The validity of the DiD estimates depends on not rejecting the null hypothesis of the parallel trend assumption between the fiber investment in Slovakia and in the control countries before ST's abuse. Section 3.6.1 empirically assesses the plausibility of this assumption. Sections 3.6.2 and 3.6.3 show the estimated effects of ST's abuse on the fiber investment made by alternative operators and total investment. Estimates are based on the control group composed of CEE countries. Robustness check with the alternative

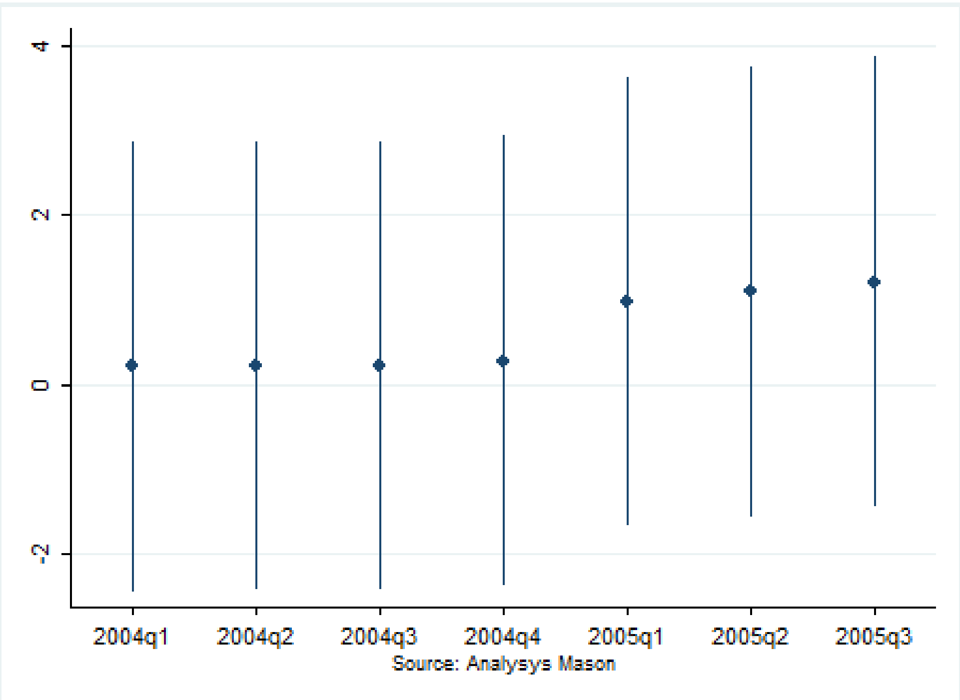
[42] This is based on EC databases, available at http://ec.europa.eu/competition/sectors/telecommunications/broadband_decisions.pdf

control groups are presented in Appendix 3.8. Finally, Section 3.6.4 operates a comparison country-by-country, and estimates the effects of the abuse on the investment made by alternative operators in Slovakia by comparing it to the investment made by alternative operators in each single European country.

3.6.1 Common trend

Figure 3.4 shows the estimated differences (and their standard deviation) in the penetration of fiber services offered by AOs in Slovakia and in the CEE countries, taking into account a set of supply and demand factors (see Equation 3.2), for each quarter before the beginning of the abuse. Coefficients close to zero or not significant imply that we cannot reject the parallel trend assumption.

Figure 3.4: Differences in penetration of fiber services offered by AOs between Slovakia and CEE countries



The coefficients are jointly equal to zero[43], and most of them are close to zero. The estimated coefficients for the first three quarters of 2005, although not significant, are positive.

Table 3.4 tests whether the penetration of fiber services offered by AOs in Slovakia and in the CEE countries trends similarly before the abuse, taking into account a set of demand and supply factors (see Equation 3.3). When the coefficient of the interaction term

[43] The F-test indicates that the null hypothesis cannot be rejected. The p-value is indeed equal to 0.97.

trendxtreated is zero or not significant, we cannot reject the parallel trend assumption. Model (1) takes into account the entire period 2003q4-2005q3, while Model (2) excludes the second and third quarter of 2005. This is in light of results shown in Figure 3.4 , and based on the fact that ST has been designed national operator with SMP in March 2005, hence the abuse could have exerted its effects starting from that date.

Table 3.4: Common trend assumption - penetration of AOs' fiber services

	Model (1)	Model (2)
treated	-12.18**	-0.0738
	(3.527)	(0.123)
trend	-0.0490***	-0.0600***
	(0.009)	(0.013)
trendxtreated	0.0691***	0.0376
	(0.020)	(0.031)
pop. dispersion	0.00802***	0.00846***
	(0.001)	(0.001)
pop. density	-0.00667***	-0.00789***
	(0.001)	(0.001)
GDP	0.0000617**	0.0000827**
	(0.000)	(0.000)
mobile penetration	0.00640***	0.00625**
	(0.001)	(0.002)
year entry EU:2004	0.242***	0.271***
	(0.056)	(0.070)
year entry EU:2007	0.564***	0.689***
	(0.115)	(0.142)
Constant	7.863***	-0.744***
	(1.509)	(0.121)
Observations	72	54
R^2	.8111886	.8342446

Standard errors in parentheses
Fixed effect at half-year level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data

The coefficient of the interaction term *trendxtreated* in Model (1) is positive and significant thereby rejecting the common trend assumption. This is likely to be driven by the first quarters of 2005: the same coefficient in Model (2) is indeed not significant thereby not rejecting the assumption that the outcome variable trends similarly in the treated and control countries before the abuse.
Similar tests have been performed on the remaining outcome variables: penetration of fiber services offered by the incumbent and total penetration of fiber services (that is the sum of the incumbent's and AOs' subscribers for fiber services). The common trend assumption is always satisfied (see Appendix 3.8).

3.6.2 Effects of the abuse on AOs' investment

Table 3.5 presents the estimate of the impact of ST's conduct on the fiber investment made by AOs, based on Equation 3.1. Model (1) shows the baseline specification, where the variation in the investment made by AOs in Slovakia (proxied by the percentage of subscribers) is compared to the variation in the investment made by AOs in CEE countries. In Model (2), to take into account the results of the common trend test, I have excluded observations from the second and third quarters of 2005 and from the country (Estonia) where the common trend assumption is rejected.[44] Finally, in Model (3), I have interacted the DiD variable (i.e. *treatedxabuse*) with a year dummy variable, to estimate the effects of the abuse over time.

Results indicate that the percentage of AO's subscribers to fiber services in Slovakia has relatively increased following ST's abuse, compared to the CEE countries. Table 3.5 indicates that the abuse caused an increase in the percentage of subscribers to fiber services offered by AOs by 1.16 (Model 1) to 1.48 percentage points (Model 2).[45] Model (3) indicates that the effects have increased over time, up to 2009. The largest effect is registered in 2009, when Orange has attained appreciable market share in the Slovak retail market.

This exercise is meant to investigate whether the Slovak incumbent's abuse has stimulated AOs investment in fiber. In the absence of reliable data on fiber investment or coverage, I have performed an analysis on fiber penetration, which suggests that the abuse has increased AO's customer base. Since the deployment of fiber networks before the abuse was negligible and limited to local areas, the increase in the number of subscribers has to be related with the greater availability of fiber connections, and hence indicates greater investment in fiber.

[44] Based on Equation 3.3, I have indeed estimate whether the outcome variable in each single control country trend similarly to the same variable in Slovakia. In Estonia, the test rejects the parallel trend assumption.

[45] Results are robust even when clustering standard errors at country level, or by including fixed effects at country level.

Table 3.5: Effects on fiber penetration offered by AOs

	(1) Baseline	(2) Common trend	(3) Time effects
treated	-0.0692	-0.371	0.00764
	(0.326)	(0.376)	(0.309)
DiD	1.160**	1.479***	
	(0.366)	(0.413)	
DiD:2006			1.154*
			(0.525)
DiD:2007			0.418
			(0.522)
DiD:2008			1.558**
			(0.529)
DiD:2009			1.716**
			(0.530)
DiD:2010			0.732
			(0.526)
pop. dispersion	0.0559***	0.0599***	0.0570***
	(0.006)	(0.006)	(0.006)
pop. density	-0.0161***	-0.0167***	-0.0163***
	(0.003)	(0.003)	(0.003)
GDP per capita	0.0000396	0.0000379	0.0000411
	(0.000)	(0.000)	(0.000)
mobile penetration	0.0593***	0.0634***	0.0607***
	(0.004)	(0.005)	(0.004)
year entry EU:2004	1.459***	-0.644	1.465***
	(0.217)	(0.362)	(0.216)
year entry EU:2007	2.164***		2.180***
	(0.364)		(0.364)
year entry EU:2013		-2.220***	
		(0.370)	
Constant	-5.489***	-3.616***	-5.610***
	(0.556)	(0.516)	(0.556)
Observations	232	216	232
R^2	.7432303	.7549345	.7501261

Standard errors in parentheses

Fixed effect at half-year level

Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Most of control variables show expected sign. GDP per capita and mobile penetration, which have been included as proxy of demand, positively affects the outcome variable, although the GDP coefficient is not significant. The later is the year of entry the higher is the penetration of fiber services, although the sign of the dummy for "Year entry EU:2013" is negatively signed. Late entry in the EU means indeed late adoption of the EU access regulation, and this may reinforce the position of the incumbent in the DSL market and increase the need of AOs to invest in alternative technologies. There is only one country in the sample that entered the EU in 2013, Croatia, and this may make the coefficient of "Year entry EU:2013" less reliable.
The sign of the coefficient of population density and dispersion is rather counter-intuitive. Population density negatively (rather than positively) affects fiber penetration. Population density is a proxy of investment costs: highly densely populated areas should make the investment more viable. Similarly, the percentage of people living in the rural areas (i.e. population dispersion) positively (rather than negatively) affects the outcome variable: when a larger fraction of the population lives in rural areas, where investment costs are expected to be higher, the penetration of fiber services should be lower. The estimate of this coefficient may be confounded by other factors: in many CEE countries, investment in fiber has been driven by municipal operators deploying the network at the neighbourhood level. This may have caused less densely populated countries or rural countries to witness a stronger wave of investments than expected.[46]

Appendix 3.8 shows that the abuse may also have spurred AO's investment in other alternative technologies, namely the fixed wireless access technologies (FWA). FWA technologies cannot be considered perfect substitutes of fiber, since they do not allow to provide high-quality broadband services, such as video-on-demand. However, FWA technologies can be used to complement the geographic coverage of the AOs broadband offer: FWA can address attractive market niches (e.g. rural/remote areas) where the timeframe and the economics of fiber deployment make the business case challenging.[47]

The analysis above does not allow to quantitatively investigate what occurred after the end of the abuse. The above shows that during the abuse, in the absence of a valid alternative, operators decided to invest in a superior technology. After the end of the abuse, operators had the possibility to resort to cheaper technologies (i.e. ULL over the incumbent's copper network) and this may have deterred further investment. The annual reports released by Orange seem to confirm such assumption:

[46]The control variable which measures the amount of aid received is not included in this specification since only one country among those considered, Lithuania, has received public subsidies for the deployment of fiber infrastructure. I have also run a robustness check by excluding Lithuania from the set of control countries and results are still robust.

[47]Please see: https://www.analysysmason.com/Consulting/content/articles/predictions-for-ma-2020-jan20. Prediction 5.

- from 2006 to 2010, OSK's FTTH network reached more than 308,000 households in 17 Slovak cities;
- in 2015, OSK's FTTH network covered over 342,000 households across 18 cities in Slovakia;
- in 2017, OSK's FTTH network covered over 370,000 households across 34 cities in Slovakia.

The additional investment made after the abuse, measured in terms of new cities and households covered, is quite limited if compared to the investment effort made during the abuse. This may be however related to the decreasing returns of investment: once covered the urban areas, the costs of deploying the infrastructure in intermediate and rural areas are expected to be higher, and in turn, the returns of the investment to be lower.

It can be interesting understanding whether the findings of this analysis are specific to the Slovak market, or can be extended to any markets where a similar infringement occurred. During the same period of the Slovak abuse, the incumbent in the Polish market for fixed telecom services was refusing to properly supply access to its copper network.[48] As in the Slovak case, the EC opened an investigation and established that the conduct was likely to foreclose competitors in the retail market, thereby fining the Polish incumbent for an infringement of the Art. 102 of the TFEU over the period August 2005 - October 2009. The available qualitative evidence suggests that the abuse has been mainly followed by investment in cable technologies. Multimedia Polska, one of the AOs in the Polish market, started investing in its own cable networks in 2008-2009, four years after the beginning of the abuse. In 2009, cable operators accounted for 1.58 million of Polish subscribers, which is about 24% of the market for fixed broadband services. Cable subscribers were, however, mostly limited to larger cities.[49] On the other hand, fiber and wireless technologies represented, together, only 4.3% of all broadband access lines in Poland in 2009.[50] The limited development of the fiber technologies in the Polish market, in the period right after the start of the abuse, may however be related to the characteristics of the territory - whose morphology may impede the efficient deployment of the infrastructure - or to the financial resources available to the AOs. The investment effort made into cable, however, still corroborates the idea underlying this analysis: banning access to the incumbent's network may stimulate AOs' investment.

[48]Similar infringements also occurred in other European countries. However, either the period when the infringement occurred was too early to expect investment in next generation access technologies (e.g. in Spain the abuse started in 2001) or there is no sufficient data to understand what occurred (e.g. in Slovenia the infringement was investigated by the National Competition Authority and the public evidence is limited).

[49]EC decision, Case COMP 39.525, §42

[50]EC decision, Case COMP 39.525, §46

3.6.3 Effects of the abuse on total investment

The analysis of the impact of the abuse on the percentage of subscribers of AO's fiber services shows that, by hindering access to its metallic network, ST has spurred AOs to invest in their own fiber infrastructure. Does this imply that, due to the anticompetitive conduct of ST, Slovakia has achieved greater investment in fiber? To answer this question, Table 3.6 provides the estimate of the effect of the abuse on the percentage of people subscribed to fiber services (regardless of the operator offering the service). Model (1) excludes the observations related to the second and third quarter of 2005[51], while Model (2) investigates the effects over time.

Results indicate that the effects of the abuse on total fiber penetration are positive and significant (at 5% significance level): because of the abuse, Slovakia has attained higher level of fiber penetration. As before, Model (2) indicates that most of the effects come from 2009, when OSK gained an appreciable market share.

[51] As before, the common trend assumption is satisfied when excluding the first quarter of 2005. I have also tested whether the common trend assumption cannot be rejected when comparing the outcome variable in Slovakia to each control countries. The test indicates that the assumption is always satisfied.

Table 3.6: Effects on total fiber penetration

	(1) Common trend	(2) Time effects
treated	0.0582	0.397
	(0.492)	(0.406)
DiD	1.113*	
	(0.544)	
DiD:2006		0.934
		(0.695)
DiD:2007		0.0242
		(0.691)
DiD:2008		1.033
		(0.698)
DiD:2009		1.312*
		(0.699)
DiD:2010		0.387
		(0.696)
pop. dispersion	0.0518***	0.0489***
	(0.007)	(0.006)
pop. density	-0.0212***	-0.0208***
	(0.003)	(0.003)
GDP per capita	0.0000531	0.0000614
	(0.000)	(0.000)
mobile penetration	0.0627***	0.0593***
	(0.005)	(0.005)
year entry EU:2004	1.637***	1.520***
	(0.273)	(0.261)
year entry EU:2007	2.325***	2.313***
	(0.414)	(0.401)
Constant	-5.639***	-5.380***
	(0.646)	(0.627)
Observations	243	261
R^2	.7408069	.7356863

Standard errors in parentheses

Fixed effect at half-year level

Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The estimated effect on total penetration seems however to be driven by AOs. When focusing on the percentage of subscribers to the fiber services offered by the incumbent ST, the effects are no longer significant. Table 3.7 provides the estimate of the effect of the abuse on the percentage of people subscribed to fiber services offered by ST. Model (1) excludes the observations related to the second and third quarter of 2005 and to the country (Estonia) where the common trend assumption is rejected[52] while Model (2) investigates the effects over time.
The variation in the incumbent's fiber subscribers, before and after the abuse, seems to be not significantly different than its counterfactual. However, the identification strategy adopted in this chapter requires that the outcome variables are independent of the treatment, after conditioning on the set of observed covariates. When examining the decision of the incumbent to invest in fiber, it is harder to claim that this is independent of the decision to engage into an anticompetitive conduct in the DSL segment. This may limit the causal interpretation of the results obtained on the percentage of subscribers to the fiber services offered by the incumbent.

[52]The common trend assumption is instead satisified for all countries when the total fiber penetration is considered.

Table 3.7: Effects on fiber penetration offered by ST

	(1) Common trend	(2) Time effects
treated	-0.0528	-0.0105
	(0.183)	(0.149)
DiD	0.157	
	(0.201)	
DiD: 2006		0.117
		(0.253)
DiD:2007		0.0281
		(0.251)
DiD:2008		0.120
		(0.255)
DiD:2009		0.204
		(0.255)
DiD:2010		0.0868
		(0.254)
pop. dispersion	0.00712*	0.00637*
	(0.003)	(0.003)
pop. density	-0.00565***	-0.00536**
	(0.002)	(0.002)
GDP per capita	-0.00000833	-0.00000611
	(0.000)	(0.000)
mobile penetration	0.00876***	0.00791***
	(0.002)	(0.002)
year entry EU:2004	0.314	0.306**
	(0.176)	(0.104)
year entry EU:2007		0.0367
		(0.175)
year entry EU:2013	-0.0196	
	(0.180)	
Constant	-0.390	-0.368
	(0.251)	(0.268)
Observations	216	232
R^2	.4456345	.4330509

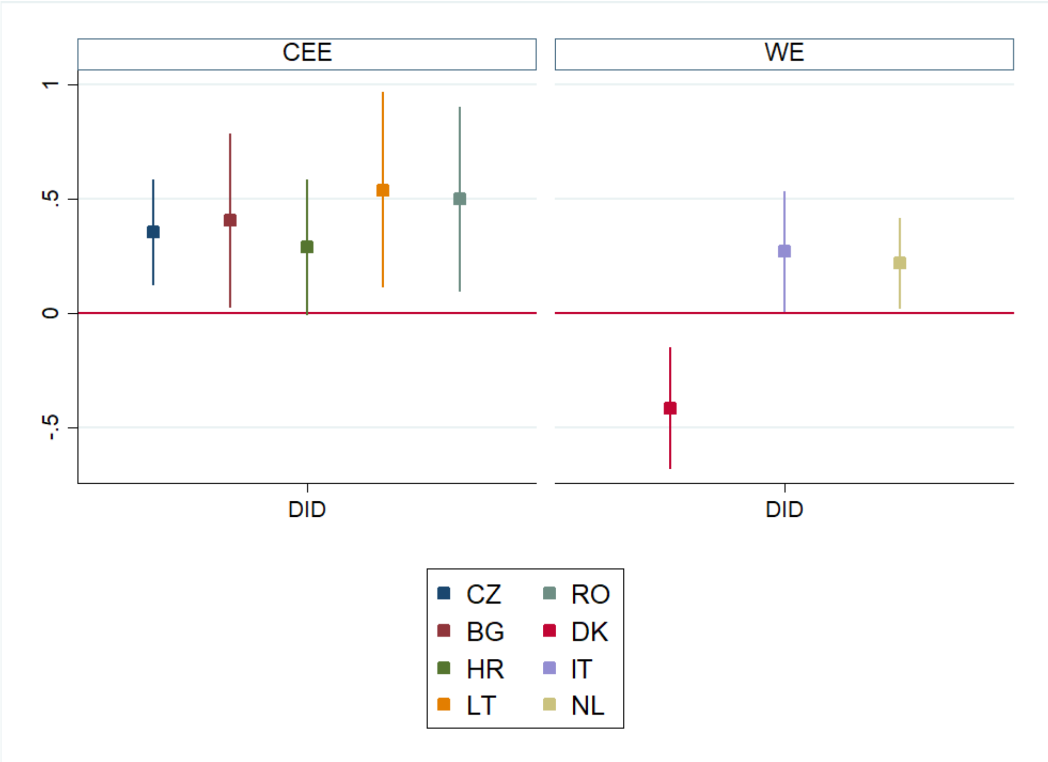
Standard errors in parentheses
Fixed effect at half-year level
Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.6.4 By-country analysis

To further explore the drivers of the obtained results, I have investigated which of the control countries mostly contributes to the estimated effect, by performing a country-by-country analysis. I have implemented Equation 3.1 on each single EU country, and I have hence compared the variation in the outcome variables in Slovakia to the variation occurred in the same variables in each single EU country, before and after ST's abuse.[53] Since results seem to be driven by the effects of the abuse on the investment made by AOs, I have focused on the analysis on the penetration of fiber services offered by AOs. Figure 3.5 shows the coefficients obtained (when statistically significant) for each country. The estimated coefficients are always positive, except for Denmark. The positive coefficients range from 0.2 to 0.5 percentage points, thereby indicating that ST's conduct have caused an increase in the percentage of people subscribed to AO's fiber services by 0.2-0.5 percentage points. The estimated effects are lower than those obtained when considering all the CEE countries as control group (see Table 3.5) and seem to be driven by CEE countries. Among the WE countries, the comparison with Italy and Netherlands provides positive and statistically significant effects, while the comparison with Denmark seems to indicate that the abuse has caused a reduction (rather than an increase) in the penetration of fiber services offered by AOs. As extensively discussed in Section 3.5, a clear identification of the causal effects through the DiD methodology requires that the treated and control group trend similarly in the period before the abuse. Although the empirical test cannot reject the assumption of common trend for all the countries, except for Estonia, Sweden and Finland, the number of observations available when comparing a pair of countries is too limited to make a valid statistical inference. Moreover, as discussed in Section 3.3, the deployment of fiber infrastructure in Denmark has been quite peculiar, since it has been driven by utilities company (e.g. DONG, Waoo!, Syd Energy) who have used their own existent infrastructure to lay down fiber optic cables. This has undoubtedly generated consistent cost savings, and facilitated the growth of fiber coverage and adoption.

[53] As before, I am however excluding Poland, Slovenia and Spain, since they have been affected by similar treatment in the same period.

Figure 3.5: Effects of abuse on investment: by-country analysis



3.7 Conclusions

A common criticism against mandatory access to the incumbent's legacy copper network is that there is a trade-off between static and dynamic efficiencies. While mandatory access may stimulate competition in the short-run at the retail level, it may reduce the incentives to invest in infrastructure, both by the incumbent, who is forced to share its network, and potential entrants, who can free-ride on the incumbent's network.

Nowadays, the deployment of fiber technologies has become a major issue for sector-specific regulators and investing firms: telecom operators need to speed up their networks to meet the growing demand for bandwidth arising from new multimedia services such as streamed video on demand, high definition television, cloud computing. There is a concern among practitioners and policy makers that regulation-induced competition in retail telecoms markets may discourage investment in new technologies. This chapter investigates the impact of mandatory access to the incumbent's DSL network on investment in fiber technologies. Differently from the existing literature on the relationship between access regulation and investment, this chapter performs an ex-post evaluation exercise and exploits the abuse of dominance of the Slovak incumbent to investigate whether banning access to the incumbent's network spurs entrant's investment. The EC has indeed ascertained that Slovak Telekom, the dominant fixed telecom operators in the Slovak market, refused to properly provide access to its unbundled local loops and set excessively high wholesale access price over the period 2005-2010. The empirical analysis presented in this chapter demonstrates that the abuse of dominance, by hindering access to the incumbent's copper network, has triggered AOs' investment in fiber technologies. Based on *Difference in Differences* method, I identify the effects of the abuse by comparing the variation in the penetration of fiber services offered by AOs in Slovakia and in Central Eastern European countries, before and after the abuse. Results show that, due to ST's anticompetitive conduct, Slovak AOs have witnessed an increase in their customer base by 1.16-1.5 percentage points. Since the deployment of fiber was limited to small neighbourhood before the abuse, the increase in the customer base is likely to be determined by an increase in the number of available connections, that is an increase in fiber coverage and investment. The empirical evidence presented in this chapter shows that, due to ST's infringement of its regulatory obligations, Slovakia has attained an higher level of fiber penetration. Such effect is however driven by AOs. Although the incumbent immediately reacted to AOs' investment by investing itself, there is no evidence that it would have invested less in the counterfactual.

While access regulation is often described as a policy tool designed to encourage entrants to enter the retail market and gradually invest in their own infrastructure, the evidence collected in this chapter shows that banning access to incumbent network can foster entrant's investment in their own and superior technology. It is hard to say, however, whether such result would support a forbearance regulatory approach. In Slovakia, AOs investment has been limited to urban areas, where investment costs were lower. The incumbent's copper network still represented the essential network to serve intermediate and rural areas, where the abuse of dominance may have strengthened the position of the incumbent and ultimately harmed consumers through higher prices or lower quality of DSL services. Moreover, the obtained findings may be confined to markets similar to Slovakia, such as the Central Eastern European markets, where the conditions are much favourable to early investment in new technologies by alternative operators. A conclusion that may be drawn is that regulated access price should be geographically differentiated, with the help of appropriate cost-based rules. Differentiated access charges, rather uniform access charges, may help to exploit heterogeneous investment incentives at local level.

3.8 Appendix

3.8.1 Common trend assumption

Table 3.8 empirically assesses the plausibility of common trend assumption for the outcome variable (i) penetration of fiber services offered by all national operators (Total) and (ii) penetration of fiber services offered by national incumbents (Incumbent). The control group of countries is given by the CEE countries, excluding Poland, Slovenia and Spain (where a similar treatment has occurred). As in Table 3.4, Model(1) test the common trend assumption on the entire pre-treatment period (2003q4-2005q3), while Model(2) excludes the second and third quarter of 2005.

Table 3.8: Common trend test

	Total		Incumbent	
	Model(1)	Model(2)	Model(1)	Model(2)
treated	-9.524*	-0.0714	2.715	0.00523
	(4.897)	(0.177)	(3.568)	(0.113)
trend	-0.0691***	-0.0714***	-0.0200*	-0.0117
	(0.012)	(0.018)	(0.009)	(0.012)
treatedxtrend	0.0538*	0.0179	-0.0156	-0.0204
	(0.027)	(0.045)	(0.020)	(0.029)
pop. dispersion	0.0124***	0.0124***	0.00439**	0.00392**
	(0.002)	(0.002)	(0.001)	(0.001)
pop. density	-0.0132***	-0.0127***	-0.00657***	-0.00490***
	(0.001)	(0.002)	(0.001)	(0.001)
GDP per capita	0.000159***	0.000150***	0.0000970***	0.0000690**
	(0.000)	(0.000)	(0.000)	(0.000)
mobile penetration	0.00746***	0.00743*	0.00120	0.00119
	(0.002)	(0.003)	(0.002)	(0.002)
year entry EU:2004	0.432***	0.429***	0.187**	0.157*
	(0.077)	(0.101)	(0.056)	(0.065)
year entry EU:2007	1.219***	1.154***	0.656***	0.477***
	(0.160)	(0.205)	(0.117)	(0.131)
Constant	10.76***	-1.210***	2.873	-0.476***
	(2.095)	(0.174)	(1.526)	(0.111)
Observations	72	54	72	54
R^2	.8636576	.8480926	.6966492	.6363079

Standard errors in parentheses
Fixed effect at half-year level
Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

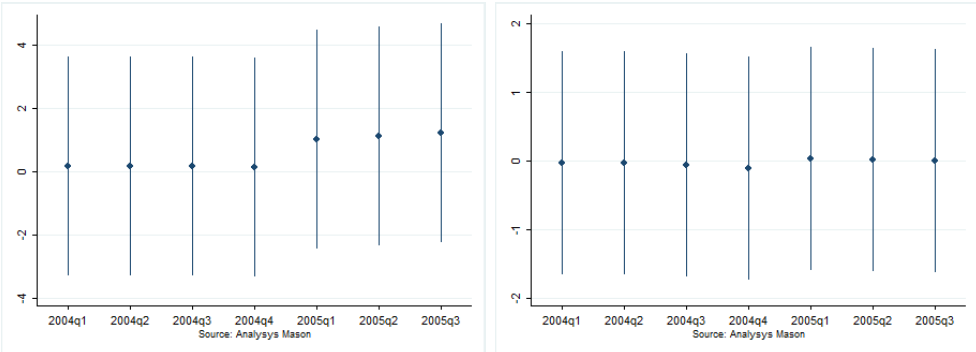
The common trend assumption is always satisfied when the outcome variable is the incumbent's fiber services penetration, while it requires to exclude the first quarters of

2005 to be satisfied when the outcome variable is total fiber services penetration. This is shown clearly in Figure 3.6b and Figure 3.6a, which presents the difference between the outcome variable in Slovakia and the CEE countries, for each quarter of the period before the abuse, estimated as per Equation 3.2.

Figure 3.6

(a) Common trend test - Total fiber penetration

(b) Common trend test - Incumbent fiber penetration



3.8.2 Robustness check

This Appendix presents robustness check based on two different control groups: (i) all European countries not affected by similar treatments, (ii) all European countries where alternative operators have made an early investment in fiber (i.e. before 2005) and have anticipated the incumbent. I have focused on the main analysis, which investigates the impact of the abuse on the investment made by alternative operators.
Table 3.9 empirically assesses the parallel trend assumption: for both control groups, the trend of the outcome variable in Slovakia does not seem to diverge from the trend of the same variable in the control countries, in the period before the abuse. The coefficient of the interaction term *treatedxtrend* is indeed not significant for both Model (1) - related to the control group of all EU countries - and Model (2) - related to the control group of all EU countries were AOs invested first in fiber and before 2005.

Table 3.9: Common trend test

	(1) All countries	(2) AOs countries
treated	-8.707	-2.649
	(10.409)	(4.656)
trend	-0.0199	0.0363*
	(0.016)	(0.015)
treatedxtrend	0.0510	0.0140
	(0.058)	(0.026)
pop. dispersion	-0.0188***	0.0133***
	(0.002)	(0.003)
pop. density	-0.00348***	0.00105
	(0.000)	(0.002)
GDP per capita	0.0000833***	0.0000363
	(0.000)	(0.000)
mobile penetration	-0.00362	-0.00559*
	(0.003)	(0.003)
aid	0.295***	0.470***
	(0.073)	(0.093)
year entry EU: 1973	-0.889***	-0.372
	(0.170)	(0.400)
year entry EU: 1981	0.877***	
	(0.211)	
year entry EU: 1986	1.374***	
	(0.249)	
year entry EU: 1995	-0.0250	1.818***
	(0.151)	(0.470)
year entry EU: 2004	1.824***	0.835*
	(0.297)	(0.371)
year entry EU: 2007	2.352***	0.325
	(0.376)	(0.531)
year entry EU: 2013	2.050***	
	(0.328)	
Constant	2.068	-7.474**
	(2.644)	(2.473)
Observations	176	72
R^2	.559865	.9627705

Standard errors in parentheses
Fixed effect at half-year level
Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.10 confirms the main results: due to ST's abuse of dominance, Slovakia has experienced a greater and positive variation in the penetration of fiber services offered by AOs. Since the fiber deployment was quite limited before the abuse, the estimated effects indicate that ST's conduct has triggered AOs'investment in fiber. Results are robust both when considering all European countries (Model (1)) and European countries where AOs invested first (Model (2)) as control group[54].

[54]In Model(2) results are significant only when we exclude those countries for which the common trend assumption is not satisfied (i.e. Estonia and Sweden).

Table 3.10: Effects on fibre penetration offered by AOs - robustness

	(1) All countries	(2) AOs countries
treated	-0.0569	33.88**
	(0.341)	(10.147)
DiD	1.070**	1.385**
	(0.376)	(0.423)
pop. dispersion	0.000749	-1.893**
	(0.005)	(0.574)
pop. density	-0.00224**	-0.102***
	(0.001)	(0.027)
GDP per capita	0.0000729***	0.000330***
	(0.000)	(0.000)
mobile penetration	0.0337***	0.0494***
	(0.003)	(0.008)
aid	-0.396***	-24.12**
	(0.104)	(7.452)
year entry EU: 1973	-0.344	3.411
	(0.189)	(2.105)
year entry EU: 1981	0.417	
	(0.257)	
year entry EU: 1986	0.467	
	(0.311)	
year entry EU: 1995	-0.978***	
	(0.219)	
year entry EU: 2004	2.163***	-5.895
	(0.322)	(4.053)
year entry EU: 2007	3.448***	65.11***
	(0.443)	(16.480)
year entry EU: 2013	1.574***	
	(0.410)	
Constant	-4.463***	48.37**
	(0.481)	(18.121)
Observations	551	203
R^2	.5147374	.8073479

Standard errors in parentheses

Fixed effect at half-year level

Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.8.3 Effects on other technologies

This appendix aims at investigating whether the refusal to supply access to the nationwide copper network has spurred investment in alternative network infrastructures, in addition to fiber infrastructure.

The available data allows to observe the penetration, across countries and over time, of the following technologies: (i) DSL, (ii) fiber, (iii) cable and (iv) fixed-wireless access networks (FWA).

Cable technologies are mainly owned by cable television operators, who provide internet services by relying on the high bandwidth of their network. Conventional coaxial cable networks used for the transmission of TV signals may be upgraded to allow the provision of broadband and ultra-broadband services. In Slovakia, UPC Broadband Slovakia, who provides fixed broadband services over its cable network, is the second largest operator in the retail market for broadband services. It may be argued that cable operators, relying on their own network, may be less affected by the consequences of the abuse of dominance of the incumbent operator. Still, the remaining alternative operators, who were used to rely on the incumbent's copper network, could have had the incentive to establish a new cable network.

The available data suggests, however, that the number of cable lines offered over the period of analysis by operators differently than the pre-existing cable operators are quite limited, especially if compared to the remaining alternative technologies (fiber and FWA). I would hence focus on FWA.

Fixed wireless technologies allow to offer broadband services to final customers via radio frequencies, without having to lay cable to connect to customer's premises. The evidence collected by the European Commission at the time of the ST's investigation,[55] shows that fixed wireless technologies are a valid substitute of fixed wire line access technologies (which includes DSL, cable and fiber). Indeed, even though wireless technologies cannot be used to provide high-end broadband services (e.g. IPTV or Video-on-Demand), they can provide a good substitute for basic fixed-line broadband offers, due to their low prices.

Fixed wireless technologies have played a significant role in Slovakia since the early days of broadband, and according to the evidence collected by the Commission[56], providers of FWA broadband were mostly small and alternative operators active at regional level, in areas with no access to DSL technology.

The following analysis assesses whether, the abuse and, in turn, the absence of wholesale access to the incumbent's copper network, had provided alternative operators with

[55] EC Decision, Case AT. 39523, § 92-94
[56] EC Decision, Case AT. 39523, § 94

incentives to invest in FWA technologies. FWA and fiber technologies are substitutes only to a limited extent: FWA does not belong to the family of the NGA technologies and only allows to offer basic broadband services. Alternative operators may still have opted to invest in FWA, besides fiber, to expand into geographic areas where deploying fibre infrastructure was too expensive.

In line with the main analysis on the effects of the abuse on fiber investment, I adopt a DiD approach and compare the variation in FWA penetration in Slovakia, with the variation in FWA penetration in three different control group of countries and namely the CEE countries, all the European countries, and countries where AOs have first invested in fiber technologies.[57]

Unfortunately, the available data only allows to observe the penetration of FWA services in the total market, and there are no FWA penetration data at operator level (as in the fiber case). Nonetheless, the qualitative evidence presented in the Commission decision shows that most of the FWA operator in Slovakia are small and regional operators. We hence assume that FWA penetration in Slovakia is mainly driven by alternative operators.

Table 3.11 shows the variation in the average FWA penetration, before and during the abuse, in Slovakia and in the three proposed control groups. FWA penetration grows over time in all countries. The highest average FWA penetration before the abuse (i.e. before 2005q4) is observed in the CEE control countries. Slovakia, however, witnesses a relevant growth over time, and almost reaches FWA penetration in the CEE control countries in the abuse period.

Table 3.11: Outcome variable:total penetration of FWA services

	pre-abuse				abuse			
group	mean	stdev	min	max	mean	stdev	min	max
Treated (SK)	.06	.01	.03	.09	1.59	1.00	.09	3.37
Control (CEE)	.25	.47	0	1.84	1.29	1.86	0	7.65
Control (AO)	.09	.10	0	.44	.66	.81	0	3.08
Control (ALL)	.12	.31	0	1.84	.66	1.32	0	7.65

Table 3.12 shows, instead, the results of the common trend test (based on Equation 3.3), for each of the proposed control groups.

[57] Even in this case, I have excluded the European countries where a similar anticompetitive infringement has occurred.

Table 3.12: Common trend test

	(1)	(2)	(3)
	CEE countries	All countries	AOs countries
treated	-0.911	-0.940	0.486
	(9.306)	(6.891)	(0.859)
trend	-0.0178	-0.0208	0.00516
	(0.023)	(0.011)	(0.003)
treatedxtrend	0.00230	0.00386	-0.00169
	(0.052)	(0.039)	(0.005)
pop. dispersion	0.000221	0.00172	-0.00570***
	(0.003)	(0.002)	(0.001)
pop. density	0.00661**	0.000116	-0.00322***
	(0.002)	(0.000)	(0.000)
GDP per capita	0.0000189	0.0000285***	-0.00000446
	(0.000)	(0.000)	(0.000)
mobile penetration	0.00928*	0.00824***	0.00328***
	(0.004)	(0.002)	(0.000)
year entry EU:1973	0	-0.265*	0.0404
	(.)	(0.112)	(0.074)
year entry EU:1981	0	0.467**	0
	(.)	(0.139)	(.)
year entry EU:1986	0	0.451**	0
	(.)	(0.165)	(.)
year entry EU:1995	0	-0.112	-0.391***
	(.)	(0.100)	(0.087)
year entry EU:2004	0.237	1.126***	-0.266***
	(0.147)	(0.196)	(0.068)
year entry EU:2007	0.202	1.210***	0.00567
	(0.304)	(0.249)	(0.098)
year entry EU:2013	0	0.914***	0
	(.)	(0.217)	(.)
aid		0.0949	-0.0376*
		(0.048)	(0.017)
Constant	1.820	1.853	-0.423
	(3.980)	(1.750)	(0.456)
Observations	72	176	72
R^2	.5891582	.4394474	.9252959

Standard errors in parentheses
Fixed effect at half-year level
Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The parallel trend assumption in the pre-abuse period is always satisfied, regardless of the subset of European countries taken into consideration. Indeed, the coefficient of the variable of interest, i.e. the coefficient of the variable *treatedxtrend* is not statistically significant, for each of the three model presented.

Table 3.13 shows the estimated effects of ST abuse on the investment in FWA technologies, made by all operators in the market. Once again, results are assessed for each of three proposed control group.

When compared to the evolution of FWA penetration in the CEE countries (Model (1)), the evolution of the overall FWA penetration in Slovakia does not seem to be affected by the abuse. However, Model (2) and Model (3), which compare the evolution of the Slovak FWA penetration to alternative subsets of European countries, shows significant and positive effects. The refusal to supply access to the DSL network seems to have positively affected the growth of FWA penetration when compared to all European countries (Model (2)) or to the countries where AOs made early investment in fiber (Model (3)).

When assessing the common trend assumption for each single country, it comes up that the few countries where the parallel trend assumption cannot be rejected are mostly those included in the control group made of "AOs countries". This may indicate that the results obtained through this control group (Model (3)) are the most reliable. The estimates in Model (3) indicate that, because of the anticompetitive conduct of ST, FWA penetration has increased by 0.88 percentage points. The estimated effect is lower than the effect estimated on fiber penetration (equal to 1.385 percentage points when considering the "AOs countries" control group).

In conclusion, the above analysis suggests that the refusal to supply access to the incumbent's copper network may have spurred investment in FWA technologies, in addition to fiber technologies. The substitutability between the two technologies is limited - fiber technologies are superior - and alternative operators may have decided to invest in FWA to extend their geographic coverage in areas where is more expensive deploying fibre infrastructure. In any case, the estimated impact seems to be smaller than the impact observed on fiber investment.

Table 3.13: Effects on FWA total penetration

	(1) CEE countries	(2) ALL countries	(3) AOs countries
treated	-0.949**	-1.016**	0.138
	(0.291)	(0.318)	(0.199)
DID	0.228	1.107**	0.822***
	(0.328)	(0.358)	(0.198)
pop. dispersion	-0.0287***	0.0108***	0.00241
	(0.004)	(0.003)	(0.004)
pop. density	-0.00718***	0.000398	0.000952
	(0.002)	(0.001)	(0.002)
GDP per capita	0.000660***	0.0000735***	-0.0000524*
	(0.000)	(0.000)	(0.000)
mobile penetration	0.00361	0.00587*	-0.00913*
	(0.003)	(0.003)	(0.004)
year entry EU:1973	0	-0.297	2.221***
	(.)	(0.171)	(0.506)
year entry EU:1981	0	1.295***	0
	(.)	(0.232)	(.)
year entry EU:1986	0	1.791***	0
	(.)	(0.263)	(.)
year entry EU:1995	0	-0.368*	0.622
	(.)	(0.178)	(0.474)
year entry EU:2004	0.603***	3.509***	0.0836
	(0.178)	(0.282)	(0.474)
year entry EU:2007	3.937***	2.822***	-0.751
	(0.273)	(0.369)	(0.626)
year entry EU:2013	0	2.218***	0
	(.)	(0.340)	(.)
aid		0.609***	1.092***
		(0.084)	(0.156)
Constant	-4.060***	-3.865***	0.615
	(0.427)	(0.441)	(0.664)
Observations	261	638	261
R^2	.8082885	.503169	.7294673

Standard errors in parentheses
Fixed effect at half-year level
Based on Analysys Mason, Eurostat, ITU, OECD, World Bank data
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Bibliography

[Abadie and Cattaneo, 2017] Abadie, A. and Cattaneo, M. D. (2017). Econometric methods for program evaluation. *WIP*.

[Aguzzoni et al., 2016a] Aguzzoni, L., Argentesi, E., Buccirossi, P., Ciari, L., Duso, T., Tognoni, M., and Vitale, C. (2016a). Ex-post evaluation in the uk retail market for books. *The Journal of Industrial Economics*, pages 170–200.

[Aguzzoni et al., 2016b] Aguzzoni, L., Argentesi, E., Ciari, L., Duso, T., and Tognoni, M. (2016b). Ex post merger evaluation in the u.k. retail market for books. *The Journal of Industrial Economics*, 64(1):170–200.

[Allain et al., 2017] Allain, M.-L., Chambolle, C., Turolla, S., and Villas-Boas, S. B. (2017). The impact of retail mergers on food prices: Evidence from france. *The Journal of Industrial Economics*, 65(3):469–509.

[Argentesi et al., 2015] Argentesi, E., Buccirossi, P., Cervone, R., Duso, T., and Marrazzo, A. (2015). Mergers in the dutch grocery sector: An ex-post evaluation, a report prepared for the autoriteit consument & markt (acm). Technical report.

[Ashenfelter and Hosken, 2008] Ashenfelter, O. and Hosken, D. (2008). The effect of mergers on consumer prices: Evidence from five selected case studies. *NBER Working Paper*.

[Ashenfelter et al., 2013a] Ashenfelter, O., Hosken, D., and Weiberg, M. (2013a). The price effects of a large merger of manufacturers: A case study of maytag-whirlpool. *American Economic Journal: Economic Policy*, 5(1):239–261.

[Ashenfelter et al., 2014] Ashenfelter, O. C., Hosken, D., and Weinberg, M. C. (2014). Did robert bork understate the competitive impact of mergers? evidence from consummated mergers. *Journal of Law and Economics*, 57(S3):S67–S100.

[Ashenfelter et al., 2013b] Ashenfelter, O. C., Hosken, D. S., and Weinberg, M. C. (2013b). The price effects of a large merger of manufacturers: A case study of maytag-whirlpool. *American Economic Journal: Economic Policy*, 5(1):239–61.

[Ater and Rigbi, 2017] Ater, I. and Rigbi, O. (2017). The effects of mandatory disclosure of supermarket prices. *mimeo*.

[Avenali et al., 2010] Avenali, A., Matteucci, G., and Reverberi, P. (2010). Dynamic access pricing and investment in alternative infrastructures. *International Journal of Industrial Organization*, 28(2):167–175.

[Bacache-Beauvallet et al., 2014] Bacache-Beauvallet, M., Bourreau, M., and Gaudin, G. (2014). Dynamic entry and investment in new infrastructures: Empirical evidence from the fixed broadband industry. *Review of Industrial Organization*, 44(2):179–209.

[Barros et al., 2006] Barros, P. P., Brito, D., and de Lucena, D. (2006). Mergers in the food retailing sector: An empirical investigation. *European Economic Review*, 50(2):447–468.

[Bauner and Wang, 2019] Bauner, C. and Wang, E. (2019). The effect of competition on pricing and product positioning: Evidence from wholesale club entry. *International Journal of Industrial Organization*, 67:102525.

[Berry and Waldfogel, 2001] Berry, S. T. and Waldfogel, J. (2001). Do mergers increase product variety? evidence from radio broadcasting. *The Quarterly Journal of Economics*, 116(3):1009–1025.

[Bouckaert et al., 2010] Bouckaert, J., Dijk, T., and Verboven, F. (2010). Access regulation, competition, and broadband penetration: An international study. *Telecommunications Policy*, 34:661–671.

[Bourreau et al., 2012] Bourreau, M., Cambini, C., and Dogan, P. (2012). Access pricing, competition, and incentives to migrate from old to new technology. *Internation Journal of Industrial Organization*, 30:713–723.

[Bourreau and Dogan, 2006] Bourreau, M. and Dogan, P. (2006). Build or buy strategies in the local loop. *Empirical investigations in industrial organizations*, 96(2).

[Briglauer et al., 2015] Briglauer, W., Cambini, C., and Melani, S. (2015). How to fill the digital gap? the (limited) role of regulation. *SSRN Electronic Journal*.

[Brito et al., 2012] Brito, D., Pereira, P., and Vareda, J. (2012). Incentives to invest and to give access to non-regulated new technologies. *Information Economics and Policy*, 24:197–211.

[Bronnenberg, 2015] Bronnenberg, B. J. (2015). The provision of convenience and variety by the market. *The RAND Journal of Economics*, 46(3):480–498.

[Bronnenberg and Ellickson, 2015] Bronnenberg, B. J. and Ellickson, P. B. (2015). Adolescence and the path to maturity in global retail. *Journal of Economic Perspectives*, 29(4):113–34.

[Brynjolfsson et al., 2003] Brynjolfsson, E., Hu, Y. J., and Smith, M. D. (2003). Consumer surplus in the digital economy: Estimating the value of increased product variety at online booksellers. *Management Science*, 49(11):1580–1596.

[Bundeskartellamt, 2015] Bundeskartellamt (2015). Sektoruntersuchung lebensmitteleinzelhandel. darstellung und analyse der strukturen und des beschaffungsverhaltens auf den märkten des lebensmitteleinzelhandels in deutschland. Technical report.

[Busso and Galiani, 2019] Busso, M. and Galiani, S. (2019). The causal effect of competition on prices and quality: evidence from a field experiment. *American Economic Journal: Applied Economic*, 11(1):33–56.

[Cambini and Jiang, 2009] Cambini, C. and Jiang, Y. (2009). Broadband investment and regulation: A literature review. *Telecommunications Policy*, 33:559–574.

[Cave and Vogelsang, 2003] Cave, M. and Vogelsang, I. (2003). How access pricing and entry interact. *Telecommunications Policy*, 27:717–727.

[Chakraborty et al., 2014] Chakraborty, R., Dobson, P. W., Seaton, J. S., and Waterson, M. (2014). Market consolidation and pricing developments in grocery retailing: A case study. In Spiegel, Y. and Peitz, M., editors, *The Analysis of Competition Policy and Sectoral Regulation*, pages 3–29. World Scientific, Singapore.

[Cho and Rust, 2010] Cho, S. and Rust, J. (2010). The flat rental puzzle. *The Review of Economic Studies*, 77(2):560–594.

[Chu, 2010] Chu, C. S. (2010). The effect of satellite entry on cable television prices and product quality. *The RAND Journal of Economics*, 41(4):730–764.

[Crandall et al., 2013] Crandall, R. W., Eisenach, J. A., and Ingraham, A. T. (2013). The long-run effects of copper-loop unbundling and the implications for fiber. *Telecommunications Policy*, 37(4):262–281.

[DellaVigna and Gentzkow, 2017] DellaVigna, S. and Gentzkow, M. (2017). Uniform pricing in us retail chains. Working Paper 23996, National Bureau of Economic Research.

[DellaVigna and Gentzkow, 2019] DellaVigna, S. and Gentzkow, M. (2019). Uniform pricing in us retail chains. *Quartlerly Journal of Economics*, 134:2011–2084.

[Deneckere and Davidson, 1985] Deneckere, R. and Davidson, C. (1985). Incentives to form coalitions with bertrand competition. *RAND Journal of Economics*, 16(4):473–486.

[Distaso et al., 2006] Distaso, W., Lupi, P., and Manenti, F. (2006). Platform competition and broadband uptake: Theory and empirical evidence from the european union. *Information Economics and Policy*, 18(1):87–106.

[Dobson and Waterson, 2005] Dobson, P. W. and Waterson, M. (2005). Chain-store pricing across local markets. *Journal of Economics & Management Strategy*, 14(1):93–119.

[Draganska et al., 2009] Draganska, M., Mazzeo, M., and Seim, K. (2009). Beyond plain vanilla: Modeling joint product assortment and pricing decisions. *Quantitative Marketing and Economics*, 7(2):105–146.

[Eizenberg et al., 2018] Eizenberg, A., Lach, S., and Yiftach, M. (2018). Retail prices in a city. *mimeo*.

[Fan, 2013] Fan, Y. (2013). Ownership consolidation and product characteristics: A study of the us daily newspaper market. *American Economic Review*, 103(5):1598–1628.

[Ford and Spiwak, 2004] Ford, G. and Spiwak, L. (2004). The positive effects of unbundling on broadband deployment. *SSRN Electronic Journal*.

[Foros, 2004] Foros, O. (2004). Strategic investments with spillovers, vertical integration and foreclosure in the broadband access market. *International Journal of Industrial Organization*, 22:1–24.

[Gandhi et al., 2008] Gandhi, A., Froeb, L., Tschantz, S., and Werden, G. J. (2008). Post-merger product repositioning. *The Journal of Industrial Economics*, 56(1):49–67.

[Gayle and Weisman, 2007] Gayle, P. and Weisman, D. (2007). Efficiency trade-off in designing competition policy for telecommunication industry. *Review of Network Economics*, 6(3):322–341.

[George, 2007] George, L. (2007). What's fit to print: The effect of ownership concentration on product variety in daily newspaper markets. *Information Economics and Policy*, 19(3–4):285–303.

[Godlovitch et al., 2015] Godlovitch, I., Lucidi, S., and Stumpf, U. (2015). Analysis of market structures in the danish broadband market - study for danish business authority. *WIK-Consult*.

[Götz and Gugler, 2006] Götz, G. and Gugler, K. (2006). Market concentration and product variety under spatial competition: Evidence from retail gasoline. *Journal of Industry, Competition and Trade*, 6(3–4):225–234.

[Hanner et al., 2015] Hanner, D., Hosken, D., Olson, L. M., and Smith, L. K. (2015). Dynamics in a mature industry: Entry, exit, and growth of big-box grocery retailers. *Journal of Economics & Management Strategy*, 24(1):22–46.

[Hitsch et al., 2019] Hitsch, G. J., Hortacsu, A., and Lin, X. (2019). Prices and promotions in u.s. retail markets: Evidence from big data.

[Hosken and Tenn, 2016] Hosken, D. and Tenn, S. (2016). Horizontal merger analysis in retail markets. In *Handbook on the Economics of Retailing and Distribution*, pages 250–286. Edward Elgar Publishing, Cheltenham UK.

[Hosken et al., 2018] Hosken, D. S., Olson, L. M., and Smith, L. K. (2018). Do retail mergers affect competition? evidence from grocery retailing. *Journal of Economics & Management Strategy*, 27(1):3–22.

[Hwang et al., 2010] Hwang, M., Bronnenberg, B. J., and Thomadsen, R. (2010). An empirical analysis of assortment similarities across u.s. supermarkets. *Marketing Science*, 29(5):858–879.

[Imbens and Wooldrige, 2009] Imbens, G. W. and Wooldrige, J. (2009). Recent developments in the economics of program evaluation. *Journal of Economic Literature*, 47:5–86.

[Inderst and Peitz, 2012] Inderst, R. and Peitz, M. (2012). Market asymmetries and investments in next generation access networks. *Review of Network Economics*, 11(1).

[Jeziorski, 2014] Jeziorski, P. (2014). Effects of mergers in two-sided markets: The us radio industry. *American Economic Journal: Microeconomics*, 6(4):35–73.

[Katz and Shapiro, 1985] Katz, M. L. and Shapiro, C. (1985). Network externalities, competition and compatibility. *The American Economic Review*, 75(3):424–440.

[Klemperer and Padilla, 1997] Klemperer, P. and Padilla, A. J. (1997). Do firms' product lines include too many varieties? *The RAND Journal of Economics*, 28(3):472–488.

[Kotakorpi, 2006] Kotakorpi, K. (2006). Access price regulation, investment and entry in telecommunications. *International Journal of Industrial Organization*, (24):1013–1020.

[Lommerud and Sørgard, 1997] Lommerud, K. E. and Sørgard, L. (1997). Merger and product range rivalry. *International Journal of Industrial Organization*, 16(1):21–42.

[Matsa, 2011] Matsa, D. A. (2011). Competition and product quality in the supermarket industry. *The Quarterly Journal of Economics*, 126(3):1539–1591.

[Mazzeo et al., 2014] Mazzeo, M., Seim, K., and Varela, M. (2014). The welfare consequences of mergers with endogenous product choice. *mimeo*.

[Muralidharan and Prakash, 2013] Muralidharan, K. and Prakash, N. (2013). Cycling to school: Increasing secondary school enrollment for girls in india. *NBER Working Paper*, (19305).

[OECD, 2013] OECD (2013). The role and measurement of quality in competition analysis. Technical report.

[Orbach and Einav, 2007] Orbach, B. Y. and Einav, L. (2007). Uniform prices for differentiated goods: The case of the movie-theater industry. *International Review of Law and Economics*, 27(2):129–153.

[Pires and Trindade, 2018] Pires, T. and Trindade, A. (2018). Ex-post evaluation of mergers in the supermarket industry. *Review of Industrial Organization*, 52(3):473–496.

[Quan and Williams, 2018] Quan, T. W. and Williams, K. R. (2018). Product variety, across-market demand heterogeneity, and the value of online retail. *The RAND Journal of Economics*, 49(4):877–913.

[Ren et al., 2011] Ren, C. R., Hu, Y., Hu, Y. J., and Hausman, J. (2011). Managing product variety and collocation in a competitive environment: An empirical investigation of consumer electronics retailing. *Management Science*, 57(6):1009–1024.

[Rhodes and Zhou, 2019] Rhodes, A. and Zhou, J. (2019). Consumer search and retail market structure. *Management Science*, forthcoming.

[Richards and Hamilton, 2006] Richards, T. and Hamilton, S. (2006). Rivalry in price and variety among supermarket retailers. *American Journal of Agricultural Economics*, 88(3):710–726.

[Rickert et al., 2018] Rickert, D., Schain, J. P., and Stiebale, J. (2018). Local market structure and consumer prices: Evidence from a retail merger. Technical Report 280, DICE Discussion Paper.

[Saxena and al., 2017] Saxena, A. and al. (2017). A review of clustering techniques and developments. *Neurocomputing*, 267:664–681.

[Shiller and Waldfogel, 2011] Shiller, B. and Waldfogel, J. (2011). Music for a song: an empirical look at uniform pricing and its alternatives. *The Journal of Industrial Economics*, 59(4):630–660.

[Sweeting, 2010] Sweeting, A. (2010). The effects of mergers on product positioning: evidence from the music radio industry. *The RAND Journal of Economics*, 41(2):372–397.

[Valletti and Verboven, 2015] Valletti, T. and Verboven, F. (2015). Unbundling the incumbent: Evidence from uk broadband. *Journal of the European Economic Association*, 13.

[Vareda, 2010] Vareda, J. (2010). Access regulation and the incumbent investment in quality-upgrades and in cost-reduction. *Telecommunications Policy*, 34:697–710.

[Wallsten and Hausladen, 2009] Wallsten, S. and Hausladen, S. (2009). Net neutrality, unbundling, and their effects on international investment in next-generation networks. *Review of Network Economics*, 8:90–112.

[Watson, 2009] Watson, R. (2009). Product variety and competition in the retail market for eyeglasses. *The Journal of Industrial Economics*, 57(2):217–251.

[Willig, 2019] Willig, R. (2019). Investment is appropriately stimulated by telric.