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The impact of local loop unbundling revisited

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Abstract

For more than 15 years, Local Loop Unbundling (LLU) has been introduced as a regulatory mean to overcome the bottleneck control over the last mile of copper cable owned by incumbent operators. However, despite its assumed positive effects on market entry and competition intensity, negative effects on network investment incentives and long run overall broadband penetration are expected. In our paper we concentrate on the potential effects of LLU on investment and penetration rates. In contrast to earlier studies, we not only consider the implementation of unbundling, but also include the tariffs of unbundling. Using a large panel, we find that unbundling itself does have a general positive effect on broadband penetration. However, if an interaction between the particular unbundling tariffs is introduced, the per se effect is even increased. Therefore, the overall effect depends strongly on the size of the tariff.

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1. Introduction

Broadband communications is one of the large innovations of the 2000s. Although access to broadband networks is widely considered as a driver for both economic and social development, there are still large differences in actual broadband penetration. Therefore most countries around the world have designed specific strategies to promote digital development (e.g. the EU initiative “Digital Agenda for Europe”)¹, and therewith underline the goal to provide fast and reliable broadband Internet connections.

Besides the creation of a sound regulatory environment to ensure incentives for ICT firms to invest in sophisticated networks, regulators naturally take care of the demand side, e.g. low prices. Therefore in many jurisdictions so called “local loop unbundling” has been implemented. This local loop unbundling allowed competitors in concentrated markets to use parts of the incumbent’s network infrastructure, which helped to increase complementary investment and increased competition in final customer’s markets. On the other hand, investment incentives of incumbents were lowered, which may have had negative long run effects on the overall broadband penetration.

This paper reports the results of a quantitative analysis on the international experience of the relationship between the regulatory mean unbundling and broadband penetration. As there is a common-sense relationship between penetration and investment, the effects of the latter on penetration will also find consideration. Instead of using solely the presence of unbundling, we also consider tariffs of unbundling. The high of these tariffs appear to play a primary role on the impact of unbundling on penetration as suggested by our empirical analysis. Our results have important policy consequences, in particular for the regulatory treatment of so-called next-generation networks.

The rest of the paper is organized as follows. In Section 2, we describe the main issues related to network unbundling. In particular, we highlight how results from the extant literature differ in regard to positive and negative effects of local loop

¹ The initiative is part of the EU 2020 strategy, <http://ec.europa.eu/digital-agenda/en/high-speed-broadband>.

unbundling on the broadband penetration rate. Section 3 presents the empirical analysis, while Section 4 discusses the empirical results and concludes.

2. Background access unbundling and its potential economic impact

2.1 Background access unbundling in telecommunication

Roughly 25 years ago, network industries in Europe were almost solely organized as state monopolies. Due to overall poor performance and a general lack of innovativeness, liberalization reforms were initiated mainly by the EU Commission, which included privatization, competitive restructuring and the establishment of new regulatory mechanisms (e.g. Newberry 1999). Economically non-replicable assets of these industries were often unbundled and put under regulatory ex-ante surveillance. For the telecommunications sector, this was to overcome bottleneck control over the last mile of copper cable (the so-called local loop²) owned by incumbent operators. Besides competitive access, vertical or structural separation was discussed, i.e. putting the ownership of the Local Loop into a different company. However, due to high costs and expected risks (potential loss of coordination of infrastructure provision and economies of scale), most regulators relied on behavioral remedies (Sutherland 2007, 1), such as Local Loop Unbundling (LLU).³ As most of the infrastructure was built a long time ago, significant updates are needed to achieve broadband transmission capacity in local access networks. For the traditional telecommunication access networks using copper pair cable in the local loop, the switch to digital subscriber line (DSL) technology is necessary. DSL requires investment to increase the transmission capacity and to split the traffic into data and voice. Similarly, cable TV infrastructure requires investment that allows for the reverse flow of data. Since in several European countries, cable TV network as a way to bypass the telecom infrastructure is not available, DSL is the most common used infrastructure (see figure 1 in the appendix).

In DSL networks, LLU is a wide-spread regulatory tool to install (at least service-based) competition. LLU includes the physical installation of equipment by the

² In the EU, the Local Loop is defined as “the physical circuit connecting the network termination point at the subscriber’s premises to the main distribution frame or equivalent local facility in the fixed public telephone network”, see Article 2(e) of the Access Directive (2002/19 EC as amended in 2009) (http://europa.eu/legislation_summaries/information_society/internet/l24108j_en.htm).

³It is important to notice that it is not the aim of the paper to provide a normative discussion of regulatory interference in general, less the persistence and potential phasing out of regulation. The objective is to provide evidence on policies as implemented in practice.

competing firm in the local exchange of the incumbent firm and connection of the subscriber line with it. For retail access, the incumbent operator keeps the physical line as it is, and the competitor resells the services supplied by the incumbent. As the final customer is still served by the same subscriber line, in most cases, full unbundling does not lead to inter-platform competition (Gruber/Koutroumpis 2013, 171). This so-called facility-based competition is assumed to bring greater benefits in various terms, e.g. in long-term pricing and consideration of innovations. However, as outlined by the European Commission in 2007, there is still no inter-platform competition on around 80 per cent of the EU's local loops. Therefore, LLU and regulatory activities connected to it, remains to play a crucial role in maintaining competition. Over time, the initially relative simple model of unbundling has been developed into a range of increasingly complex regulatory products (incl. shared access, Wholesale Line Rental⁴ and naked DSL). Further (also regulatory) complexities are expected to be connected with the increasing deployment of Next Generation Networks (NGN) by telecommunication operators (see also Sutherland 2007, 1).

2.2 The complex nature of local access unbundling in the context of investment and penetration

LLU and investment

This section outlines the potential impact of local access unbundling under consideration of the main literature and with a focus on the regulatory situation in Europe. The effects of access regulation are mostly investigated on in terms of investment and broadband penetration. However, the potential impact on, and of other determinants and the general high complexity of the issue complicate any empirical analysis on the issue.⁵

The availability of reliable and quick communication services is increasingly seen as a key input for growth and productivity in an economy. Typically, any activity in the sector of telecommunication strongly relies on the underlying network infrastructure. Therefore, the investment in infrastructure is outlined to be a vital contributor to

⁴ Wholesale Line Rental enables operators who obtained both Carrier-Pre-Selection Services (CPS) interconnection and wholesale line rental from the incumbent to offer their customers a single bill for call and access, something that previously could only be done by those operators who owned the access line (see Walden 2012, 411).

⁵ Likewise Crandall et al 2013, 266.

economic growth, as confirmed by various empirical studies (e.g. Röller/Waverman 2001, Koutroumpis 2008). However, there was a worldwide downward trend in telecommunication investment on the firm-level after 2001 with a slight upward trend in recent years (Cambini/Jiang, 2009, 561; Figure 2 in the appendix). This underinvestment is *not only* a particular threat to the spread of competitive high-speed broadband networks, but also includes severe hazards to general social welfare and competition (e.g. Kotakorpi 2006). Therefore, regulatory supervision should take this problem into careful consideration.

In Europe, political initiatives such as the Commission's "Digital Agenda for Europe" and the "Europe 2020 strategy" cover the stimulation of investment in communication networks as a key objective (EU Commission MEMO/10/424).

The outlined numerical targets in terms of broadband penetration are ambitious. The EU Commission noted in 2010: *"To match world leaders like South Korea and Japan, Europe needs download rates of 30 Mbps for all of its citizens and at least 50% of European households subscribing to internet connections above 100 Mbps by 2020."* This can only be achieved by the comprehensive roll out of broadband networks with high-speed capacity across Europe. Therefore, telecommunication operators migrate from copper-based telephone and cable television networks to fiber-based networks. However, this migration requires considerable time and major investment. In addition, infrastructure investment needs to be carried out with a long-term view to ensure the ability of technologies to evolve to meet future needs.⁶

In a current approach, the European Commission estimates that civil engineering can account for up to 80 percent of the costs of deploying high-speed broadband networks. In a draft regulation (COM (2013) 147 final) proposed on March 26, 2013, the Commission has put forward a number of measures which it calculates could reduce capital expenditure for operators by 20-30%, saving up to €63bn by 2020 on an estimated €221bn of total Next Generation Access (NGA) investments.⁷ Still, the regulatory challenge to ensure efficient firm-level investment remains a major issue.

⁶Zhao et al (2014) compare the performance characteristics of fiber-based access technologies with those of the latest copper-based access technologies DSL and coaxial cable networks.

⁷ However, this issue will be addressed by means of a directive, instead of a regulation, giving member states more flexibility to adjust to local specificities. Whereas a regulation would have had direct effect, and could possibly have come into force by April 2014, member states now have until January 1, 2016 to adopt national provisions to comply with the directive, which will not come into force across the EU until July 1, 2016. The agreement is expected to be adopted during the plenary session of April 3. Council will formally adopt the draft text shortly after Parliament's vote.

What is the current role of local access unbundling? In network industries, the rationale for access regulation is to intensify competition and therewith efficiency and social welfare. Considering a static environment, with open access to competitors, competition is increased which decreases margins and prices ultimately leading to a higher consumer surplus. In dynamic settings however, as in the case of telecommunication markets, the relationship between access regulation and welfare is more complex. As outlined by Laffont/Tirole (2000), lower access prices might increase competition in the short term, but undermine incumbents' incentives to invest in the network. Higher access prices promote more incentives to invest, but hamper the entrants' use of incumbents' infrastructure (and thus reduce competition). As access regulation lowers market entry barriers, entrants' might see lower incentives to invest in own network elements since infrastructure can be leased from incumbents at prescribed prices.

These inherent trade-offs challenge the regulatory surveillance. In European telecommunications, national regulatory authorities widely adopted a regulatory approach, which includes the idea of a "ladder of investment" proposed by Cave (2006). The concept of a ladder should reflect the idea that entrants acquire, as a first "rung", access to the incumbents' infrastructure at a level which typically requires little investment to provide a service (e.g. resale). With a growing number of customers, entrant firms are encouraged to invest in network elements necessary to bridge their first level of access. Therefore, the firms climb up the "ladder" and acquire access to the next level, and so forth. New entrants are therefore provided with temporary assistance by the regulator, but they are also invited to build up their own network in the long run. The regulator does so by ensuring entrants access to the incumbents' infrastructure at reasonable terms and sets incentives to climb to the next level.⁸

The "ladder of investment" found much attention in Europe. The European Regulators Group (ERG 2005) used this approach to analyse the development of broadband markets in the EU, and found a positive relation between the implementation of the *ladder of investment* and the pace of development of

⁸ The underlying idea is that service-based entry and facility-based entry are seen as complements, with the ladder of investment as a means to solve the trade-off, that service-based entry promotes short-run competition and facility-based entry fosters long-run (and therefore sustainable) competition (Bourreau et al 2010).

broadband markets in the member states. However, to test the real validity of the ladder of investment is challenging, and empirical approaches did not find evidence that unbundled access leads to facility-based competition (e.g. Hausman/Sidak 2005). Similarly, Distaso, Lupi and Manenti (2009) can only find occasional evidence that entrants climb up the *ladder of investment* when there are increasing access charges on lower rungs of the *ladder* over time in 12 EU countries (2005-2007). A reduction of entrants' facility-based lines through low local loop rental rates is outlined by Crandall, Ingraham and Sidak (2004). Conversely, Chang et al. (2003) find that low access prices stimulate the incumbents' investments.

Waverman, Meschi, Reillier and Dasgupta (2007) chose a different perspective. They underline that access regulation tends to promote service-based competition, and see a trade-off between aggressive access regulation and the goal of promoting facility-based competition. Therefore the authors attempt to quantify this trade-off and calculate its impact on investment in EU telecommunications (Waverman et al 2007). By using LLU prices and new access lines for new entrants in 27 EU countries for 2002 to 2006, they demonstrate that a 10 per cent reduction in LLU prices leads to a 19 percent decrease in the share of new entrants' facility-based lines (e.g. cable, fiber).

A similar focus on the regulatory trade-off between access regulation and investment incentives is provided by Grajek/Röller (2009). The authors utilize a comprehensive data set, including 70+ fixed-line operators in 20 countries over 10 years. In their findings, a varying impact of regulation on the investment decisions of incumbents and entrants is indicated, i.e. investment is discouraged by incumbents and individual entrants, whereas entrants' total investment increases. Grajek/Röller conclude that as facility-based competition requires substantial firm-level investment, the current European regulatory framework fails to deliver effective incentives to move towards facility-based competition (Grajek/Röller 2009, 18).⁹

Overall, regulation to unbundle the local loop is assumed to have at least two main effects on investment. First, it strengthens service-based competition, and therefore it helps to increase complementary investment and increased competition in final customer's markets.

⁹ Another interesting aspect of the paper is the detected commitment problem of regulation in this context. Thus, regulatory responses to infrastructure investments may differ between incumbents and entrants. Regulators seem to respond to higher infrastructure investment by incumbents by providing easier access (thereby eroding incumbents' incentives to invest in infrastructure in the first place).

However, second, incentives for facility-based competition seems to be lower and therefore, (network) investment incentives of incumbents are most likely reduced in the middle and long run (in particular, if access prices are set low). This is also outlined in a theoretical paper by Haucap/Klein (2012), where ambiguous effects of regulation on investment are indicated. The general regulatory challenge is to promote short- and long-term investment by meanwhile encouraging competition. These trade-offs found much attention in the telecommunication economics literature.¹⁰

LLU and broadband penetration

Coming from a rather long-run perspective, focusing on the supply side and their potentially reduced incentives for investment, a regulator must also consider the demand-side effects of unbundled access on penetration. As wholesale access prices are controlled, reduced retail prices are to be expected. But does empirical evidence exist to support the finding that unbundled access regulation increases broadband penetration in a market?

The adoption of fixed wired broadband often varies significantly between EU member states. Whereas broadband penetration rapidly increased in the Netherlands and Denmark, the adoption rates in the UK and France were more modest.

Competition on different levels is seen as a major driver of broadband adoption. As already noted in the last section, facility-based competition is more sustainable in the long run in terms of investment. This holds true for penetration rates. For example, Distaso, Lupi and Manenti (2006) and Höffler (2007) find for the EU that higher penetration rates are reached if competition between DSL and cable is present.

LLU was seen as a means to enforce competition in the first place. But as the final customer is still served by the same subscriber line, and, thus no dependence on access regulation is given, unbundling does not lead to inter-platform competition. Therefore, no positive effects of unbundling on penetration at this level are to be expected. In terms of intra-platform competition, empirical studies are divided over the effects of unbundling on broadband penetration. Denni/Gruber (2006) study the effects of intra-platform competition (incumbents vs. entrants) on broadband penetration.

¹⁰ For a good overview see Cambini/Jiang (2009).

The authors only identify a positive impact on the diffusion rate of broadband at the initial stage, which disappears over time. The relationship between DSL-broadband penetration and different forms of broadband regulation is also studied by Wallsten (2006), who finds that more extensive sub-loop unbundling is negatively related to broadband penetration, whereas LLU shows no significant effect on broadband penetration.

The regulator has to also decide on the “fine-tuning” of access regulation, namely the height of the fees that users of the infrastructure have to pay. If access regulation is more intense (indicated by lower LLU tariffs), intra-platform competition is stimulated, which often includes an overall expansion of the broadband market. However, lower LLU tariffs also cause a substitution away from broadband offered over alternative access platforms to copper-based platforms (see Waverman et al 2007).

The current study differs from prior work that investigates effects of LLU in important respects. First, as former studies can often only observe cross-sectional data, we cover structural differences across countries and implement for country specific data a fixed-effects panel approach. Second, the respective design of unbundling has been widely ignored. Therefore, we will consider in particular the unbundling tariffs themselves. Additionally, this paper benefits considerably by using only recently available data.

3. Empirical analysis

We now provide an empirical analysis of the determinants of Public Telecommunication Operators (PTO) investment and broadband penetration in 17EU countries. We are particularly interested in understanding the relationship between unbundling (interacting with the respective unbundling tariff) and broadband penetration.

3.1 Description of the sample

The dataset used in this study is based on different sources. First, we use the OECD Telecommunications-database with data available on an annual basis. This data provides a wide range of indicators regarding the diffusion of telecommunications usage and availability among OECD and partner countries. Other studies utilized OECD data for similar purposes, however, often for a more limited time horizon (e.g.

de Ritter 2007). Additionally, we take advantage of the World Telecommunication/ICT Indicators database, provided by the International Telecommunication Union (ITU). This dataset contains time series of traffic, prices, investment and statistics on ICT access on an annual basis for most countries across the world.

Moreover, we use information on how regulation has been implemented, which includes primarily regulatory tariffs. This data comes from Cullen International¹¹, which collected detailed information on regulatory measures in the European member states for the last 20 years. The data is available within bimonthly reports describing the most important regulatory changes across most European Countries, in particular also regarding unbundling. Since the information is not always available for all European Countries, we also added information from the ITU World Telecommunication/ICT Indicators database to fill in data gaps.

Since a large spectrum of explanatory variables is used, and full data is not always available for each country and in every year, the final sample included in the actual estimation, consists of a 17 countries panel throughout the years 2000 – 2010. All equations are estimated via fixed effects and robust standard errors options. However, the panel is unbalanced¹² resulting in a total of 138 observations. Table 1 lists the variables used and presents summary statistics.

Table 1 Summary statistics

<i>Variable</i>	<i>Obs</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
BBP	369	.1170215	.1078629	6.58e-06	.3743209
INV	917	8.08e+09	2.55e+10	6974261	2.43e+11
LLU	272	.4595588	.4992805	0	1
InstallFee	255	108.7635	59.53988	0	470.0081
Monthsub_t	267	226.6806	1640.84	6.749817	19397
Monthlyact	272	11.72193	3.955086	5.87	32
Monthlynew	262	12.44793	9.626914	5.87	99.6

In order to empirically investigate the relationship between unbundling regulation and penetration, with a consideration of unbundling regulation on investments, we have built the variables listed below.

¹¹ Cullen International is a regulatory consultancy in Brussels (<http://www.cullen-international.com>).

¹² For example, not all countries had mandated LLU at the end of 2000.

BBP The first dependent variable in our linear regression model is broadband penetration rate. This is the total number of broadband connections per country as a share of the total population and expressed as a percentage. Therewith the demand side is covered, which the regulator must consider, reflected in subscriber shares. (OECD)

INV The second dependent variable, covered by a second regressing using mostly the same explanatory variables, is investment. More in detail, PTO Investment, expressed per capita in USD and in logarithm.

As penetration obviously includes major investment, the causal effects of unbundling on this item are of ultimate interest.

The explanatory variables consist of two categories: regulatory variables and market demographics. The main focus is on the regulatory variables, which are outlined below.

LLU The first explanatory variable: A dichotomous variable taking the value 1 when local loop unbundling is available to access seekers given in a country and 0 when it is not (likewise used by Grosso 2006; Garcia-Murillo 2003).

X A vector of monthly fees for active loop (Monthlyact), new loop (Monthlynew) and subscription fee for residents (Monthlysub_t). Subscription fee for businesses were also included in the first place, but as monthly subscription fees for residents and businesses appeared to be correlated (the two were almost identical), we decided to drop out fees for businesses because they had fewer observations.

LLU*X Interaction terms between the LLU dummy and each of the monthly fees noted above.

Table 2 summarizes the used variables and connects them with the former discussion. As allowing access to the local loop is likely to promote competition and investment into broadband by other firms, a positive relationship between the LLU dummy and broadband penetration is expected (e.g., Grosso 2006, 14). However, in particular for the long run, negative effects may also appear (Crandall et al., 2013). Therefore the expected impact is inconsistent. This can also be assumed for BBP on

investment, as incumbents may reduce their investment volume if LLU is present, whereas it is assumed that entrants may increase their investment.

In respect to the fees entrants have to pay in order to either lease an active loop or to get access to a new loop, higher fees may reduce broadband penetration by reduced incentives for entrants to provide services. However, if investment incentives are taken into consideration, higher fees may, at least for incumbents, increase investment per capita. For subscription fees it is intuitive to expect a negative impact on broadband penetration, as demand may decrease with higher price. However, as investment may increase with higher subscription fees, as the cash flow of firms is higher; more investment may lead to a higher level of broadband penetration, as more infrastructure is available. The assumption that broadband penetration does not only depend on the availability of LLU, but also on the chosen level of the fees (approved or fixed by the regulator), make interaction terms a promising mean. If it is assumed that higher fees lead to higher penetration through more investment, these advantages may increase over time. With the multiplication of the variables, varying effects of the new variable are expressed. From the assumption made before, expected impact on broadband penetration, but also on investment can be either positive or negative.

Table 2 Summary of key variables and expected impact on BBP and Investment

Variable	Description	Expected Impact on...	
Dependent variables	BBP Inv		
BBP	Broadband penetration rate = Total Broadband / Population	n.a.	n.a.
INV	PTO Investment / capita in USD in logarithm	n.a.	n.a.
Explanatory Variables			
LLU	local loop unbundling dummy, 1 if present, 0 otherwise	+/-	Incumb.: - Entrants: +/-

X includes Fees active loop Fees new loop	All fees are monthly, USD	-*	Incumb.:+ Entrants:+/-
Subscription fee for residents		-/+	+
LLU*X	interaction terms between the LLU dummy and each of the monthly fees noted above	-/+	-/+

*Read: If wholesale fees go up, broadband penetration declines, and vice versa;
Not covered: year dummies, installation fee for residential telephone service, population and the percentage of households with internet access.

3.2 Econometric model

In order to analyse the impact of regulatory introduction of local loop unbundling (LLU) on the telecommunications sector and to countercheck our assumptions, we have developed a model where the subject of interest is the total broadband penetration in selected EU countries. To ensure that we control for unobserved heterogeneity we use a standard panel fixed effects model for the estimation. The level of observation is a particular country that is observed over time.

The model has the following specification:

$$BBP_{i,t} = \alpha_{i,t} + \beta_1 LLU_{i,t-1} + \beta_2 X_{i,t-1} + \beta_3 LLU_{i,t-1} * X_{i,t-1} + \beta_4 InstallFee_{t-1} + \text{Fixed Effects} + \varepsilon_{i,t} \quad (1)$$

The specification attempts to explain the current period Broadband penetration rates $BBP_{i,t}$ by the presence of $LLU_{i,t}$ and other explanatory variables (i.e. different monthly fees, covered in X). Since the immediate effects of LLU introduction on BBP are not very realistic, our specification utilizes lags by one period $X_{i,t-1}$ of both the LLU dummy and the monthly fees. Interaction terms of the LLU dummy and corresponding fees are also included in the estimation.

As investment is the second key parameter that regulation aims at, we test a similar set of explanatory variables for the investment of PTO operators using the following specification:

$$Inv_{i,t} = \alpha_{i,t} + \beta_1 LLU_{i,t-1} + \beta_2 X_{i,t-1} + \beta_3 LLU_{i,t-1} * X_{i,t-1} + \beta_4 InstallFee_{t-1} + \text{Fixed Effects} + \varepsilon_{i,t} \quad (2)$$

3.3 Results

Table 3 provides the Fixed Effects analysis of unbundling regarding the total broadband penetration. Column (1) uses a one period lag of unbundling implementation. It can be seen that the effect of unbundling is positive and highly significant on broadband penetration. Still to investigate whether the unbundling decision of unbundling in earlier periods may be important, we use different lags (column 2). Still, the effect remains positively significant in all used lags.

Column (3) proceeds using the one period lag, adding the One off fee for an active loop. The higher this is, the higher is the penetration. The same can be found adding an interaction in column (4). This interaction indicates that the effect of unbundling is higher, the higher this one off fee is. These columns (3 & 4) seem to indicate that a high fee is correlated with a high penetration. Here, we also face the reverse causality problem. When using the interaction this indicates that unbundling may be more efficient when the fee is high. Column (5) now analyses the Monthly subscription fee for residents. This is negatively correlated with a high penetration, which confirms intuition. The interaction effect in column (6) now shows that unbundling is having a stronger positive effect on the penetration if the fee is rather high. This is intuitive since the higher the fee, the higher the potential that it prevents customers from using those services. Column (7) now tests whether intermodal competition may have an effect. In particular, the cable-penetration variable shows, the more people use cable networks for broadband, the more people participate in broadband markets. The interaction confirms, the lower the higher the cable penetration rate, the lower is the potential benefit of unbundling on the broadband penetration.

Table 3 Impact on total broadband penetration, fixed effects estimation

	1	2	3	4	5	6	7
Unbundling _{c,t-1}	0.1513*** (0.0129)	0.0849*** (0.0149)	0.1197*** (0.0152)	-0.0254 (0.0268)	0.1683*** (0.0187)	0.1226*** (0.0281)	0.1081*** (0.0346)
Unbundling _{c,t-2}		0.0163*** (0.0057)					
Unbundling _{c,t-3}		0.0207** (0.0091)					
Unbundling _{c,t-4}		0.0693*** (0.0157)					
Oneofffee activeloop _{c,t}			- 0.0002*** (0.00004)	- 0.0019*** (0.0003)			
Unbundling _{c,t-1} #One off fee activeloop _t				0.0017*** (0.0003)			
Monthlysubscriptionforresident _{c,t-1}					-4.21e-06*** (9.51e-07)	-4.61e-06*** (1.05e-06)	
Unbundling _{c,t-1} #Monthlysubscriptionforresident _{c,t-1}						0.0011* (0.0006)	
CablePenetration _{c,t-1}							- 0.2153*** (0.0396)
Unbundling _{c,t-1} #CablePenetration _{c,t-1}							-0.1585** (0.0663)
Constant	0.0546*** (0.0058)	0.0657*** (0.0064)	0.1395*** (0.0072)	0.2688*** (0.0219)	0.0768*** (0.0059)	0.0682*** (0.0088)	0.201*** (0.022)
R ²	0.2313	0.3696	0.2909	0.5134	0.1722	0.1864	0.5340
Observations	271	225	134	134	177	177	224

Since the literature also shows that the unambiguous positive effects of unbundling may not hold when taking into account long run effects considering also investment into availability, table 4 provides some information on investment behaviour. Column (1) shows a positive effect on investment, but the R² is rather low. The effect, however, vanishes if one considers the effect of the One off active loop fee. Most probably the positive effect found before is so weak that it is only arbitrary. The size if the one off active loop fee may be an indicator for the market value such that this correlates with investment. Column (3) shoes that the monthly subscription fee tends to reduce the investment, but also the identification is weak. The same counts for the test for intermodal competition (4). These preliminary results show that the effect of unbundling on investment is at most unclear and sensitive to the specification. Still there is a problem with a low sample size and selection bias with the variables. This problem cannot be excluded for table 3, but there the overall results seem to be consistent.

Table 4: Impact on PTO investment per capita, fixed effects estimation

	1	2	3	4
Unbundline _{t-1}	1.42e+09*** (3.46e+08)	-4.34e+08 (2.58e+08)	1.28e+08 (3.10e+08)	-2.49e+08 (5.56e+08)
Oneofffee activeloop _{t-1}		- 7603086*** (2484073)		
Unbundline _{t-1} #One off fee activeloop _{t-1}		8365549*** (2596085)		
Monthlysubscriptionforresident _{t-1}			-65270.2*** (4395.614)	
Unbundling _{t-1} #Monthlysubscriptionforresident _{t-1}			-1965596 (2577597)	
CanblePenetration _{t-1}				7.20e+08 (9.16e+08)
Unbundling _{t-1} #CablePenetration _{t-1}				-5.34e+08 (9.55e+08)
Constant	3.69e+09*** (1.09e+08)	4.04e+09*** (1.88e+08)	3.34e+09*** (4.69e+07)	4.05e+09*** (3.11e+08)
R ²	0.04	0.10	0.01	0.03
Observations	396	134	182	222

4. Discussion and conclusions

The estimations have shown that the effect of unbundling on the broadband penetration seems to be positive and dependent on the price level of the market observed. Moreover, the intensity of intermodal competition seems to be important as well. One drawback is that we have not solved the issue of endogeneity in total. However, in contrast to earlier studies the fixed effects approach can avoid a lot of unobserved heterogeneity that may lead to an endogeneity inducing omitted variable bias.

To interpret the results one has also to consider that the positive effects may be short run effects that are countervailed by negative effects on investments. Still our estimates on investments are not clear and lack observations. Therefore, testing the effect on investment is the next step in the analysis of unbundling regulation on broadband markets performance.

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Appendix

Figure 1 OECD Fixed (wired) broadband subscriptions per 100 inhabitants, by technology

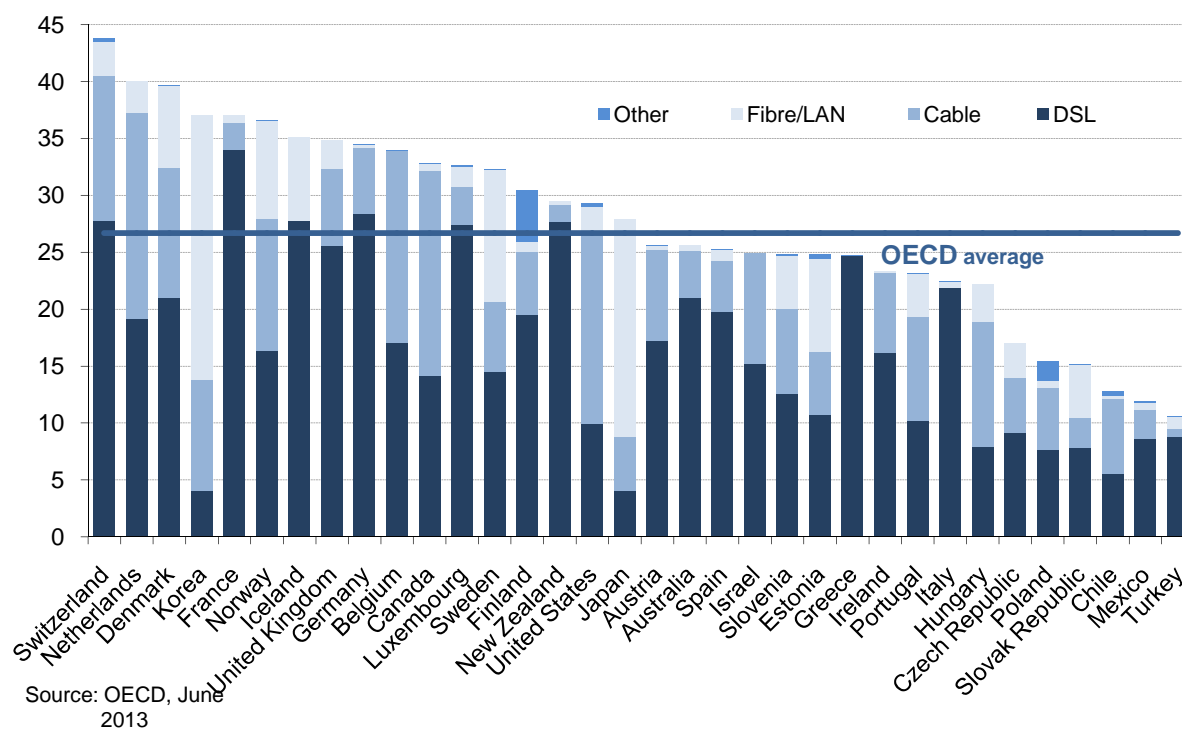
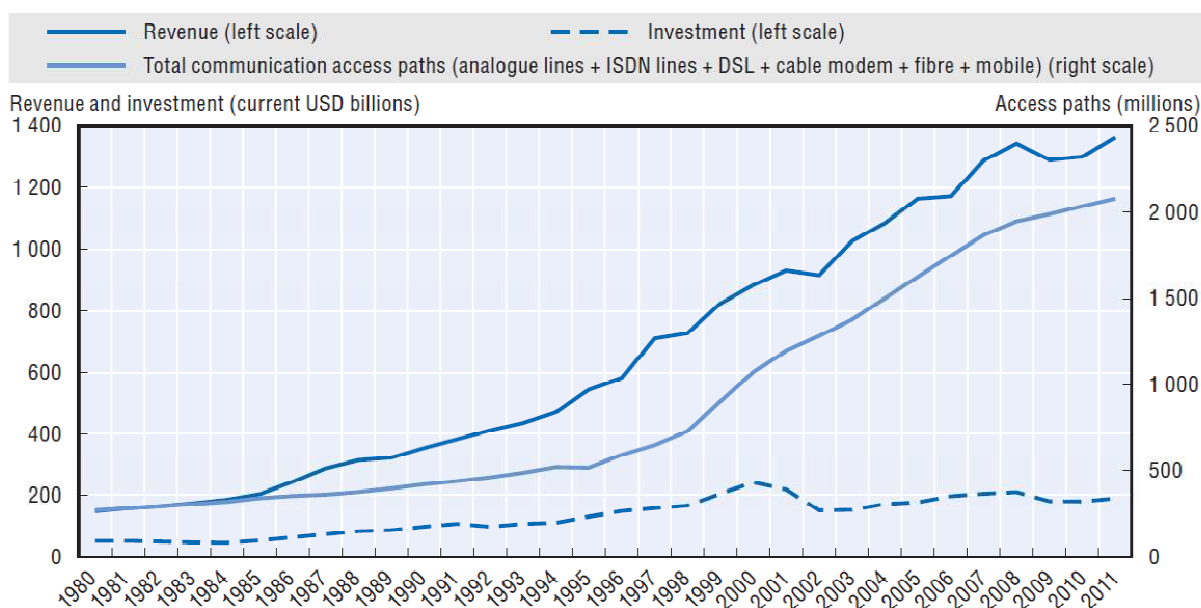


Figure 2 Subscriptions, revenue and investment growth, 1980-2011



StatLink <http://dx.doi.org/10.1787/888932798449>

Source: OECD Outlook 2013, p. 32