Geographic Regulation and Cooperative Investment in Next Generation Broadband Networks - A Review of Recent Literature and Practical Cases

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A review of recent literature and practical cases

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Abstract:

Alternative telecom operators have continuously invested in their own infrastructure in recent years. After more than a decade since liberalisation, competitive conditions have substantially changed, especially in urban areas. European regulatory authorities have acknowledged this development by starting regional deregulation. Additionally, different forms of cooperative investments in next generation broadband have appeared on the market. The effects of such schemes on competition, investment and welfare crucially depend on the fine details of implementation. For instance, in the case of joint-ventures, it matters how investment costs are shared and how internal and external access prices are determined. In the case of long-term access agreements, it is essential to consider how access tariffs are structured, whether they can adapt to market developments ex-post and whether contracts are signed before or after the investment takes place. Generally, many of these agreements allow some extent of risk sharing, offering the possibility to increase investment incentives when firms are not risk neutral. This article reviews the theoretical and empirical literature on geographic regulation and co-investments in next generation broadband. It is suggested that regulators consider introducing regulated co-investment agreements complementing current regulation or in some cases even substituting for it, in addition to considering geographically segmented access prices.

1.Introduction

The continuous investment of alternative operators in telecommunications infrastructure in the years after liberalisation has led to increasingly differing competitive conditions across geographic areas. This is particularly the case in those network segments where alternative operators have invested; in national and regional backbone segments and also increasingly in local access directly connecting households in urban areas with next generation broadband. The latter investment may be seen as particularly valuable as high speed broadband has substantial positive spill-overs for the economy (Bourreau, Cambini and Hoernig (2012a) review relevant literature and estimates). Given that the regulators' main objective is to ensure competition, uncertainty arises about whether a nationally uniform regulatory approach remains valid or whether some form of regional deregulation would be warranted. Positive spill-overs from investment for the economy may reinforce this uncertainty. In Europe deregulation in dense, more competitive areas has accordingly increasingly been undertaken. The regulatory options a regulator has to implement this may range from regional full deregulation to access only obligations or forms of price regulation and will be reviewed in chapter 2 as well as their effects on competition, investment and welfare.

In addition, firms as well as regulators seem to start to understand that network duplication, which traditional infrastructure competition has sometimes implied, is inefficient from a welfare point of view as investment costs are also duplicated. A natural solution is the use of cooperative investments whereby an infrastructure able to host both partners is rolled-out. Such co-investment schemes may also be used to distribute and share investment risk between the partners implying higher investment incentives, leading to higher quality broadband and more innovation. The presence of such co-investment agreements increases the complexity of the assessment of competition and investment incentives substantially, as the details of such agreements matter. In particular, allowing some co-investment clauses may be welfare optimal, while others may restrict competition too strongly (e.g. an high internal or external access price). Chapter 3 reviews the literature on cooperative investment in next generation broadband, considering the fine details of these mechanisms, as well as possible regulatory options such as the introduction of regulated joint-ventures in which the firm rolling out must offer the entrant the option to join it in a joint-venture at equal conditions[1]. The development of the literature on these topics is still a work in progress, as the introduction of regional regulation took place only around 2008 and large scale broadband co-investment agreements began only around 2009 – less than half a decade before this paper was written. Given the complexity of such agreements, many questions still remain open.

Both geographic regulation as well as co-investments take place in a context of migration from legacy to next generation access (NGA) networks[2]. Traditional copper networks will be only progressively substituted by next generation infrastructure, and the regulation of both legacy and next generation infrastructure may affect this process and, in particular, investment incentives. Bourreau, Cambini and Hoernig (2012a) review the literature on migration. Most importantly, Bourreau, Cambini and Doğan (2012) find that regulated legacy access charges may affect investment in NGA in different ways. While an increase in the regulated access price to the new network in all cases increases investments, the effects of access prices associated with the legacy network are unclear. The authors show that with a high legacy network access charge:

i) the entrants' opportunity cost of investment is low, increasing its investment incentives (replacement effect)

[1] A generic overview on the effects of access regulation on investment incentives is provided by Cambini and Jiang (2009). Also, a high-level review of the literature on geographic regulation, co-investments and migration may be found in Bourreau, Cambini and Hoernig (2012a).

[2] Also NGN, considering any type of next generation network not only related to access networks

ii) the incumbent risks to lose (or cannibalize) wholesale profits (wholesale revenue effect) from an investment (it is assumed that an entrant can more easily roll-out its own network infrastructure once the incumbent has deployed it (investment spill-over).

iii) pressure on retail prices for legacy network based services is low. When the access price is low instead, as long as next generation services are seen as substitutes, the overall profitability of the investment is reduced (business migration effect).

Overall, it is therefore unclear whether a relatively high legacy network access charge can increase investments in next generation broadband or not[3]. A high legacy access charge increases investment incentives of the entrant and sometimes those of the incumbent, potentially increasing dynamic efficiency, while negatively affecting static efficiency. The welfare maximising access prices a regulator should set in case of regulation of the legacy network are then shown to depend on the market environment and in particular on the amount of investment spill-overs (with high spill-overs the regulator would set a high access charge to counterbalance the negative effect it has on investments of the incumbent). Finally, when setting both copper and fibre access prices, these effects interact. Whenever a legacy network is present in the models reviewed, such migration issues are considered in some way. Most papers that will be analysed in this survey assume, however, given regulated marginal cost access to the copper network for all operators, implying absence of rent from this infrastructure minimizing distortions.

This paper consists of two major sections that explore different theoretical issues related to the deployment and regulation of next generation broadband networks in Europe. Chapter 2 introduces geographic segmentation of regulation, reviews regulatory principles and practices in Europe as well as the theoretical and empirical literature on the subject. Chapter 3 describes different types of co-investment agreements for the roll-out of next generation broadband networks in Europe and describes regulatory principles and practice. In addition, theoretical and empirical literature on the subject will be reviewed. Chapter 4 concludes the paper, and integrates ideas in the two prior chapters.

2. Geographic segmentation of regulation

The cost of rolling-out fixed access infrastructure is typically related to population density which in turn varies strongly across areas. Such geographic differences in investment costs may lead to geographically different market structures such as a higher number of entrants in urban areas. Increasingly competitive conditions in different geographic areas start to differ within European countries. As effective competition is the main objective of telecoms regulation, there is an ongoing debate about whether full or partial deregulation of geographic areas under increased competition is socially optimal. Since the liberalization of the telecoms market alternative operators are investing in their own network infrastructure. This is especially the case with the roll-out of NGA infrastructure, as explained in the European Commission Recommendation on regulated access to next generation access networks[4]. Consequently, the coverage of regional alternative networks as well as their number has increased over time. Authors such as Cave (2008) argue that this must trigger a geographically differentiated regulation[5].

[3] Hoernig, Jay, Neu, Neumann, Plückebaum and Vogelsang (2012), a report for the European Competitive Telecommunication Association (ECTA), states that a high copper access charge reduces investment incentives focussing on the wholesale revenue effect. Plum (2011), a report for the European (incumbent) Telecommunications Network Operators (ETNO), instead states the contrary focussing on the business migration effect.

[4] The 2010 NGA recommendation states for these cases that "*where the incumbent deploys FTTH, NRAs should in principle mandate unbundled access to the fibre loop. Any exception could be justified only in geographic areas where the presence of several alternative infrastructures, such as FTTH networks and/or cable, in combination with competitive access offers is likely to result in effective competition on the downstream level".*

[5] In particular Cave proposes to distinguish three areas ("potentially competitive", "probably monopolistic but where NGA investment can be commercially justified" and "non commercial") regulated by principles of

While it is always difficult to draw direct inferences on the effects of regulation from the market outcome, it is convenient to describe some fundamental market characteristics at this stage.

Download speeds via the legacy network (xDSL[6]) vary significantly across Europe (Figure 1). While the average xDSL speed in 2012 was 7.23 Mbps (around 35 Mbps for Cable and 37 Mbps for fibre to the home (FTTH)), speeds in Denmark were on average 11 Mbps while those in the Slovak Republic were 3 Mbps[7]. The major cause of slow DSL speeds is insufficiently upgraded backhaul networks. While on aggregate Europe scores well when compared to the US[8], other sources show that comparisons with countries such as South Korea or Japan are less favourable[9]. While this may also be a consequence of different population densities or customer preferences it can also be the result of lacking investment incentives in higher speed access networks generated by access regulation and in particular also by geographic regulation (and co-investments) or its absence.

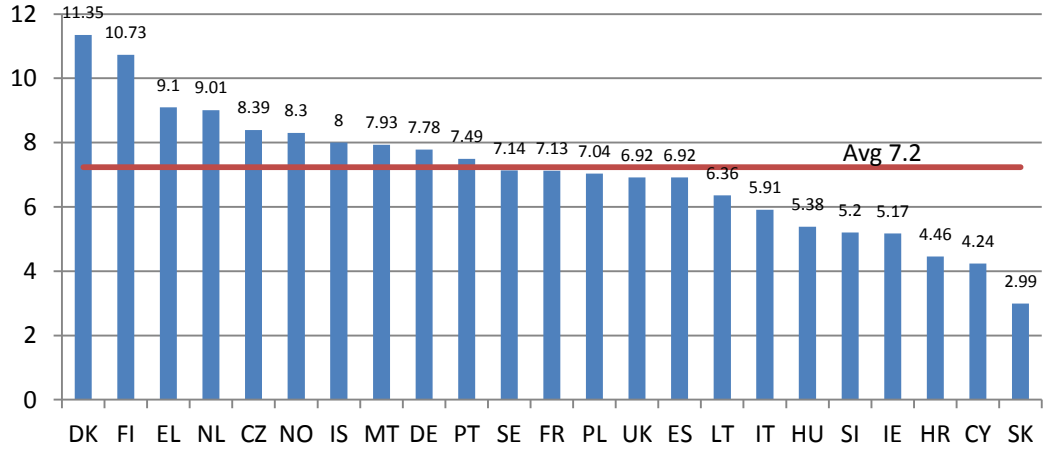

Figure 1 – Actual xDSL Speeds in Europe (Source: Samknows, March 2012)

We will see that pioneering NRAs in this field include Austria, Portugal and the UK. From the aggregate data these countries do not seem to have a particularly high or low performing broadband infrastructure when compared to other European countries. It should, however, be noted that such geographic deregulation efforts are relatively recent and concerning only strongly limited areas. Any impact on infrastructure investment at national level may therefore still be limited.

It may be interesting to point out that overall broadband access prices do not seem to be higher in countries with higher xDSL performance on the market. Van Dijk (2012) shows for instance that at speeds between 12 and 30 Mbps prices in Italy and Ireland, where few infrastructure investments in xDSL seem to have taken place are also higher (around 43€ and 45€ per month[10]) than in Denmark and Finland (29 and 35€ per month) for the median offer. This also holds when comparing the least expensive offers in Italy in Ireland (around 26€ and 29€ per month) with Denmark and Finland (around 24€ and 25€ per month). The same is true for lower speeds at 2-4 Mbps[11]. When comparing national population densities the picture is not coherent. For instance Finland has a very low population density (44 per sq mi) and Italy a very high density (512 per sq mi), while Denmark and Ireland have an intermediate density (333 and 153 per sq mi respectively). This suggests that it may be insufficient to compare nationally aggregate market outcomes. For instance population density in Helsinki is not

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"forebearance", "mandatory access to dominant NGA" and "mandatory access to one or more collectively dominant NGAs" respectively.

[6] xDSL describes all digital subscriber line based technologies such as ISDN, ADSL or VDSL. These are copper-based.

[7] Industry average speeds are not calculated for Europe

[8] Actual download speeds in the U.S. are 5.3 Mbps for xDSL, 17 Mbps for Cable and 30 Mbps for FTTH

[9] Akamai (2012)

[10] In €/PPP (VAT incl.), see p.116 and p.84

[11] There is no data in this category for Italy though.

lower than in other capitals. Until recently only few disaggregated data was available. The increasing adaption of regulation to geographic market conditions and the will to support investments locally has, however, led to a recent increase of monitoring. The European Commission has asked Point Topic to map progress with next generation investments in members states and regions (30 mbps or above). Figure 2 shows NGA coverage in urban and rural areas. Overall NGA coverage seems to be highest in relatively dense countries such as the Netherlands, Switzerland and Belgium. At the same time these countries have historically strong cable competitors. In addition NGA coverage in rural areas is in all (large) countries significantly lower. This digital divide seems, however, still to be stronger in countries without a historical cable competitor.

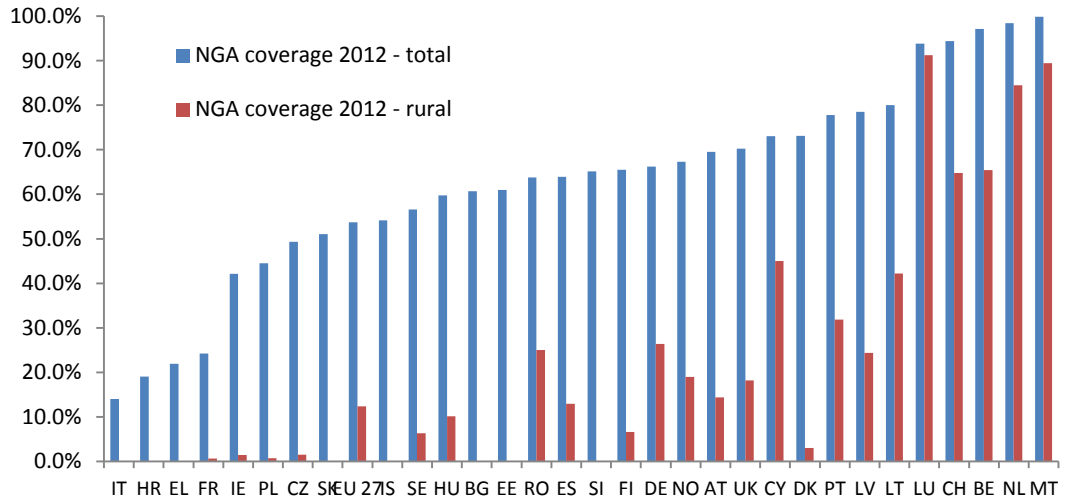

Figure 2 – NGA coverage in Europe, total and rural areas (Source: Point Topic)

The following sections will describe the regulatory principles at EU level guiding regulatory action in this field and regulatory practices implementing geographic segmentation of regulation. In a subsequent section the academic literature is reviewed.

2.1. Regulatory principles in the European Union

Geographical market analysis has always been a part of the European regulatory framework. It states that even if demand and supply-side substitution patterns may suggest a national market, sub-national markets can be defined when competitive conditions differ to a sufficient extent (e.g. urban and rural)[12]. This approach will be referred to as geographic segmentation of markets. In this case it is possible that the absence of significant market power of a firm or firms in a geographic sub-market can be demonstrated. In such cases, the regional market would then not be subject to any kind of asymmetric regulation anymore (full deregulation). Moreover, lighter remedies can be imposed in sub-areas with stronger competitive constraints within an area where significant market power is found. This approach will be referred to generically as geographic segmentation of remedies. While it will be shown that the high flexibility with remedies means that technically this difference may not be of fundamental importance, the regulatory processes which lead to one or the other are – in Europe –

[12] European Commission (2002), 56.: *"the relevant geographic market comprises an area in which the undertakings concerned are involved in the supply and demand of the relevant products or services, in which area the conditions of competition are similar or sufficiently homogeneous and which can be distinguished from neighbouring areas in which the prevailing conditions of competition are appreciably different. The definition of the geographic market does not require the conditions of competition between traders or providers of services to be perfectly homogeneous. It is sufficient that they are similar or sufficiently homogeneous, and accordingly, only those areas in which the conditions of competition are 'heterogeneous' may not be considered to constitute a uniform market."*

fundamentally different. Finally, the aggregate of both approaches will be referred to as geographic segmentation of regulation or geographic regulation.

A series of national regulatory interventions regarding geographic segmentation of markets and remedies have been notified to the European Commission since 2008. While the European Commission currently has veto power on member states decisions on market analysis issues (i.e. in this context the definition of geographic markets), this is to date not the case on remedies (i.e. in this context the geographical differentiation of remedies).

The BEREC Draft Common Position on Geographic Aspects of Market Analysis[13] (2013) acknowledges the described market developments and sees an increasingly importance of geographically differentiated regulation in Europe. BEREC (2013) aims at giving European NRAs guidance on geographic regulation[14] and follows an earlier Common Position of 2008.

The Common Position states that NRAs should consider making a detailed geographical market analysis when some key indicators are present:

- *One or several alternative operators have significant but less than national coverage and exert a significant competitive constraint at the retail level in the areas where they are present*
- *The incumbent operator differentiates retail prices geographically or the incumbent operator is setting a national uniform retail price but there are significant price differences between the incumbent operator and alternative operators where the latter is present; and*
- *There are significant geographic differences in product characteristics*

The telecommunications sector consists of complex markets and technical products. For a detailed description of the markets and products analysed in the upcoming sections the reader may refer to BEREC (2010a). In recent years operators have been increasingly climbing the ladder of investment being able to replicate for example wholesale broadband access (WBA) products based on local loop unbundling (LLU). Also, in several countries independent alternative operator technologies (cable, FTTx, mobile broadband) are expanding rapidly allowing the provision of similar services. Provided that the described technologies are found to be retail product substitutes, indicators have to be analysed hinting to regionally different competitive wholesale conditions. The Common Position states that most likely candidates for segmentation are the WBA and leased line markets (wholesale services). Another likely candidate would be the market for physical access to the end customer[15] (essentially LLU).

The Common Position distinguishes two types of countries. First there are countries - especially in Western Europe - where competition was mainly driven by LLU-based market entry and only partially by alternative infrastructures such a as cable (**scenario** 1). Secondly, there are countries - especially in Eastern Europe - where it is mainly driven by alternative infrastructures such as cable (**scenario** 2). Romania is an interesting example, as in the broadband retail market intense competition of the incumbent with cable operators is taking place. Today cable operators hold a higher share of the retail market than the incumbent. In addition there are regions where even two cable operators are present. The reason for this situation may be that the incumbent was slow to enter the broadband market and when it did, it did not enter aggressively (also because it has to offer uniform retail prices while cable operators are only present in urban areas). An additional reason may be that regulation on the incumbent was introduced only recently meaning that DSL-based competition was less aggressive than in other countries[16].

[13] BEREC (2013), public consultation version
[14] A similar document has been product at OECD level (OECD, 2012)
[15] Under the so called “modified Greenfield approach” regulation on the market under examination is disregarded, but regulation on other (upstream) markets is treated as exogenous. I.e. an analysis of the competitiveness of the WBA market will consider LLU regulation to remain in place.
[16] Informa (2011)

In case a geographical segmentation of the market is indicated the Common Position suggests choosing adequate geographic units. Generally there are two approaches: political/administrative boundaries or a network approach based on the topology of the incumbent operator. In any case, the Common Position states that the units should satisfy the following four conditions

a. *Mutually exclusive and less than national*
b. *The network structure of all relevant operators and the services sold on the market can be mapped onto the geographic units*
c. *Have clear and stable boundaries*
d. *Small enough that the competitive conditions are unlikely to vary significantly within the unit but at the same time large enough that the burden on operators and NRAs with regard to data delivery and analysis is reasonable*[17].

Homogeneously competitive areas should then be aggregated from the chosen geographic units. Homogeneity is judged essentially with the following criteria:

a. *The barriers to entry in the market*
b. *The number of operators that exert a relevant competitive constraint on the SMP operator*
c. *The market shares of the SMP operator and the alternative operators*
d. *The prices*

Typically geographic areas in scenario 1 could, for instance, be defined as the areas covered by unbundled MDFs[18] (e.g. UK WBA case UK/2010/1123 in Table 1). Depending on the extent of alternative parallel networks the segmentation could also be made based on the alternative networks topology or administrative geographic areas. In scenario 2, such areas could be based on administrative geographic areas (for example communes (e.g. Polish WBA case PL/2011/1184 in Table 1) or municipalities (e.g. Czech WBA case CZ/2012/1322). In addition, where a vertically-integrated cable operator is present, the competitive effects on the wholesale market need to be considered only to the extent that they are relevant[19].

In practical cases, regulators often analysed whether the incumbent operator in a given area would have a market share below a certain threshold (e.g. 40-50%) and whether sufficient alternative infrastructures existed (number of players). More concretely the BEREC report on co-investment and significant market power (SMP) in NGA networks notes that "*a market characterised by two operators implies automatically that one of the players disposes of a market share of 50% or more and that it is therefore to be expected that a market with high entry barriers with one or two operators in the market raises concerns about dominance and more generally the competitive situation of the market."* Conversely, it is concluded that only markets with three or more independent operators can lead to effective competition in the physical access market in such an environment. An access market consisting of two infrastructures (e.g. incumbent and cable) is therefore generally not being considered to be sufficiently competitive. There are, however, various cases in Switzerland and France (usually as a consequence of co-investment) where three or more independent infrastructures currently co-exist (e.g. Basel, Paris, Zurich). In a full market analysis assessing the level of competition several other important factors next to the number of players, such as entry barriers, market shares, downstream

[17] As noted in the Common Position, if the choice of a geographic unit that is too small may lead to a very significant number of units (even in the thousands). While the aggregation of geographic areas may contribute to solve part of the administrative burden derived from this fact, it is nevertheless a factor that may have to be weighted carefully by the NRA before deciding on the appropriate geographic unit.
[18] Main distribution frames, in practice at the local exchange facility.
[19] Whether technologies are retail substitutes and whether they can indirectly constrain the wholesale market under consideration in case no wholesale product is offered (e.g. Cable) needs to be analysed in detail. See also BEREC report on self-supply, BEREC (2010b).

competition, indirect effects and commercial or regulated wholesale products (e.g. often not given for Cable) would need to be assessed, however.

As has been shown sub-national geographical markets are defined in case they are indicated by demand and supply side substitutability analysis or in case of sufficiently heterogeneous competitive conditions. The resulting sub-national markets must in turn be sufficiently homogeneous and have stable borders themselves. Typically, the Common Position states, geographic market segmentation is applied when an national regulatory authority (NRA) believes that some (non SMP) areas are competitive enough to fully withdraw regulation. Finally, it should be noted that possible closing of redundant traditional local exchanges (MDF) during the migration to NGA network may have consequences on the geographical market definitions.

In case that the heterogeneity of economic conditions is not sufficiently strong to justify geographic markets or where the borders of the market are not sufficiently stable or sustainable the Common Position suggests the definition of a national market with the imposition of – more flexible - geographically differentiated remedies. In these cases, typically no fully deregulated areas are defined. Interestingly, the full or partial deregulation of an area may according to the Common Position also have an economic impact in the remaining areas in case of cost-based regulation. In case of a segmentation of markets, it is likely that deregulation could take place in dense, low cost areas leaving only the higher cost areas subject to regulation, featuring a network with a higher cost base per user and higher regulated average prices than before the deregulation of urban areas[20].

2.2. Regulatory practices in Europe

Since the first decisions imposing geographic segmentation of regulation (UK and Austria in 2008) a number of European national regulatory decisions in this field have been added (Table 1). For a more detailed review of WBA geographic segmentation of regulation in Europe the reader can refer to Houpis et al. (2011). For a review of the approach to geographic segmentation of regulation in the U.S. the reader can refer to Stockdale (2011). Finally, for a review of worldwide cases covering also countries such as Australia the reader may refer to Xavier & Ypsilanti (2011).

This section will review recent decisions and summarize the current situation of geographic regulation in Europe across all communications markets. In particular, proposed and implemented geographic access regulations in European member states in the following markets will be analysed: i) wholesale broadband access, ii) wholesale leased lines and iii) wholesale (physical) network infrastructure access. Detailed references to the regulatory decisions summarized below can be found in Table 5.

In a first decision proposal the **Austrian NRA** originally wanted to introduce geographically segmented markets as the first NRA in 2008 in the WBA market. The European Commission (EC) had signalled to veto this decision as the boundaries of this market seemed unstable. The NRA had then adapted its proposal to define a national WBA market and proposed to withdraw most remedies in the more competitive segments of the market. Lighter remedies were proposed to be imposed in MDF areas with two or more alternative operators present, incumbent market share below 50% and serving more than 2'500 households. The European Commission had accepted this proposal[21]. Regarding remedies it stated that "*the geographic differentiation of remedies may be appropriate in those situations where, for example, the boundary between areas where there are different competitive pressures is variable and likely to change over time, or where significant differences in competitive conditions are observed but the evidence may not be such as to justify the definition of sub-national markets*". The imposition of geographical remedies was then, however, rejected by the Austrian Administrative Court on 12

[20] See also BEREC Common Position 2013

[21] "*Based on the general principle that remedies should be tailored and proportionate to the identified competition problem, it can be appropriate for NRAs to impose remedies which take account of locally/regionally differentiated competitive conditions while retaining a national geographic market definition.*"

August 2008 leading to an implementation of regulation without geographical differentiation (without lighter remedies in more competitive areas). In the recent fourth round of market analysis (2013) RTR again proposes a national market, this time with uniform remedies (retail minus price control; products are restricted to only business-grade products). The proposal is still pending.

On the market for leased lines instead, the **Austrian NRA** proposed in 2008 a geographic segmentation of markets of high speed (>2 mbps) terminating segments of leased lines in two geographic markets: 12 competitive cities and the rest of the country. The cities would be those communes having i) population of more than 15'000, ii) more than three operators offering terminating leased line segments based on own infrastructure and iii) a market share of the incumbent <50%. The European Commission stated, however, that it would have doubts about the homogeneity of competitive conditions within these markets and that the incumbent could well not have SMP also in the rest of the country for high speed leased lines. In particular, more information about the geographical distribution of market shares and pricing structures as well as their evolution over time was been requested. The European Commission also reminded that a defined market should have stable boundaries over time. The decision has then been withdrawn implying that currently high speed wholesale leased lines are deregulated in 12 cities but not (yet) in the rest of the country. In its more recent fourth round market analysis (2013), the Austrian NRA reverted back to a national market and uniform remedies. The European Commission vetoed this decision as there seems to be a lack of evidence for homogeneous competitive conditions across all regions in the country. BEREC has shared this view. Especially from the 2008 analysis in the mentioned 12 cities TAs market shares are low between 23 and 34% in the relevant urban market, while the incumbent would not face significant competition in more rural markets. The European Commission has asked for an updated and a detailed analysis. Also the European Commission argues any reregulation should be carefully evaluated.

The **Czech NRA** in 2012 proposed for the WBA market two geographic submarkets: districts where at least three infrastructures are present and the incumbent has less than 40% market share and other districts. Consequently, it proposed to fully deregulate the area under infrastructure competition while continuing to regulate the rest of the country with relatively light remedies excluding cost-orientation. The European Commission stated that this proposal is mainly based on the number of independent networks and therefore insufficient. It stated that for instance the incumbent's wholesale offer would be national with national prices. Also, the homogeneity of competitive conditions would seem not to be given within the "urban" areas as they seem to include also some small cities (with lower economies of scale). Moreover, the European Commission had doubts about the competitiveness of such areas. In particular it doubted whether Wi-Fi networks may be retail substitutes to DSL as Wi-Fi coverage would be limited and offer only lower speeds. It also stated that indirect constraints on the wholesale market would be unlikely to be sufficient for Wi-Fi as well as for Cable. While BEREC had supported the NRAs proposal, it was vetoed by the EC.

In 2009 the **Dutch NRA** has formally notified a national market including copper and fibre local loops and national remedies were set. Binding price caps for fibre, however, were in practice set per cost area (NL/2009/0868, NL/2013/1439). For unbundled optical distribution frame access to FTTH lines and ancillary services such as backhaul and collocation the NRA proposed to take as a starting point the concrete FTTH business case of Reggefiber, the joint-venture formed by the incumbent and an alternative utility operator, to roll out the NGA network (including an effective and not hypothetically efficient capital expenditure as in LRIC). The authority has decided to allow the joint venture to generate a reasonable rate of return including a risk premium. The fundamental idea is to set a first year access price such to make the investment viable (profitable) in a discounted cash flow (DCF) model estimating cash inflows (the revenues of an FTTH model over the assumed lifetime of the network) and cash outflows (capital expenditure and operational expenditure). Assuming that (real) access prices remain constant over the lifetime of the investment, the initial regulated price cap for access products is calculated such that the net present value of future cash flows is equal to the initial

capital investment, when applying an initial (reasonable) rate of return (between 7-10%, the exact initial amount is not disclosed). Over time the market environment may then change, e.g. demand, costs and competition may develop positively or negatively for the operator and the internal rate of return (IRR) may then varies over the years. However, such profits are not to exceed the standard risk cost of capital (WACC), increased by a risk premium for fibre, by more than 3.5% (representing regulatory risk). As long as this is not the case (verification every three years) maximum access prices are allowed to remain constant in real terms, i.e. to increase over time along with the consumer price index (1.5% per year). If instead the IRR is too high the prices are adjusted downwards by the authority[22].

The main inputs into this cost model include the expected economic lifetime (25 years), the expected penetration rate (60% after 2 years), capital expenditure per area, the operating costs (12-18€ per line per year), revenues and an initial reasonable rate of return (7-10%). In case of too pessimistic expectations (of demand for instance) the price would be set such (high) that too high profits could be generated. In the converse - too optimistic - case instead profits would ex-post be too low and investment incentives would be adversely affected. Using the DCF model the NRA can adjust its prices over time when expectations turn out to be wrong. While this is a highly flexible setting, targeting essentially regulatory, cost and demand uncertainty of investment over time and flexibility regarding the offering of different price schemes (e.g. volume discounts), it was also decided to set geographically different price caps for 14 areas with differing average capital expenditure requirements. Across these cost clusters fibre unbundling prices 2013 vary substantially from 15.52€ to 25.99€ per line per month in 2013 (Autoriteit Consument en Markt (2013)[23]). In addition to these tariffs, however, there is a national tariff scheme (18.84€ per line per month), which is calculated as the weighted average of all areas. Wholesale customers can choose between the national tariff scheme or the local tariff scheme, but the choice cannot vary from area to area. However, in the longer term this may imply that firms are active either in urban areas where they choose the local tariff (as it is lower than the national tariff) or in rural areas, where they choose the national tariff (as it is lower than the local tariff). Interestingly in the long term the binding prices in rural areas could then be lower than the price necessary to cover all area costs as calculated by the business case. In line with what will be show in the next chapter cost recovery prices are reasonably reduced in urban areas, while, however, not increasing them in rural areas.

It should be noted here that the DCF results could also be largely achieved with traditional LRIC pricing as long as identical information is used[24]. Both approaches consider initial capital expenditure, forecast demand developments and use a WACC to calculate the revenues/prices for the first year. The European Commission has in any case accepted the Dutch regulation proposal. To date the Dutch NRA is the only NRA applying geographically differentiated regulated prices according to cost clusters. Interestingly up to now the incumbent had consistently priced about 2.50€ below the price cap, which seems to indicate the presence of relevant infrastructure competition with cable and regulated copper products (Middleton and Van Gorp (2010)). Next to the European Commission notifications the reader may refer to Middleton and Van Gorp (2010) for a review of the Dutch case.

The **Finnish NRA** is facing a particular market with a large number of regional incumbents. Initially, geographic markets were defined along traditional operating areas, where 27 regional incumbents have a market share of more than 90% in their wholesale physical network infrastructure access markets. After the NRA had identified that the regional incumbents started to invest in fibre networks outside of their traditional operating areas, a more refined concept of regional markets was defined. The NRA has started by analysing the competitive conditions in 336 municipalities. It has then aggregated these municipalities based on the following criteria: i) the municipalities compose a physically contiguous geographic market area; ii) in terms of the number of local loops, the market share of the area's market leader in the municipalities belonging to one area is more or less equal

[22] The approach is broadly described in OPTA (2008)
[23] See Bijlage B
[24] See Neu, Neumann and Vogelsang (2012), p. 69

(variation of ± 10%); and iii) the number of competing telecommunications operators owning their own local loops in municipalities belonging to the area is more or less equal (± 1 telecommunications operator). The result was the definition of 111 sub-national markets for both the WBA market and the wholesale (physical) network infrastructure access market. In 2012 the NRA in a corresponding full market analysis found seven of these WBA markets to be effectively competitive and full deregulation in these areas was proposed (including Helsinki). In the remaining 104 areas light regulation excluding cost-orientation for WBA of the regional 27 incumbents is proposed. The European Commission did not comment on these issues and the decision has been adopted.

In the market for wholesale (physical) network infrastructure access instead the **Finnish NRA** has defined 111 sub-national markets as in the analysis of the WBA market. None of these markets was, however, deemed to be sufficiently competitive and regional incumbents (at least larger ones) are subject to cost-based regulation. The European Commission did not comment on these issues and the decision has been adopted.

The **German NRA** in 2010 has analysed the WBA market and had identified 771 MDF areas (covering about a quarter of all households) where i) the incumbent has less than <50% retail market share, ii) there are at least four operators offering DSL and iii) the MDF has more than 4'000 subscribers (i.e. sufficiently large to allow unbundling to efficient entrants). However, while the UK and Portugal had proceeded with full deregulation in similar areas the German NRA did not follow this approach and propose a national market. The reasons include that the incumbent pursued a national pricing and product strategy. While the NRA did not propose a geographically segmented remedies it proposed uniform light set of remedies at national scale, i.e. excluding cost-orientation. The European Commission agreed that there is no conclusive evidence for a geographically differentiated regulation. The decision has been adopted.

The **Italian NRA** has analysed the competitive conditions in the WBA access market in 2011 and concluded that these are not sufficiently heterogeneous to warrant the definition of sub-national markets. The NRA has, however, proposed to differentiate remedies between areas with infrastructure competition and areas without (details to be defined in a later decision). The Commission advised the NRA to follow the criteria for NGA remedies in the NGA recommendation. It reminded the NRA that for a definition of geographic markets the number of operators in a given exchange area, the size of the area to ensure possible entry at the given scale, the distribution of market shares and geographic pricing would need to be analysed. A separate proceeding on geographically differentiated remedies will be opened. With regards to remedies the NRA plans to impose a lighter form of price control in more competitive areas leading to higher prices.

The **Polish NRA** in 2012 has proposed a national WBA market with a lighter set of regulatory remedies for the four largest cities (where there is retail competition from cable and other operators) and one for the rest of the country. In the first segment of the market, mostly urban areas, the NRA proposed to remove the remedies of cost-orientation, accounting separation and transparency, leaving only access and non-discrimination obligations. The European Commission has recommended that the NRA withdraw the proposal and strengthen its analysis of competitive conditions. While the European Commission has no veto on remedies, the NRA has withdrawn its decision proposal.

Also in the WBA market but in an earlier round of analysis of the WBA market of the **Polish NRA** than the one cited above geographically segmented markets with a fully deregulated area of 11 cities under competition. The European Commission had, however, vetoed this proposal as differentiated prices and market shares as well as indirect constraints and potential competition would not have been sufficiently demonstrated and market data had been judged to be outdated.

The **Portuguese NRA** suggested in 2010 a WBA geographic market definition with competitive MDF areas where there is at least one ULL based alternative operator and a cable operator (taken into consideration when the percentage of connected cable households is at least 60% in the area) and

non-competitive MDF areas on the other side. The competitive area was proposed to be fully deregulated. The non-competitive areas would still feature a form of light price regulation (retail-minus approach). The European Commission had raised concerns that in some competitive MDF areas the market share of the incumbent is still above 50%. It has therefore invited the NRA to carefully monitor the evolution of competitive conditions in the future, but the decision was not vetoed and has been adopted.

In the leased line market, instead, the **Portuguese NRA** proposed in 2010 a geographic segmentation of the trunk segments of leased lines market (which usually connect the exchanges of the country) in a competitive trunk market connecting 110 local exchanges where at least two alternative operators are present with own infrastructure and one "non competitive" trunk market connecting the rest of the exchanges. It was then proposed to fully deregulate the competitive leased lines routes (as done by the Swiss NRA) and to impose regulation including cost orientation on the remaining lines. Given that the terminating segments are regulated similarly, the regulatory outcome would be similar to the one in Switzerland. The European Commission has stated that the geographical market segmentation is primarily based on the number of operators, which it considers to be insufficient, and that further evidence is necessary, such as markets shares over time and regionally differentiated wholesale and retail pricing. Given the important differences in market shares and network duplication the Commission did however not contest the decision and it was adopted. It invited the NRA, however, to base its next market analysis on more detailed data.

The **Spanish NRA** had identified in 2008 differing competitive conditions in the WBA market but these were not deemed sufficient for a definition of regional markets. It argued that the incumbent's retail pricing was still national. It was also argued that the current NGA roll-out would affect the boundaries of possible geographic markets meaning that sub-national market boundaries would be unstable. However, unlike the German NRA, the Spanish NRA proposed geographically differentiated remedies. In areas where the incumbent faces infrastructure-based competition (at least Cable and at least two LLU-based competitors) and where the incumbent's market share is below 50%, the NRA proposed the withdrawal of the cost-orientation obligation. The Commission has asked the Spanish NRA to detail its geographic analysis further by analyzing different geographic commercial strategies, average retail prices, functionalities provided and market shares (retail and wholesale) in both areas. Also the Spanish NRA was suggested to analyse in detail the stability of boundaries and a possible trend to competition in the urban areas. BEREC supported the Spanish NRAs view of a national market, in particular because of the unstable character of geographic borders and the fact that different retail prices could reflect different technologies rather than market pressure[25]. It also agreed that competitive differences could warrant geographic differentiation of remedies. Finally, however, the Spanish NRA has withdrawn the proposal imposing remedies formerly proposed only in more rural regions also on national scale. No further round of market analysis has yet been notified.

In the leased line market the **Swiss NRA** in 2010 had defined the market for trunk segments of leased lines as the market of lines between Communes where two or more alternative operators to the incumbent are present with own infrastructure (e.g. 25 Communes in 2009 and 41 Communes in 2010). The trunk market defined in this way has in a second step been deemed to be competitive and fully deregulated. Not being part of the EU framework, the Swiss NRA did not need to notify the EC. If it would have had to, in light of the Portuguese case, the decision might have been vetoed for unstable market borders. It should be noted, however, that geographic segmentation of markets is the only legal tool for geographic segmentation of regulation available to the Swiss regulator as the Swiss framework foresees no flexibility of remedies. Imposing geographically differentiated remedies is therefore currently not a viable option for the regulator.

The **UK NRA** has been the pioneering NRA regarding geographic segmentation of markets in Europe. Its current WBA access regulation foresees three markets: 1) MDF areas where BT is the only

[25] IRG (09) 01 Phase II Case Spain 090116

operator present, 2) MDF areas where in addition two or more alternative operators with own infrastructure or over LLU are present[26] (or three when BTs market share is greater than 50%) and 3) areas where in addition four or more alternative operators are present (or three when BTs market share is lower than 50%). While market 3 is fully deregulated as it ensures competition, in market 1 full regulation including cost orientation and price-control (RPI-X) is imposed. Finally, in market 2 the additional price control remedy is withdrawn. Combining full deregulation with a segmentation of remedies between different markets, this proposal corresponds to date to the most flexible regulatory approach adopted in the EU. The European Commission reminded the NRA, however, that the sole criterion of the number of operators is not sufficient for geographic market segmentation, but that homogeneity has to be ensured checking for possible geographic variations in market shares and pricing. It invited the NRA in particular to provide additional structural and behavioural evidence, such as data on barriers to entry, marketing and sales strategies and service characteristics, which could further sustain the geographic market delineation. The European Commission did, however, not veto this decision and it was subsequently adopted.

Moreover, in the leased line market, the **UK NRA** in a detailed analysis in 2013 has defined geographic markets for high performance traditional interface terminating segments of leased lines (>8mpbs). Effective competition has mainly been found in the Western, Eastern and Central London area (WECLA). The WECLA has been slightly extended in the recent market analysis and follows 421 post code areas where competition is assumed, i.e. two or more competitors with own infrastructure and relatively low market shares of the incumbent. In practice the NRA estimates the number of potential competitors in a postal sector with a flexibility point within 200m of business sites. It is supposed that 200m can be reasonably bridged by any new installation of fibre to provide high performance leased lines services to a client. Then, the average number of potential operators per business site in the postcode sector was calculated and contingent postal codes with at least two alternative operators were grouped together. Market shares of the incumbent in this area were shown to be considerably lower and some geographic differences in prices have been detected. The only area with significant differences in economic conditions when compared to the rest of the country was given was then shown to be the WECLA. Finally, very high speed leased lines (622 Mbps) were defined separately (as a joint national market) as both submarkets seemed to be equally competitive. Regarding regulation, the NRA proposed to fully deregulate competitive markets (this is automatic) and to impose price control on the remaining markets. The European Commission has cleared this proposal and it was subsequently adopted.

It should further be notes that in some countries the low performance copper-based WBA market has been fully deregulated at national level (**Malta**, **Romania**). In Malta, in the retail market, two equally large competitors were found (incumbent and cable) and joint dominance could not be demonstrated in 2008. The assessment could possibly be different in light of NGA services and deployment today. In Romania, strong infrastructure competition seems to take place on a national level with the incumbent having relatively low market shares when compared to cable competitors. Also, competitive conditions were not judged sufficiently heterogeneous to warrant sub-national markets. The European Commission has accepted full national deregulation in 2010, but cautions the NRA to follow market development especially of competitive conditions across areas closely.

To sum up, even though the European Commission works towards a homogenous approach to regulation across Europe, current regulatory policy on geographic segmentation of regulation is highly fragmented. Various different approaches and criteria still co-exist. This may also be a result of the current absence of a veto of the European Commission on remedies.
As the review of relevant regulatory cases shows, in several cases a geographic segmentation of markets has not implied full deregulation. On the other hand depending on the concrete details of regulation a remedy set can also nearly correspond to no regulation. The Austrian NRA in its WBA

[26] Presence means here a coverage of at least 65% of the MDF area.

decision, for instance, had imposed only accounting separation in competitive areas[27]. Therefore, both the segmentation of markets as well as the segmentation of remedies may in practice imply near equivalent market regulation. The amount of fine-tuning then also depends on the preference of the regulator and the instruments it is ready to impose. The simplest form of fine-tuning would be cost-orientation and full deregulation. But different regulators have proposed different solutions than that including access-only obligations preventing foreclosure[28].

To conclude this overview, the approach of lighter regulation where competition is more intense is in line with theory when looking at static welfare – as increasing competition decreases the necessity of safeguarding competition. What is scarcely discussed are the detailed effects on investment incentives and the implementation of the remedies. For instance, LLU prices are usually based on uniform "cost-oriented" LRIC prices. As costs in many cases significantly differ across areas[29], uniform prices in regional markets may not set the correct investment incentives in all areas as will be seen in the next sections. Of the reviewed cases there is one exception to this: The Dutch regulator has – under formally national regulation - imposed geographically segmented prices according to local capital expenditure requirements.

[27] This decision was only rejected by a national court.

[28] Generally, it can be noted that remedies in service-based markets could also be lighter as entry barriers are lower than for instance in the market for wholesale (physical) network infrastructure access.

[29] Ilic et al. (2009) show that in Switzerland costs can differ by a factor 6 across geographic cost clusters.

Table 1 - Regulatory practice – recent cases of sub-national geographic markets and geographically segmented remedies in Europe (August 2013)

Country	EC Case No.	SMP operator(s)	Product market	Geographic market	Geographic Segmentation of Remedies	Type of regulation imposed	Status	Comment on status
Geographic Segmentation of markets								
Austria	AT/2013/1442-1443 AT/2009/0932	Telekom Austria	Terminating segments of leased lines > 2 Mbps and < 155 Mbps	1) 12 competitive communes having population >15'000, more than three infrastructure based competitors and a market share of the incumbent <50% 2) The rest of the country	-	1) None 2) Access, non-discrimination, price control, accounting separation and transparency	Withdrawn (partially)	A first market definition of 12 cities and the rest of the country has been contested by the EC. The partial decision of regulating high speed lines in the rest of the country had been withdrawn. In its more recent fourth round market analysis (2013), the Austrian NRA reverted back to no geographic markets and uniform remedies. The EC vetoed this decision as there seems to be a lack of evidence for homogeneous competitive conditions across all regions in the country. BEREC has shared this view. A new final decision is still pending.
Czech Republic	CZ/2012/1322	Telefonica CR (incumbent)	Wholesale broadband access	1) Districts with at least three infrastructures 2) Rest of the country	-	1) None 2) Access, non-discrimination, cost-orientation, accounting separation and transparency	Withdrawn	BEREC supported largely the NRAs proposal. However, the proposal was vetoed by the Commission and it has not entered into force.
Finland	FI/2013/1328-1329	27 regional incumbents	Wholesale broadband access	111 regional submarkets aggregating contingent municipalities with similar competitive conditions (number of competitors and market share of incumbent), 104 of which are non competitive and 7 competitive	-	7/111 markets: None 104/111 markets: Access, non-discrimination, and transparency	Adopted	The EC did not comment on geographic issues and the decision has been adopted.
Finland	FI/2013/1328-1329	27 regional incumbents	Wholesale (physical) network infrastructure access	111 regional submarkets aggregating contingent municipalities with similar competitive conditions (number of competitors and market share of incumbent) all of which are non competitive	-	111 markets: Access, non-discrimination, cost-orientation, accounting separation and transparency (small regional incumbents are subject to lighter regulation)	Adopted	The EC did not comment on geographic issues and the decision has been adopted.
Portugal	PT/2008/0850-851	PT	Wholesale broadband access	1) MDF areas where Cable (at least 60% coverage) and one LLU operators are present 2) Other MDF areas	-	1) None 2) Access, non-discrimination, price control (retail minus), accounting separation and transparency	Adopted	The EC had raised concerns that in some competitive MDF areas the market share of the incumbent is still above 50%. It has therefore invited the NRA to carefully monitor the future evolution of competitive conditions, but the decision was adopted.
Portugal	PT/2010/1121	PT	Leased lines (trunk)	1) Competitive trunk segments (between 110 local exchanges where	-	1) None 2) Access, non-discrimination, cost orientation, accounting	Adopted	The EC has states that the geographical segmentation is primarily based on the number of operators and was insufficient. Given the important differences in market shares

				two or more alternative operators are present) 2) Other, non competitive trunk segments		separation and transparency		and network duplication the Commission did, however, not contest the decision.
Switzer-land	-	Swisscom	Leased lines ("trunk" segments, where trunk corresponds here to the a competitive backbone segment of the leased line market)	1) Lines between communes where more than 3 operators are present (25 Communes in 2009 and 41 Communes in 2010) 2) Other leased lines ("terminating" segments)	-	1) No regulation 2) Access, non-discrimination, cost-orientation and transparency	Adopted	This decision is in force. Not being part of the EU framework, the Swiss NRA did not need to notify the EC. If it would have had to, in light of the other cases, the decision would probably have been vetoed for unstable market borders.
UK	UK/2010 /1123 UK/2007 /0733	BT	Wholesale broadband access	1) MDF areas where the incumbent is the only operator present , 2) MDF areas where two or more alternative operators are present (or three when BTs market share is greater than 50%) and 3) Areas where in addition four or more alternative operators are present (or three when BTs market share is lower than 50%	-	1) Access, non-discrimination, cost orientation, accounting separation and transparency as well as an additional strict form of price control (RPI-X). 2) Access, non-discrimination, cost orientation, cost orientation, accounting separation and transparency 3) None	Adopted	The EC reminded the NRA that the sole criterion of the number of operators is not sufficient for geographic market segmentation, but that homogeneity has to be ensured checking for possible geographic variations in market shares and pricing. The EC invited the NRA in particular to provide additional structural and behavioural evidence. It did, however, not veto this decision.
UK	UK/2013 /1428 UK/2008 /0747-0749	BT	Terminating segments of leased lines 8> Mbps with tradition interface leased lines	1) WECLA: Areas with two or more alternative competitors with own infrastructure and low market shares of the incumbent 2) Rest of the country	-	1) None 2) Access, non-discrimination, price control (RPI+X), accounting separation and transparency (for bandwidth at 622 Mbps no remedies are imposed)	Adopted	The EC has cleared this proposal and it was subsequently adopted.

Geographic Segmentation of remedies

Austria	AT/2013 /1475 AT/2007 /0757	Telekom Austria	Wholesale broadband access	1) MDF areas with two or more alternative operators present, incumbent market share below 50% and serving more than 2'500 households 2) other areas	-	1) Accounting separation 2) Access, non-discrimination, price control (retail minus), accounting separation and transparency	Adopted but rejected by national court	The EC had signalled to veto a first proposal of the NRA to introduce geographic markets in 2008. The NRA had then adapted its proposal to define a national wholesale broadband access market and proposed to withdraw most remedies in more competitive segments of the market. The EC had accepted this proposal. It was, however, rejected by the Austrian Administrative Court 2008 leading to an implementation of regulation without geographical differentiation. In the recent fourth round of market analysis (2013) the NRA again proposes a national market, this time

								with nationally uniform light remedies (retail minus price control). But no geographical differentiation of remedies is proposed. A new final decision is still pending.
Germany	DE/2010/1116	Deutsche Telekom	Wholesale broadband access	National	-	Access, non-discrimination, accounting separation and transparency	Adopted	While the NRA had analysed a possible submarket, national pricing strategies of the incumbent indicated a national market. The Commission agreed that there is no conclusive evidence for a geographically differentiated regulation. The decision was then adopted.
Italy	IT/2011/1230	Telecom Italia	Wholesale broadband access	National	1) Infrastructure competition 2) No infrastructure competition (the definition of areas under infrastructure competition is still pending)	1) Access, non-discrimination, cost-orientation (however a particular methodology leading to higher prices), accounting separation and transparency 2) access, non-discrimination, cost-orientation, accounting separation and transparency	Adopted (partially)	The market has been defined nationally. A concrete proposal on the geographical extent of the segmentation of remedies is still pending.
Netherlands	NL/2009/0868	KPN/Reggefiber	Wholesale (physical) network infrastructure access	National	National, but fibre LLU access prices are geographically segmented according to capital requirements (14 areas in 2013).	Access, non-discrimination, transparency and price control. For fibre: Max. Internal rate of return (IRR) allowed up to risk adjusted WACC + risk premium 3.5%. If exceeded price caps are reduced. Local fibre LLU access price caps currently range from 16-26€/month. There is also a cap for a national tariff of 18€	Adopted	The EC has accepted the Dutch regulation proposal.
Poland	PL/2011/1184	TPSA	Wholesale broadband access	National (earlier proposal : 11 cities, rest of the country)	1) Four largest cities 2) Rest of the country	1) Access and non-discrimination 2) Access, non-discrimination, cost-orientation, accounting separation and transparency (earlier proposal in 2011: no regulation in 11 cities, cost regulation in the rest of the country)	Withdrawn	Both decisions have been withdrawn, meaning that currently national cost-based regulation is still in place.
Spain	ES/2008/0805	Telefonica	Wholesale broadband access	National	1) MDF areas where Cable and two LLU operators are present and the incumbent has less than 50% market share 2) Other MDF areas	1) Access and non-discrimination 2) Access, non-discrimination, cost-orientation, accounting separation and transparency	Withdrawn	While BEREC had supported the NRAs view on both a national market and the possibility of geographic remedies in this case, the EC had asked the Spanish NRA to withdraw the proposal for insufficient evidence.

2.3. Review of Literature

As described above the subject of geographic segmentation of regulation is receiving increasing attention of regulators as the mass market roll-out of new access infrastructures by the incumbent, but also new entrants at local scale, are increasingly requested by the public and taking place. A popular example described in regulatory practice section is the UK WBA market, where the regulator has first introduced geographic differentiation of regulation by essentially adopting full deregulation in areas where four or more alternative infrastructures are present and imposing differentiated regulatory remedies in areas where only the incumbent is present and in areas where two or more alternative infrastructures are present.

Some academic articles analyse the geographical impact of geographically uniform access prices (Lestage & Flacher (2010) or Flacher & Jennequin (2012)). To date, however, a comprehensive theoretical analysis of geographically segmented access regulation has been undertaken only by Bourreau, Cambini and Hoernig (2012b)[30]. In addition, De Matos & Ferreira (2011) analyse similar effects. In this section this literature will be summarized. An overview is presented in Table 8. The detailed effects of the different regulatory options according to the literature are described in the next section.

In Bourreau, Cambini and Hoernig (2012b), in a Greenfield setting two potential vertically integrated incumbent firms locally roll out own equivalent infrastructure with increasing fixed costs in more rural areas and with identical cost functions. Both operators can choose in which areas they will deploy own infrastructure and decide on the level of their investments, but they are supposed to start roll-out in densest areas first and roll out subsequently in ever less dense areas. While one operator can roll out in more areas than the other the possibility that operators deploy alone in different areas is not given.
In a static game in a first stage a regulator is setting the regulated wholesale access charges in all areas. In a second stage the two firms simultaneously and non-cooperatively set their investment levels. Then, a possible downstream entrant (and an incumbent in areas where only the other incumbent is present) decide whether to enter or not considering the access charge. The entrant chooses randomly an operator for access in case two incumbents are present. Finally, in a fourth stage all retail operators compete with horizontally differentiated broadband products for final broadband customers by setting possibly also geographically differentiated retail prices. The model uses quasi-linear preferences following Shubik and Levitan (1980) and an exponential investment cost function for the market model. Using this framework the effects of a variety of possible geographic regulation instruments are analysed. In particular the authors describe the effects of geographically differentiated access price regulation in areas with different cost levels and/or competitive conditions and geographically differentiated remedies.

Similarly, in the absence of legacy networks and assuming a fibre Greenfield market, in an endogenous entry setting, De Matos & Ferreira (2011) perform a market simulation with Cournot differentiated goods retail competition. It is assumed that two areas exist, one with low deployment cost and one with high deployment cost such to contemporarily exclude the possibility of infrastructure competition. In the first stage integrated and downstream operators decide in which markets to enter and in the second stage they compete on the retail market for end customers. The paper simulates the resulting geographic market structure and welfare.

While there are to date no other articles taking geographic regulation explicitly into account, some look at the converse problem: the impact of uniform regulation on geographic coverage considering geographic differences in cost levels. Lestage & Flacher (2010) in a similar static stage game as Bourreau, Cambini, et al. (2012b) assume Bertrand retail competition with vertically differentiated

[30] Pereira & Ferreira (2011) also consider geographic access prices. As the detailed functions of their algorithm is, however, not disclosed it is difficult to compare their model.

goods. In most of the paper the source of quality is assumed to be generated by the service provided on the infrastructure, i.e. duplication of access infrastructure is not socially valuable[31]. They then analyse the impact of uniform access price regulation on the geographic market structure and welfare.

In a setting with legacy technology and geographically uniform prices Flacher & Jennequin (2012) show that maximum coverage is reached without regulation but that this is not optimal. With one potential vertically integrated fibre incumbent and a potential downstream entrant as well as Cournot retail competition with vertically and horizontally differentiated goods it is shown that the social optimum is achieved in case the regulator sets not only access prices but also a coverage requirement[32].

Regarding the effects of regulation, the details of the imposed regulatory instruments matter. In European regulatory practice the debate on options to geographically fully deregulate or impose lighter sets of remedies is intense as the review of regulatory cases shows. On the other hand in academic research the analysis of welfare effects of geographically segmented regulated access prices or the problems implied by uniform pricing have not yet received much attention. In the next section the detailed findings of the existing papers with respect to the different regulatory options will be reviewed and put into perspective. The literature is summarized in Table 8 in the annex.

2.4. Review of regulatory options and effects

The different regulatory options to approach geographical access regulation identified by the literature include geographically uniform access regulation as well as competition and/or cost-based geographical segmentation of remedies and prices. Uniform access regulation is a regulation which does not foresee any geographic segmentation. Such a regulation may include any of the regulatory access remedies (access, non-discrimination, transparency, cost-orientation, price control) or none (full deregulation). In case price control is imposed, prices under uniform access regulation do not vary across areas. On the other hand geographical segmentation of regulation is a type of regulation where the detailed regulatory instruments may imply geographically different regulatory conditions. This includes the imposition of different regulatory access remedies in different areas, the imposition of access prices which vary geographically based on the level of competition and/or the required investment cost in a given area and full deregulation of some areas. The detailed effects of different geographic regulatory policy options in light of the literature under consideration are analysed in this section.

1) Uniform access regulation

Uniform access regulation describes settings where there is no geographic segmentation of regulation of any kind. Nevertheless, uniform regulation can have geographic effects on the market. Uniform regulation analysed in the reviewed literature include: full deregulation (free market), cost-based access prices and (any other) uniform access price regulation (e.g. maximising static and dynamic welfare). A particular form of uniform conditions in the access market is given by the case where no access products are available.

i) Uniform access pricing

Under **uniform above-cost access pricing** an access charge above marginal cost is set at the same level in all areas, independently of the level of competition or investment cost in these areas. This is a common case as current regulatory practice in Europe implies that remedies do not necessarily need

[31] The authors provide, however, an alternative specification where the source of quality is supposed to be driven by the underlying infrastructure. In this case firm B accessing a high quality infrastructure A is able to replicate its high quality services. With a possible own lower quality infrastructure this is not possible.
[32] Technically this would correspond to a beauty contest including minimum coverage requirements.

to be differentiated geographically even if competitive differences are present. It should be noted that long run incremental cost (LRIC) price regulation is also considered to be an above cost access price regulation as it applies a positive rent. Bourreau, Cambini and Hoernig (2012b) show that setting a high uniform access charge means that investment incentives increase both the extent of single infrastructure areas (SIAs) and of duplicate infrastructure areas (DIAs). The typical trade-off between maximising per area welfare of connected areas applying low access prices and increasing coverage to generate additional area welfare in marginal areas applying high access prices arises. It should be noted that this analysis assumes Greenfield investments and therefore the absence of a legacy network. This allows to abstract from migration effects which would in the context of this model likely lead to an excessive level of complexity.

Independently of how investment cost is specified the authors show with their market model that the social benefits from investing in duplication in a marginal area in case of uniform prices are negative. A regulator would therefore in this setting wish to decrease the investment incentives for duplication and therefore the extent of the DIAs with respect to the extent of SIAs, the reason being essentially the duplication of fixed costs in case of duopoly[33]. This can only be done by decreasing the prices in DIA areas relatively to SIA areas. Any uniform pricing (including cost-based pricing described below) is therefore never optimal and higher welfare can be achieved with geographically segmented regulation according to competition.

Lestage & Flacher (2010) show in a substantially similar game-theoretic setting as Bourreau, Cambini and Hoernig (2012b) that, when investment costs increase towards rural areas and two potential fibre incumbents - having an outside option with "traditional" low-quality technology - decide on investments, imposing (uniform) regulated access prices limits the area of total coverage and retail prices is reduced when compared to the free market. On the other hand, high differentiation of retail services can increase coverage. In addition, the authors show that access regulation limits the areas where both operators roll out as in Bourreau, Cambini and Hoernig (2012b). Subsequently it is shown that there are areas between DIAs and where no operator rolls out, where one operator rolls out in equilibrium (SIAs); but that for a subset of these areas there are two equilibria[34], where it is not clear which operator would invest and it is then uncertain whether there will be investment at all or not. This zone of uncertainty would only disappear in case the quality advantage between the firms is small. In addition, this zone is supposed to be moving towards more dense areas when the access price falls.

Also, Avenali et al (2010), while not directly modelling geographic effects, expect that geographically de-averaged access prices (above-cost in urban areas and at cost in rural areas) would raise welfare as this would induce more efficient investment in high density areas and low-density areas.

Cost-based access regulation is a particular case of uniform pricing as it would imply the uniform setting of prices at (nationally averaged) marginal costs. Fixed investment costs in the industry are typically very high (and varying across regions) and marginal costs are typically very low and do not differ substantially across regions. It can therefore be expected that a geographically differentiated cost-based access pricing (access prices per area set at marginal cost per area) would be equivalent to a uniform implementation. In Bourreau, Cambini and Hoernig (2012b), uniform cost-based access charges would reduce total coverage with respect to an unregulated setting. The trade-off between static and dynamic welfare does not arise here as SIA and DIA prices are set at the same level, implying that no additional profits can possibly be generated by an operator by investing in duplication. The duplicated infrastructure would have to be resold at marginal cost at wholesale level generating no additional potential wholesale profits while the potentially investing operator would already have access to the infrastructure at minimal possible cost from its rival to generate the same retail profits as without investment. Such regulation would be optimal only in cases where duplication is not feasible

[33] In case of high access charges and a high level of service differentiation further incentives for duplication would be necessary.

[34] Such areas are only present when the exogenous quality advantage of firm A over B is insufficient

(i.e. investment cost in a marginal area is very high). When duplication is feasible instead and cost-based regulation prevents it from taking place, this would correspond to a loss of welfare. Uniform cost-based access regulation is therefore not optimal. While duplication is not possible in this setting, it is instead with uniform prices above-costs as this starts to create wholesale profits for a duplicate infrastructure and lower opportunity costs for the second incumbent to invest. For this reason welfare would tend to be lower with cost-based uniform access prices than with uniform above-cost prices.

Lestage & Flacher (2010) similarly show that uniform cost-based pricing is not optimal as it is not taking into account the correct investment incentives and is reducing total and duplicate coverage even more than under uniform above cost access pricing. They also show that, when tastes are sufficiently heterogeneous, an optimal regulated access charge would depend on: the lowest investment cost across areas (or in other words the maximum population density), the lowest and highest quality valuations of consumers and quality (where the quality of the traditional copper network is assumed to be zero and the quality of new infrastructures strictly positive). Moreover, it is shown that the optimal access charge increases in the lowest investment cost across areas (and decreases in the highest population density).

ii) Other forms of uniform regulation

There exist also other forms of uniform regulation, namely full deregulation and the case where wholesale access is not available (for example for technical reasons). In the case when access is not available the firms can make retail offers only where they have their own infrastructure. Firms then roll out both up to a point where per area duopoly profits become lower than the per area investment cost. Then one of the firms may roll out up to a point where per area monopoly profits become lower than the per area investment cost. While firms are symmetric ex-ante this leads still to differences ex-post, as in some regions only monopoly profits can ensure coverage and hence only one provider is present. Also, the case of full deregulation (when access is available) is a type of geographically uniform regulation. However, differently to the above cases it may imply geographically segmented commercial wholesale access prices. The market model of Bourreau, Cambini and Hoernig (2012b) shows that when services are sufficiently differentiated, downstream entry is beneficial to the industry due to a demand expansion effect (even though the retail profits of incumbents decline when giving access). In particular they show that in this case foreclosure (prices set to exclude the entrant) can never happen in SIA areas as giving access can increase overall industry profits with differentiated goods and the incumbent is able to extract such profit. In DIA areas, instead, foreclosure is possible only when there is low differentiation at the retail level. In such case the regulator could impose an access-only obligation preventing foreclosure, which might be welfare enhancing as will be also shown below. Finally, a regulator would only set regulated prices below the potential commercial wholesale prices.

Lestage & Flacher (2010) show with their model in a free, fully deregulated market, when considering two firms A and B, of which A always provides the higher quality service[35], that where firm A has rolled out infrastructure as a monopoly, it will not provide wholesale access to B, while a monopolist B would set a wholesale price such as to allow the provision of (higher quality) services by A. This, as excluding product A from the market would reduce the total profits possibly extracted from the market. Regulatory intervention is therefore necessary in monopoly areas to avoid foreclosure in SIA areas.
A different case is given when considering that the quality is driven by the infrastructure instead of services. Then, there is no more reason for foreclosure, as B can also provide high quality services when accessing infrastructure A. In this case, however, duplication is not desirable as infrastructure investment by B would only lead to a provision of the market with lower quality goods.

[35] Both quality A and B are considered to be preferred to a “traditional” outside quality which is provided in case of no investment.

From a practical point of view it might be interesting to consider company statements during the consultation of the BEREC Common Position on Geographic Aspects of Market analysis in 2008. Some local alternative infrastructure providers seemed to have a critical view on geographic deregulation leading to de-averaging of wholesale prices[36]. In the current situation the incumbent needs to charge a uniform wholesale access price (at a national price cap) and cannot offer lower prices as this would imply charging lower prices in rural areas as well. The price is in urban area therefore in practice also a price floor. These regulated prices could potentially be very high when compared to local urban DIA investment costs and deregulation in presence of any form of competition may potentially lower them decreasing the value of all infrastructures in the market especially of alternative investors[37].

2) Geographical segmentation of regulation

Geographical segmentation of regulation describes general settings where regulated conditions vary across areas. Regulatory instruments that can be segmented include regulated access prices according to competitive conditions and/or investment cost, as well as geographic segmentation of remedies in general - as for instance cost-based regulation in rural areas and "lighter" forms of regulation such as access-only obligations in urban areas.

i) Geographical segmentation of access prices according to competitive conditions and investment costs

Bourreau, Cambini and Hoernig (2012b) describe pure geographical segmentation as optimal regulated access charges which are set in areas of different population density and therefore investment costs separately and which are differing in addition according to the competitive conditions in the area (SIA or DIA). No European NRA has to date chosen such a highly differentiated model with varying regulated access prices also according to the level of investment cost and there is currently no significant public debate. Also, No European NRA has to date implemented such a SIA/DIA distinction purely (rule of thumb) as it is assumed that the number of operators is not the only driver of competition. Furthermore, no NRA has proposed differing directly regulated access prices based on a single methodology according to competition. As has been shown the Dutch NRA offers, however, regionally segmented regulated NGA access prices.
While the authors indicate that such a type of regulation would offer maximum flexibility to the regulator and therefore lead to maximal welfare they also assume that it would be complicated to implement in practice as in-depth knowledge about local retail demand and cost structures as well as competitive retail market interaction would be necessary. Optimal regulated per area access prices would maximize per area welfare while ensuring that investment in the areas is viable (both for the SIA and the DIA case defining separate prices). As welfare in SIA areas decreases with the access charge, the SIA access charge is set just high enough to make an incumbent operator break even with its total area profits when investing. If its retail profits would be higher than the investment cost, the optimal access charge would be zero. The socially optimal extent of the SIA region is shown to correspond to the SIA region which would also develop when the operator could set monopoly access

[36] http://berec.europa.eu/doc/publications/consult_erg_geo_markets_2008/fastweb.pdf
[37] Also, some regulators have imposed some form of **uniformity of retail prices.** Valletti et al. (2002) show that in the context of universal service a uniform retail pricing obligation is creating strategic links between areas that would otherwise remain unrelated. The paper shows that uniform retail pricing leads to lower equilibrium coverage of both incumbent and entrants. The effect depends also on the regulatory context of other universal service policies such as price caps or coverage constraints. For instance, in presence of a minimum coverage obligation the effect may be compensated, but the measure would lead to an increase of (uniform) prices. Anton et al. (1999), Choné et al. (2000, 2002) and Foros & Kind (2003) find similar effects. Hoernig (2006) arrives at similar results by stating that a uniform price imposed on the incumbent would reduce its coverage as it seeks to avoid duopoly entry. If imposed on entrants it reduces the incentive for duopoly entry and may lead to independent regional monopolies.

charges freely as it would extend its network as long as this is profitably possible too (i.e. the last covered SIA region would optimally have regulated access prices at monopoly level).
In DIAs on the other hand duplicative investment incentives exist as long as the investment cost in duplication is lower than the difference between expected DIA and SIA profits (for the incumbent, which does not provide access). Given the expected demand and cost functions and the SIA access charges, the socially optimal wholesale price can be calculated. If the incumbents DIA retail profits with respect to its SIA profits (when not being the access provider) are sufficiently high, the DIA access price can be set to zero, maximising static welfare while safeguarding investment incentives. A particular case is given when the SIA access charges are set at marginal cost. In this case investment in duplication would incur high opportunity costs in addition to investment costs which could not be compensated by any benefit. In this case, the optimal DIA charge would also be zero and investments in duplication would be unprofitable as no additional wholesale profits or additional retail profits could be generated. Duplication in this case brings no social benefits. In the market model used by the authors it is shown than duplication is optimal in no area when SIA access prices have been chosen optimally per area. Finally, it is shown that cost-based access prices (LRIC) per area are higher than the described optimal SIA prices as they include by design a positive rent (which is incompatible with a zero profit condition), and as it does not take into account retail profits. LRIC is therefore problematic even if it would be applied per area.

De Matos & Ferreira (2011) show in an endogenous entry market simulation with Cournot differentiated goods competition that geographically differentiated wholesale prices (areas are differentiated according to cost/competition) are socially optimal. At the same time, the authors state that in case of regional markets which are not independent implementation of geographic regulation becomes a highly complex task. Interdependencies may be justified by economies of scale and scope and network effects, or as will be shown later, by uniform (retail) pricing obligations. In particular, deregulation of the more competitive areas may trigger unexpected consequences such as a change to a monopoly situation in an adjacent market. They also show that therefore a deregulation of a subset of regions based on an "N-plus" rule of thumb (Xavier, 2010)[38] is not sufficient to guarantee that the introduction of geographic remedies is welfare enhancing.
The problem of interdependencies raised by De Matos & Ferreira (2011) is largely avoided by Bourreau, Cambini and Hoernig (2012b) by setting independent per area cost structures and by not considering network effects.

In Bourreau, Cambini and Hoernig (2012b) with duplication-based regulated access prices instead, different access charges in SIAs and DIAs are set, but the charges does not vary between areas with different investment cost requirements (or between providers). No European NRA has to date implemented such an approach purely (rule of thumb) as it is assumed that the number of operators is not the only driver of competition. Furthermore, no NRA has proposed differing directly regulated access prices based on a single methodology according to competition. Such an approach is less flexible than pure geographic remedies and therefore implies lower social surplus as optimally charges should vary also across cost clusters as has been shown above. Duplication-based regulated access prices have the advantage, however, to be more transparent and easier to implement for NRAs.

As before in Bourreau, Cambini and Hoernig (2012b) show that the effect of an increase of both SIA and DIA access charges on welfare is ambiguous. An increase in SIA access charges leads to a loss of static efficiency in the concerned areas, an increase in coverage and possible welfare gains from transforming SIA in DIA areas via opportunity costs. However, this last effect is positive only if increased competition outweighs the costs of additional investment. On the other hand, an increase in DIA charges would decrease static efficiency in DIA areas while also having an effect on the transformation of SIAs in DIAs via potential wholesale revenues. This last effect again is positive only

[38] Such are rule would foresee that the threshold number of firms below which regulatory remedies remain.

if increased competition outweighs the costs of additional investment. If this is not the case, then the regulator should set the DIA access charge to zero in order to limit duplication.

One feature of this analytical framework is that optimality conditions are such that there is a positive correlation between the socially optimal SIA and DIA access charge. Setting a very low SIA access price (increasing opportunity cost, lowering DIA investment incentives) would imply also lowering DIA access charges. This as low SIA access prices imply an already high per area welfare, meaning that the net benefit of extending the DIA area decreases substantially and that the regulator should reduce its incentives to invest in duplication by lowering also DIA access prices.

In equilibrium, finally, using the market model the authors find that optimal regulated SIA access charges are set above cost. DIA access charges, however, should be set above cost only in case of sufficient differentiation. Otherwise, the social benefit of duplication is insufficient to cover investment costs. Also, the market model predicts that optimal access charges in SIA regions are to be set higher than in DIA areas in order to provide investment incentives but keeping static welfare losses in DIA as low as possible. Also it is shown also in this case that (SIA) LRIC would not be optimal and tend to lead to too low access charges reducing welfare.

ii) Geographical segmentation of remedies

The European regulatory framework provides the possibility to impose a lighter set of access remedies in more competitive areas. From a legal point of view, this can be the consequence of a national market definition (with regional remedies) but theoretically also of geographic segmentation of markets. Popular examples of geographic differentiation of remedies may be the cited cases of the Spanish and Polish WBA markets where the NRAs proposed to lift cost-orientation in more competitive areas, imposing essentially only an access obligation to prevent foreclosure.

Bourreau, Cambini and Hoernig (2012b) assume that the regulator could maintain (welfare maximising) price regulation in SIA areas while imposing only an access obligation in DIA areas. Typically in this case wholesale access prices in DIA areas would then be freely negotiated. If the entrant feels, however, that the access price is exceeding a level that it allows to enter the market sustainably it may under the access obligation ask the regulator to impose a price based on a dispute resolution procedure. The regulator would then impose a DIA access charge lower than the foreclosing price and then set the corresponding optimal SIA access charge. With this procedure the incumbents would compete freely on the access price, provided it falls below the dispute settlement price.

Adjusting slightly the game setting (Bertrand competition with homogenous goods at wholesale level, where the entrant chooses the more convenient offer) Bourreau, Hombert, Pouyet and Schutz (2011) show that in an unregulated environment the softening effect makes the rival not providing wholesale access to a more aggressive retail competitor (setting lower prices) leading to multiple equilibria. The new wholesale profits have to be traded-off against possible losses of retail profits due to increased retail competition and demand expansion effects due to differentiation. This means that it is not always optimal to provide access, that undercutting at wholesale level is not always optimal and that the usual Bertrand result at wholesale level does generally not hold. It should be noted, however, that the softening effect disappears in case of full differentiation (i.e. independent goods) as then softening competition with relatively higher retail prices would not lead to higher wholesale revenues. When the softening effect is present though, Bourreau, Cambini and Hoernig (2012b) show that a low access charge implies higher profits for an access provider than for the rival which is not providing access. When the access charge is high enough, in turn, the contrary holds. This means that in a DIA setting there may be an access price below which giving access is more profitable than not giving access. Undercutting prices at wholesale level is therefore always an individual best response triggering a race to the bottom for providing wholesale services between the incumbents leading to marginal cost prices for both operators. In the market model used by the authors this equilibrium is unique when services

are sufficiently differentiated and the expected dispute settlement prices are sufficiently low. If instead services are sufficiently homogeneous, the access prices of both operators will be set at the second equilibrium such that profits of providing or not providing access are equalised (and the access charge is above marginal costs). In this case no operator would again have an incentive to deviate. Finally, instead if the dispute settlement price is set sufficiently high, both incumbents may prefer not to make feasible offers (third equilibrium) but expect the regulator to set access prices hoping it will subsequently not be chosen for access provision. This is in particular the case when the expected dispute settlement price is higher than the access price that equalises anticipated duopoly profits with the profits generated ex-post when providing access in the DIA area at the profit maximising access prices (subject to the condition that the entrant is not foreclosed).

Finally, with both sufficient product homogeneity and a low enough dispute settlement price one firm offers a monopoly access price, while the other makes no feasible offer. An anticipated low dispute settlement price can therefore unexpectedly lead to monopoly prices.

Using the market model the authors then show how socially optimal prices could be enforced. If the socially optimal access charge is below the access price that equalises profits of providing and not providing access, the race to the bottom of DIA access prices must be stopped as strong competition has a too negative effect on investment incentives lowering welfare. The race to the bottom can only be stopped by setting a price floor at the socially optimal access price. If instead the socially optimal price is higher, it can in many cases be enforced by setting the dispute settlement price at the socially optimal price. In case, however, that the socially optimal access price is lower than the access price that equalises anticipated ex ante duopoly profits with the profits generated ex post when providing access in the DIA area at profit maximising access price (subject to the condition that the entrant is not foreclosed), this price cannot be achieved in equilibrium without further instruments.

Geographically segmented remedies can therefore lead to a socially optimal outcome. Whether this outcome is achieved or not depend on the details of how such regulation is implemented (especially for instance whether floors and caps are imposed). Overall this type of regulation seems to have similar informational requirements to the other approaches proposed to maximise local welfare.

2.5. Conclusion

In the preceding sections the effects of geographically segmented regulation have been analysed in detail. Simplifying, the typical welfare effects of geographic regulation options that can be inferred by the existing literature are represented in Table 2.

	Static welfare (competition)	**Dynamic efficiency (investment incentives in SIA and DIA)**	**Total welfare**
Geographically segmented regulated welfare-maximising access prices according to investment cost and competition	Optimal	Optimal	**Optimal** (even if in the market model this implies no duplication)
Geographically segmented LRIC prices according to investment cost and competition (SIA)	Suboptimal	Suboptimal	**Suboptimal** (but better than uniform LRIC[39])
Geographically segmented remedies	Can be optimal	Can be optimal	**Can be optimal** (depends on mechanism)

[39] This is an interpretation and not demonstrated in the relevant articles.

Uniform/geographically segmented cost-oriented access price regulation (at marginal cost)	Suboptimal (but optimal in already covered areas)	Suboptimal	**Suboptimal**
Uniform above cost access price regulation (including LRIC)	Suboptimal	Suboptimal	**Suboptimal** (but better than marginal cost-oriented)
Uniform full deregulation	Suboptimal	Suboptimal	**Suboptimal**
Geographically segmented full deregulation	Suboptimal	Suboptimal	**Suboptimal**
Geographically segmented prices according to competition only	Suboptimal	Suboptimal	**Suboptimal**
Geographically segmented LRIC prices according to competition only	Suboptimal	Suboptimal	**Suboptimal**

Table 2 - Welfare effects of different geographic regulation tools

In light of the reviewed literature summarized above and the practical cases considered it is possible to draw conclusions for all identified regulatory options of geographically segmented regulation.

Geographic full deregulation

As has been shown, various NRAs have proceeded to full deregulation of some areas of the country (Austria, Finland, Portugal, Switzerland and UK). Different authors have argued that geographic (full) deregulation may lead to foreclosure. While Lestage & Flacher (2010) argue that this is possible even in SIA areas in case there is substantial quality advantage on the potential second incumbent, Bourreau, Cambini and Hoernig (2012b) argue that this possibility may be given, but only in DIA areas and only in case of low (horizontal) differentiation. Regulators should therefore use this tool with caution.

Geographical segmentation of access prices

In regulatory practice in Europe uniform above-cost access price regulation (e.g. LRIC) is still a commonly applied remedy (e.g. WBA in Sweden). The theoretical literature shows clearly that uniform access price regulation is no longer optimal, in particular in case of a roll-out of new infrastructures under geographically varying costs leading to geographically differentiated market structures. In particular local investment incentives are not sufficiently taken into account. Instead, Bourreau, Cambini and Hoernig (2012b) show that welfare optimizing prices would vary according to investment cost levels and competition and should be largely set be the regulator. No European NRA has to date, however, used a coherent geographically differentiated access price model according to the level of investment cost and competition. A first step towards such an optimal solution is however made by the Dutch regulation. Geographically segmented fibre access prices according to investment cost (even though not according to competition) were defined resulting in access prices ranging from 16 to 26€ per month per unbundled fibre line depending on the cost cluster. Surprisingly the decision has to date received few attention regarding this particular aspect by other regulators in Europe, BEREC or the European Commission. It should be noted that such a regulation can be close to a solution which also differentiates prices according to competitive conditions as it is likely that in the urban areas where Reggefiber deploys such conditions may be rather homogeneous (cable competition). The question is then rather whether the price imposed by the authority is also welfare optimal.

Also regarding segmentation of regulation according to competitive conditions no pure SIA/DIA distinction has been adopted yet, as the European Commission judges such “rules of thumb” to insufficiently represent the level of competition. In light of the above regulators and researchers should consider increasing their efforts to evaluate possibilities to approach current access price regulation to a feasible form of socially optimal geographically segmented access price regulation. The benefits in case of success would be important. Today, for instance, higher uniform access charges would lead to

both higher total coverage as well as more duplication. Regulators are therefore currently facing a trade-off on whether to increase such access charges to incentivise investment (e.g. with risk premia on top of cost-based regulated prices) or not. In such a situation regulatory action may well depend on the subjective preferences of regulators, or in other words on how much competition they are ready to sacrifice in order to induce investments in more rural areas. A regulator could for example also decide to only target static welfare (competition), by imposing marginal cost access prices. These preferences may be an additional driver of the state of broadband networks in European countries today, representing the result of past investments decisions (seeFigure 1 – Actual xDSL Speeds in Europe (Source: Samknows, March 2012) Figure 1). When adopting an optimal regulatory regime of setting welfare-maximising SIA and DIA charges in all areas (such that SIA and DIA investment is viable and static welfare maximised), regulators would need to take into account the degree of product differentiation at retail level, investment costs and retail competition. Imposing optimal prices would lead to a total coverage which is maximal and to maximum static welfare per area (lower prices would mean that entry would not have been viable and welfare could not have been generated in the first place). When a geographically segmented access pricing approach could be adopted the regulators dilemma of trading-off static and dynamic efficiency would therefore be solved.

Reaching this objective seems a complex task and may require a long time for the development of appropriate regulatory instruments. It should be considered whether current regulation would not have simple options to make small steps in this direction.

In the framework of Bourreau, Cambini and Hoernig (2012b) it is shown that a local SIA LRIC price is not optimal as it includes a positive rent (and also the incumbents retail profits are not considered) and therefore it is higher than the price necessary to make local investment viable. Regulators, however, to date essentially use uniform LRIC prices. While Bourreau, Cambini and Hoernig (2012b) do not explicitly show this, their results can be interpreted such that local LRIC prices are leading to higher welfare than uniform LRIC. This is the case as in urban areas a local LRIC price would already exceed both marginal cost as well as a price that would make the investment viable (as it includes a positive rent. In case of uniform SIA LRIC prices the prices applied in urban areas will usually be much higher than local LRIC prices as a national cost base is considered. Therefore in urban areas uniform SIA LRIC prices would be such that welfare could be increased by decreasing the SIA access price towards local LRIC as the investment would continue to be viable and static efficiency would be enhanced. Conversely, in rural areas a uniform SIA LRIC price would likely exceed marginal costs but may in many cases be lower than the price that would make a SIA investment viable. In such areas an increase in the price could trigger investment and lead to higher welfare. In other rural areas, especially where investments have already taken place an increase of the charge towards local LRIC might, however, have the only consequence to reduce static efficiency. Overall, however, a scheme, which for instance would approach regulated price in urban areas to local LRIC while leaving the access charges in rural areas unchanged would be invariably welfare enhancing. Interesting this is largely corresponding to the practical implementation of the Dutch regulation, which foresees local tariffs in parallel to national tariffs. Regarding implementation the circumstance than in the Netherlands an operator can only choose one of the two tariff models may, however, distort this result and potentially lead nevertheless to welfare losses in rural areas. When compared to theory the regulator would then still need to develop a potential regulatory strategy for DIA cases. Overall, however, the Dutch approach seems to be largely supported by the literature.

Geographical segmentation of remedies

Recently introduced risk premia show that there is increasing awareness at the political level that investment incentives may be currently insufficient. However, a clear link of the extent of the premia to the dynamics of optimal local investment incentives is to date lacking and a significant debate on (partial) de-averaging of regulated wholesale access prices according to cost clusters seems still not to be taking place. Since 2008, however, several regulation proposals and decisions of member states

not only of geographic full deregulation (as described above) but also of geographic segmentation of remedies have been observed leading in their result to (to some extent) geographically differentiated wholesale prices. The latter approach consists in practice mostly in imposing an access-only obligations in urban areas implying some form of retail-minus regulation, avoiding foreclosure of the entrant, and standard cost-based regulation in rural areas (e.g. Spain, Poland).

Given the informational requirements on setting welfare-optimizing geographically segmented access prices, Bourreau, Cambini, et al. (2012b) analysed whether a set of geographically segmented remedies can also achieve maximal welfare. In practice they proposed to largely deregulate DIA prices defining a dispute settlement procedure, which would prevent foreclosure of access seekers in case no viable access price results on the free market (corresponding to an access-only obligation). Foreseeing the market outcome the regulator would then need to set a welfare maximising SIA charges as well.

This type of deregulation may, however, have unwanted consequences. For instance (for sufficiently heterogeneous products) in DIA areas a race to the bottom for wholesale access prices may result in equilibrium. But too strong competition on the wholesale level may not be socially optimal as at some point investment incentives are reduced in a way to reduce overall welfare. Hence, there may be cases where a DIA access price of zero may not be socially optimal and the regulator should step in to prevent too strong wholesale competition setting a price floor at the socially optimal DIA price. As currently regulators still focus on maximising competition, this proposal is in contrast with current regulation. Furthermore, when the socially optimal access price instead is high (and above the DIA equilibrium price) it can be achieved in some cases by setting the dispute settlement price equal to the socially optimal price. In other cases also further instruments would be necessary. Overall it seems that there would be few cases when the socially optimal charge would be reached spontaneously on the market. While the regulator could add safeguards to ensure socially optimal prices (such as a price floor and cap) this would imply similar informational requirements as with geographic segmentation of regulated access prices. Regarding price floors it should be noted that to date no major practical case has received attention where access prices have been set by a regulated firm below the regulated dispute settlement prices. Even though this example seems not encouraging, regulators and researchers should try to further evaluate feasible dispute settlement processes able to lead to socially optimal prices.

To conclude, many issues still remain to be explored. Methods to approximate socially optimal SIA and DIA access charges and to implement them should be the focus of future research. Other subjects of interest may include the structural assumptions of the models explaining the effects of geographic regulation. For instance, only static settings are currently analysed and regulatory commitment could be a problem. Also, possible strategic links between areas due to scale and scope economies, network effects or uniform retail price obligations are not sufficiently considered. Moreover, a legacy infrastructure an investment sharing options should be present integrating the migration debate described in the introduction. Also, alternative competition models could be considered as well as endogenous entry in an extended theoretical model. Finally horizontal and vertical differentiation play a key role. The two alternative hypotheses of the source of vertical differentiation (service or infrastructure) in Lestage and Flacher (2010) indicate that researchers and regulators may still need to uncover the driving forces of innovation in the broadband market.

3. NGA Co-investment models

The roll-out of next generation access networks implies the largest investments in telecommunications since the beginning of the 20th century, when the copper telephone access networks were deployed by the state. In the preceding chapter operators were assumed to fully duplicate infrastructure when they would roll-out second NGA network. This is, however, not always necessary as operators can also invest jointly and share investment cost. This chapter will review joint roll-out possibilities and risk sharing agreements in general. In this introductory section, the extent of investment requirement is described and put into perspective.

Elixmann, Ilic, Neumann and Plückebaum (2008) show that single fibre[40] deployment costs are as high as 2'100€ per home connected (Table 3) even in a very urban cluster (Germany). There are, however, countries with substantially lower deployment costs in such areas such as Italy (1'160€). There are different reasons for this as differing construction costs across countries, differing existing duct and aerial cabling and their corresponding access conditions[41] and network topology. In particular, in addition, investment costs for in-house cabling are supposed to be higher in northern than in southern countries.

	Germany	France	Sweden	Portugal	Spain	Italy	Switzerland
FTTH investment cost (homes connected)	2'111€	2'025€	1'333€	1'548€	1'882€	1'160€	1'643€ (2'465 Fr.)[42]
FTTH investment cost (homes passed)	919€	930€	530€	776€	859€	504€	-

Table 3 – Fibre Greenfield deployment costs per home connected and passed, FTTH P2P (source: WIK)

Investment comparisons per home passed follow a similar pattern. Homes connected consider also costs that are incurred to activate a customer's connection which include in-house cabling, customer premises equipment and trunk cards[43]. The investment is in this case, distributed on an expected target market, i.e. 50% of the potential customer base[44] while for passed homes it is by definition distributed on 100%. Consequently, investment cost per home connected is higher than twice the investment cost per home passed. Overall, even in a small and dense country such as Switzerland full national coverage with a single fibre FTTH network would require investments as large as €14,3bn (connected homes)[45]. With 4.5m homes, this corresponds to a national average investment cost per home connected of around 3'200€ [46]. These high costs are again driven by the fact that connections become exponentially more expensive as population density decreases towards rural areas. Ilic, Neumann and Plückebaum (2009) show that in Switzerland in this case the last (very rural) cluster 16

[40] FTTH (P2P)

[41] e.g. in France it is assumed that operators may to some extent use existing infrastructure (sewer systems) reducing Capex costs significantly (increasing Opex though). The case in Italy is similar where ducts, covering about 8% of the population, used by Telecom Italia to deploy a CATV network between 1995 and 1997 (Socrate project) were opened to competition by the Italian Antitrust authority in 2001. Free duct capacity was in the past mainly used by Fastweb. In the case of Switzerland, the model assumes that incumbent overall digging costs are reduced by 20% by the possibility of using existing ducts[41]. In practice it should be noted that an EVU may save even a larger part of these costs as in many cases their duct networks have sufficient space left for a roll-out of an FTTH network.

[42] Ilic, Neumann and Plückebaum (2009) show that in Switzerland the investment per home connected in an urban area (the comparable cluster is cluster cluster 2) is 1'642€ per month. There it is however considered that FTTH would reach a market share of 75% and not 50% as this is more realistic in the Swiss case. Calculating a comparable value deployment costs in Switzerland would be around 2'000€ and therefore comparable to Germany or France. The exchange rate was assumed to be 1.50 Fr./€. When applying a more recent 2013 exchange rate (1.20 Fr./€) deployment costs would be comparably highest with around 2'500€.

[43] In the Swiss case in-house cabling is also included in homes passed.

[44] in Switzerland in the baseline model foresees 75%, the value in the table is adjusted to 50% though

[45] 21,4 Mrd. Fr.

[46] 4'800 Fr.

requires 10 times higher investments per access than the urban cluster 1 (around 1'320€). In the last cost cluster, then, it is shown that subsidies of around 11'000€[47] per home connected would be required to make an investment viable.

3.1. Regulatory principles in Europe

Improvement of competitiveness of the duct market

In this section possible ways to reduce investment costs for any type of investor (single investor or co-investment partner) will be explored. In light of the monumental investment cost described a prominent question in the recent political debate in Europe was if there is anything that can be done to reduce investments required for an NGA and in particular a FTTH roll-out for all operators. The European Commission (2013) has recently published a legislative proposal to reduce the cost of rolling out high speed communication infrastructures in Europe. The initiative concentrates on civil engineering costs (i.e. digging up roads and lay down fibre) as around 80% of deployment costs seem to be associated with it. The European Commission hopes thereby to reduce investment requirements via efficiencies by 20-30%. The adoption by EU Parliament plenary vote is expected in the beginning of 2014.

The European Commission's proposals include the following specific measures:

i) Telecoms operators should have the right to access the physical infrastructures of other network industries (e.g. electricity, water, sewage, transport) to deploy high-speed networks.
ii) Telecoms NRAs should be able to take binding decisions in case of a dispute and act as a single information point dealing with information on infrastructures and permit applications.
iii) All newly-constructed buildings and those that undergo major renovation would be required to be equipped with "high-speed broadband-ready" in-building physical infrastructure.

Essentially this proposal gives telecoms NRAs full control over the duct market. In practice, the draft regulation would firstly require all utility companies (such as electricity, gas, water, sewage, heating and transport) to meet reasonable requests by telecoms companies for access to their physical infrastructure in order to deploy high-speed networks. In the event that there are no legitimate reasons to reject the request (e.g. availability of space, security, interferences), the access seeking operator may request access at fair and non-discriminatory terms, i.e. at conditions and charges to be set (by default) by the telecoms NRA. Moreover, when performing civil works, companies which are partly or fully publicly financed would be required to meet reasonable requests from telecoms companies for coordination of and participation in civil works. Secondly, a set of rules is laid down regarding the access to information about these facilities. The minimum information which operators of such network must provide to a single point of contact operated by the NRA include *i) location, routes and geo-coordinates of the infrastructure, ii) the size, type and current use of the infrastructure and iii) the name of the owner of the infrastructure and a final contact point*. Applications for permits for civil engineering work for telecoms operators will be made over a coordinating single point of contact electronic platform operated by the NRA. Moreover, local authorities are requested to answer any request within six months. Thirdly, all newly-constructed buildings and buildings undergoing major renovation would be required to be equipped with high-speed broadband-ready in-building physical infrastructure. While it is unclear which technologies are included in this definition, it seems reasonable to think that traditional copper in-house wiring is excluded.

It can be expected that in many countries where such measures have not yet been applied, this proposal may lead to additional NGA investments using alternative duct infrastructures. As in many cases, entities operating duct infrastructures (other than telecoms operators) are publicly controlled – often by local authorities - and not necessarily operating in a profit maximizing environment, an access obligation can be reasonable in order to ensure potential entry in the broadband market via alternative

[47] 16'411 Fr.

network ducts. In addition, the proposal aims at increasing transparency and reducing bureaucratic costs. However, even if the potential investment cost reductions indicated by the European Commission are fully realised (20-30%) and single, duplicate and co-invested coverage is increased, the required investments in FTTH will remain very high and a profitable full coverage will remain unfeasible.

NGN co-investments

While the European Commissions' legislative proposal (2013) addresses generic possibilities to reduce operator deployment costs, cooperative investment may reduce investment cost further in case of a roll-out of more than one operator in an area. The most typical case would be in areas where two operators decide to roll-out fully in parallel[48]. With a joint roll-out and mutual access agreements the total investment incurred may be reduced substantially. Such a co-investment agreement, as will be shown, would not necessarily imply less flexibility for the operators or reduce competition.

NGA investment cooperations in Europe have been discussed by the NGA Recommendation of the European Commission which states that *co-investments and risk-sharing mechanisms should be promoted.* Such schemes are also analysed in BEREC (2012a)[49]. It is shown that to date there are few practical examples of co-investments in Europe and even less examples of interventions by regulatory or competition authorities on the conditions of such agreements. Cooperations have been registered only in France, the Netherlands, Portugal and Switzerland and they only account for a small portion of total FTTH deployments in Europe yet. BEREC (2012a) describes that NGA investment cooperations usually foresee two components. On one side the mutual access terms and on the other obligations regarding the roll-out, i.e. which part of the network an operator is responsible to construct and give access to to the other operator. In some cases such agreements are purely financial where one of the partners does not need to roll-out infrastructure or give access to its existing or future infrastructure at all. In case of joint-ventures, which is the strongest form of cooperation, investment costs and profits are shared under some rule and the entity would act independently, but as one single firm.

Both the European Commission (in an earlier draft version of the NGA recommendation[50]) and BEREC are concerned with possible limiting effects of such cooperations on competition. BEREC (2012a) notes that *"whether a market with more than two operators (e.g. three or four) may be compatible with competition depends however on numerous factors and in particular on the level of independence that these operators enjoy, especially within a co-investment agreement. While such a situation has to be assessed in detail in a market analysis or while national authorities may adapt more specific guidelines in this respect it may be said in general that if sufficient independence between the operators is ensured, a market with more than two, i.e. three or more, operators may under optimal circumstances raise low concerns about collusion and the competitive situation"*.

Of the different sharing regimes considered the BEREC report assumes that sale of long term IRUs (indefeasible rights of use) on a fibre in a multifibre network to a competitor may be regarded as largely equivalent for it to controlling a fully independent own network[51]. Similarly to a case where infrastructure is fully duplicated, it is in the current regulatory framework possible that co-investments lead to sufficient competition in the market for wholesale (physical) network infrastructure access to

[48] I.e. in separate duct systems
[49] A detail review can be found in annex 2
[50] The European Commission stated in annex III of the second draft of the NGA recommendation that to create sufficient upstream competition co-investment agreements need to be i) based on multifibre, ii) partners should have strictly cost-oriented access, iii) they must effectively compete downstream and iv) sufficient duct capacity must be installed. Also a sufficient number of access providers would be necessary (three or four). This draft is no longer available on the European Commission homepage.
[51] This view is shared by the EC in the NGA recommendation where it is stated that "multiple fibre lines allow alternative operators each to fully control their own connection up to the end-user. In addition access seekers can obtain full control over fibre lines, without risking discriminatory treatment in case of mandated single fibre unbundling."

justify full deregulation of LLU (copper as well as fibre). Overall, it can be assumed that co-investment schemes may lower duplication costs and increase duopoly coverage, while having potentially negative effects compared to traditional duplication.

Multifibre deployment

Ilic, Neumann and Plückebaum (2009) estimate costs and potential network coverage under different scenarios. Compared to a single fibre network they explain multifibre networks and relevant cost drivers as follows:

- In-house wiring: The higher number of fibres implies the deployment of larger cables (depending on the number of fibres per home, e.g. four) and more splicing work at the building entry point.
- Drop cable deployment: In the drop segment of the access network (i.e. between the distribution and the building entry point) larger cables have to be deployed. Ducts, however, are here dimensioned in the model in a way that they could hold cables both in case of single and multiple fibre lines and there are no additional construction costs involved.
- Distribution point: Contrary to the single fibre case a distribution point where all operators have the possibility to connect drop multifibre lines has to be installed and every participating operator has to conduct splicing work.
- MPoP: In case of handover to the other operator at the more distant local metropolitan point of presence level (MPoP) and not at distribution point level, the network operating partner has to install additional feeder capacity and splice fibres through at the distribution point. This may imply constructing larger feeder ducts. At the MPoP the fibres also have to be connected to the respective optical distribution frames.

The additional costs for an operator to deploy a multifibre networks therefore depend on where the access point (splice closure) for alternative operators is installed. When compared to a single fibre network in the Swiss market Ilic, Neumann and Plückebaum (2009) estimate additional investment necessary for a multifibre network (before any interconnection of alternative operators) at around 12% (cluster 1) decreasing to around 2% (cluster 16) for handover at distribution point level (i.e. multifibre up to the distribution point). In case of handover at MPoP level (i.e. multifibre up to the MPoP) the additional investments required would be of 26% (cluster 1) and 12% (cluster 16). When considering the first six (urban) clusters, overall the multifibre model would imply around 9% higher investments in case of distribution point handover and 18% higher investments in case of MPoP handover. Intuitively, in rural areas the investment share of the drop segment increases (longer lines). As in the drop segment no additional investments for cables in case of multifibre are assumed to be necessary the relative additional investment for multifibre decreases towards rural areas.

What has to be considered also, however, is that once an operator is granted access to the multifibre network, it also has to invest in order to connect to the network. In case of distribution point handover, for instance, the alternative operator would need to duplicate investments to reach the distribution point. The estimated costs by Ilic, Neumann and Plückebaum (2009) are representing this, meaning that for a four fibre network and distribution point handover, total investment requirements increase with the number of cooperation partners connecting to the network. For instance in the first six clusters with distribution point handover the total investment requirement for a multifibre network increases by 21% (from 4'124 Fr. to 4'996 Fr.) with one cooperation partner (instead of none). Considering the above, the MPoP solution can be socially optimal in cases when multfibre backhaul is more efficient than duplicate network backhaul. In fact in the Swiss case even though there was an extended debate on this, several cooperation partners agreed on handover at MPoP level. The cost estimates of Ilic, Neumann and Plückebaum (2009) are broadly in line with other estimates of Polynomics (2009) which estimated additional costs of 10% for multifibre networks and of the Swiss incumbent Swisscom estimating additional costs of 10 to 30%, depending on the case considered. Considering the above a possible national multifibre obligation as discussed in Switzerland might therefore raise costs also in

monopoly areas reducing typically total coverage to some extent. These additional costs to society need to be traded off against benefits.

The European Commission's acknowledges the potential of multifibre in its NGA Recommendation (2010) stating that multifibre has several advantages and may be conducive to long term sustainable competition. It is stated that multifibre

- *allows partners full control of their own connection up to the end user*
- *enables an end-user to subscribe simultaneously to several service providers connected at the physical layer, which could in turn help develop new applications;*
- *facilitates churn, since no manual cross-connection operation is needed at the concentration point, any churn request may be dealt with without any down time*
- *lowers operating costs when compared to a single fibre FTTH scenario;*
- *ensures that access seekers can obtain full control over fibre lines, without risking discriminatory treatment in case of mandated single fibre unbundling.*

The main use for the customer in urban areas is therefore that a multifibre dose is installed at the home which allows potentially to choose one or more physical access provider simultaneously and easily switch between them (in Switzerland for instance four fibre connectors are installed). Cases where more than two operators are chosen simultaneously seem to date, however, rare in the Swiss market.

Coverage

Ilic, Neumann and Plückebaum (2009) assume a fixed average revenue per user of 57€ per month independently of the service purchased (single, double, triple play)[52] and independently of the number of entrants. For Switzerland, it is then estimated that traditional fibre infrastructure competition, i.e. investment in two independent parallel networks, would be profitable in this case for up to 16% of households. Using multifibre co-investments it is estimated that this coverage can be increased to up to 54% of households[53]. Surprisingly, even four operators would be economically viable under these assumptions for 36% of households[54]. These results are, however, assuming certainty of (symmetric) market shares after investment. As such certainty is not given in reality the actual coverages may be significantly lower. Finally, (maximum) total coverage under these demand assumptions is given by the potential profitable coverage by a single operator roll-out (single fibre) at around 60% of households (corresponding to 8.3% of the national territory)[55]. In the model of Ilic, Neumann and Plückebaum (2009), it is therefore predicted that - even in presence of cable - about 60% of the population could profitably be covered by an FTTH network (single fibre) and that for a very large part of these accesses (54%) physical FTTH infrastructure competition on the basis of a multifibre co-investment is viable[56].

3.2. Regulatory practices

While co-investments can lead to operators having a comparable level of independence as in the case of a fully parallel roll-out, this is not necessarily the case. BEREC (2012a) distinguishes two forms of investment cooperations. On one side long-term cooperation agreements are considered where no common company is founded and access agreements are made for instance on a single fibre infrastructure or also under indefeasible rights of use (IRU) on dedicated fibres in case of multifibre.

[52] Assuming 35 CHF for single play (telephony), 65 CHF for double play (telephony and broadband), triple play 80 CHF (telephony, broadband and IPTV) and business 252 CHF, and applying services shares of 15%, 16%, 51% and 9%, an average ARPU per connection of 85 CHF results.
[53] 43% when handover is done at distribution point level instead of MPoP
[54] 16% when handover is done at distribution point level instead of MPoP
[55] In case of single operator multifibre roll-out 54% of households (in both the MPoP and the distribution point scenario).
[56] In the WIK model multifibre cooperations and costs structures do not affect total coverage.

On the other side the authors consider joint ventures, where the companies take equity stakes carrying jointly the full financial risk of the investment and reselling wholesale products jointly to the shareholders as well as possible downstream outsiders.

Long term cooperation agreements

Typically, many co-investment cases observed to date in Europe have foreseen limitations to independence and flexibility of participating operators. The following horizontal agreements part of NGA multifiber long-term cooperation agreements had for example been notified under objection proceedings to the Swiss competition commission[57]:

- Layer 1 exclusivity (notified in all major cities) foreseeing a clause whereby a partner commits not to give access at layer 1 to third parties

- Compensation mechanisms (notified in all major cities except St. Gallen), foresee that from a certain degree of usage of the network a transfer payment between the partners is necessary

- Investment protection clause (or non-discrimination of the partner) (notified in all major cities), foresees that access products cannot be offered at lower prices to third parties than to the partner

- Information exchange clauses (notified in all major cities except St. Gallen)

The Swiss competition authority has found that all these clauses (with the exception of information exchange) could potentially restrict competition. Such a finding could still be confuted by sufficient competition in the market (wholesale physical network infrastructure access and wholesale broadband access). However, in both markets, restricted to only fibre and including both dedicated and shared fibres, significant market power was found, especially for the technical problems making it difficult for cable operators to directly enter the market for wholesale physical network infrastructure access. Indirect effects through the retail market were supposed not to be sufficiently strong given that the only operator able to offer LLU on national level is supposed to be Swisscom. The competition authority was therefore unable to exclude an intervention in case the operators would agree and implement these clauses. Most clauses have subsequently been cancelled by the operators. BEREC (2012a) show that it is essential whether the investment cost is shared upfront or whether there are subsequent usage based charges transforming via the legal instrument of the co-investment potentially fixed costs in marginal costs manipulating competition. This is possible both in the case of long term access agreements as well as under joint venture.

Unlike in Switzerland in France cooperation agreements are largely defined ex-ante by regulation. Consequently there is less space for intervention of the competition authority. Essentially, the French regulation foresees that any firm wanting to roll-out FTTH in an area consults the market (via NRA) for interested firms in layer 1 co-investments[58]. If there is interest by other operators to participate in such an investment, multifibre is rolled out (at least one fibre per co-investor) and the operators essentially participate bearing equal shares of the investment cost for the multifibre infrastructure between the home and the distribution point[59]. In exchange, they receive a long term indefeasible rights of use (IRU) which define access agreements largely equivalent to property.
Independently of whether the roll-out took place by a co-investment or not, infrastructure operators in France must then provide (ex-post) access at reasonable and non-discriminatory terms to unbundling products at the distribution point. Differently to the co-investment such prices include a risk premium. This applies to very high density areas (i.e. communes with more than 250’000 population, where at

[57] See BoR (12) 41, Wettbewerbskommission (RPW2012-2)
[58] ARCEP Decision 2009-1106 of 22 December 2009
[59] ARCEP Decision 2009-1106 of 22 December 2009, article 3

least 20% of the houses consist of more than 12 units[60]). There, the distribution points are set for houses with more than 12 units directly inside the building. Similar terms apply in non dense areas[61] where, however, the distribution point is much more distant (such as to collect more than 1'000 lines). The NRA therefore imposes a larger extent of shared network outside dense areas. As an example France Telecom and Free have signed an agreement in July 2011 where 5 million households should be reached outside very-high density areas by 2020. Legally the French approach is interesting as it regulates fibre access in a symmetric way (i.e. applied to any firm on the market independently of the competitive situation). Also, in Portugal Optimus and Vodafone both construct own independent NGA networks in different cities. An agreement foresees mutual access.

Joint Ventures

Structural joint ventures of multiple telecoms operators in Europe are rare. In this case operators jointly control a company and divide investment costs and profits. In Holland a Reggeborgh-KPN joint-venture rolls-out an FTTH network. KPN, Reggefibre and other operators then buy access to layer 1 products from the joint-venture at regulated prices. The price caps are differentiated according to cost (capex) levels ranging from 15.52€ to 25.99€ per month in 2013 (14 different areas proposed). As described in the earlier chapter these prices are the result of a DCF model taking into account cost and demand over the lifetime of the investment (the regulated price sets the net present value to zero).

Also, under a proposed joint venture in Fribourg in Switzerland (Swisscom-Groupe E) other horizontal agreements have been rejected[62] by the competition commission. In this case, the agreement would have foreseen that ducts would remain under the control of the respective partners and that non-discriminatory wholesale offers are made. The competition authority had, however, ruled that the agreement would not constitute an independent new unit on the market taking over relevant assets of the partners – so-called full function joint venture - and considered therefore only the horizontal agreements. The main agreements were:

- The joint ventures layer 1 access price[63] is fixed over the whole term of the contract (same for co-investors as also third parties) in the agreement
- There is a minimum order quantity for layer 1 products (same for co-investors as also third parties). I.e. small alternative operator could not provide sufficient scale and would not be served by the joint venture.
- The operators fix a common price for access to their ducts (which remain under their respective control).
- Both operators make bids to the joint-venture indicating total roll-out costs per area. A clause foresees that the costs taken into account – bid of the winning operator – are increased by a fixed agreed mark up.
- The operators commit to not compete with the joint-venture operations at later stage
- The sale of layer 1 access products at the building entry point to third parties is restricted

The authority has shown that all these clauses could potentially reduce effective competition in the market for wholesale (physical) network infrastructure access. In June 2012 the joint-venture has adapted the clauses according to the decision of the authority. In order to ensure full coverage of the region, the Canton was requested to enter the capital of the joint-venture. The Cantonal Government had agreed to do so. At the same time Swisscom has decided to abandon the project and the cooperation form is now similar to the other Swiss agreements. Finally, in Italy Trentino NGN (controlled by the district authority) and Telecom Italia have set up a joint-venture where it would roll-out in dense areas (70%), while Trentino NGN would roll-out alone in the rest of the area.

[60] The decision states some further conditions for definition
[61] ARCEP Decision 2010-1312 of 14 December 2010
[62] Swiss Competition Commission. Case 41-0623: FTTH Freiburg
[63] terminal segment, i.e. from the distribution point to the home.

Structurally as will be seen under a joint-venture the partners can control the access costs of all downstream players. Under (long term) access this is not the case, as the incumbent may always retain access at marginal cost.

3.3. Review of Literature

The essential question the literature explores is the effect that different regulated and unregulated co-investment options have on investment, competition and welfare. As is the case with the applied regulatory work on the subject, theoretical and empirical literature essentially distinguish joint-ventures and (long term) access agreements. The key feature of a joint-venture is that the roll-out may be undertaken jointly and that the partners maximise joint profits and set a single downstream access charge for the partners (and a possibly different one for outside operators). While such agreements are generically considered to be co-investment agreements, it is not entirely clear which types of access agreements should be considered co-investments. In an access agreement, the (local) network remains under full control of an incumbent which gives access at a price possibly above marginal cost. In this an asymmetry in the market is created as the investor active on the downstream market may face only its marginal network cost upstream. It may consequently in these cases be impossible for the operators to reach efficient monopoly allocations as under joint-venture. In theory any above marginal cost access price may create additional rent (an investment contribution) for the investor supporting its investment. While many types of access options are considered by the co-investment literature, only the subset of these agreements including an ex-ante fixed investment contribution are usually considered to be co-investments[64], as in this case the investment risk can be equally shared. This section will, nevertheless, compare all joint-venture and (long-term) access options analysed.

Most of the co-investment literature considers (ex-ante contracted) joint-ventures. One particular form of joint-ventures is when insiders can access the infrastructure at marginal cost (access price set by the regulator or by the partners), where the network therefore can be used freely after the investment has taken place. Typically such a configuration would lead to intense downstream competition. Cambini and Silvestri (2013) call this basic investment sharing[65]. Also, in addition to these broad categories of cooperation an intermediate case is considered. The access innovation literature considers the case where the joint-venture maximises joint profits setting a jointly optimal investment level, but where the competitor would not enjoy marginal cost access as the incumbent paying above-marginal cost (regulated) prices.

Regarding access agreements instead, a broad range of options is considered. Essentially, access charges can be fixed (independent of quantity) or linear or nonlinear in quantity (e.g. fixed plus a usage base charge together or a usage based charge with quantity discounts). Ex-ante is considered, as usual, to consist of contracts signed before the investment takes place, while ex-post contracts are signed afterwards. Fixed charges can be optional (i.e. are effectively paid only when access is actually requested, which may not be the case when demand turns out to be low ex-post) or non-optional (to be paid in any case). In addition charges can be unconditional or conditional on the market outcome and in particular the level of demand in case of uncertainty. All these access options can refer to prices on the free market as well as to regulated prices (e.g. LRIC, FDC or marginal cost). In addition

[64] This seems in line with the definition given in the NGA recommendation: *Co-investment in FTTH means an arrangement between independent providers of electronic communications services with a view to deploying FTTH networks in a joint manner, in particular in less densely populated areas. Co-investment covers different legal arrangements, but typically co-investors will build network infrastructure and share physical access to that infrastructure*.

[65] Usually in one way or the other marginal cost is born by the partners. Be it via the joint-venture or via own NGN marginal costs equal for both operators.

to the mentioned co-investment and access options often a benchmark case is considered where no access is possible.

Essentially, the literature shows that co-investments can extend duopoly (and sometimes total) coverage but risks reducing competition. As welfare effects are therefore contradictory, the social desirability of a particular co-investment depends on the fine details of the co-investment agreement and the outside option to which it is compared: for instance, whether both operators have non-discriminatory access to the infrastructure built, the regulatory environment, downstream competition, uncertainty, risk aversion, the structure of the access charges and the amount of investment required. Unsurprisingly, theoretical conclusions depend on the hypotheses assumed. It will be shown, however, that nevertheless conclusions and recommendations to date are largely consistent. The following section will provide an overview of the literature based on one basic paper (taking also into account geographic aspects) described initially. Table 9 in the annex summarizes the NGN co-investment options considered in the literature and the main assumptions and results of the respective papers.

3.3.1. Co-investment under NGN regulation

The most detailed analysis of co-investment (basic sharing) to date is provided by Bourreau, Cambini and Hoernig (2013). The authors use a similar model than Bourreau, Cambini and Hoernig (2012b) considering next to geographic effects also uncertainty[66] and access to outsiders once the investment has been undertaken. However, unlike most other co-investment papers, the authors consider a Greenfield investment and therefore no migration effects from copper to NGA reducing model complexity (and practical relevance) to some extent but defining a good starting point for further analysis. While most other articles consider access regulation an alternative scenario to a co-investment scheme, this article considers the two simultaneously.

Regional incumbents can here decide on the extent of Greenfield NGN investments in their respective home areas. They invest up to the (most costly) area where gross profits can just cover the investment cost. They then announce their plans and can decide to what extent they would like to co-invest in the home area of the other incumbent - where investment cost would be split and access granted at marginal cost. This as the authors assume that higher internal access costs reducing competition would not be tolerated by the regulator (largely corresponding to the regulated ex-ante co-investments proposed by the French regulator). The paper also assumes that the co-investors then set jointly a local access charge to the co-invested infrastructure for the outsiders seeking access. The paper analyses the investment incentives for both total and duplicate/co-invested coverage that a co-investment option creates in three market regulatory environments: no access (benchmark), traditional regulated (NGN) access and the free market (in duopoly areas only).

When only (regulated or commercial) co-investment options exist (i.e. the outside option is that no access is granted), the only way to provide NGN products is by having access to their own infrastructure (be it via single roll-out, duplication or co-investment). In the case when the competitor can somehow share investment costs and then access the technology at marginal cost, as under duplication, operators would earn duopoly profits in the areas concerned (which are reduced compared to the profits in monopoly areas). The only difference being that the investment cost can now be shared, reducing the cost for duplication and extending the duopoly coverage (which is usually lower than the monopoly coverage) when compared to a case with no access option. Duplication would therefore be fully substituted by co-investment and the duopoly coverage extended. In line with the rest of the literature, which will be described, the paper concludes that usually total coverage is not affected by co-investment options. This might be case only when co-investment duopoly profits exceed monopoly profits, i.e. when a joint roll-out would lead to efficiencies reducing the total investment cost or when there is a strong demand expansion effect. Reasonably the former is not the

[66] but assuming risk neutrality

case. For instance Schneir and Xiong (2012) show that additional investments would in reality be necessary in case of any co-investment, as infrastructure would need to be more flexible and necessitate more equipment to be able to host two partners (even when considering a relatively economic passive optical network (PON) FTTH infrastructure[67]). Regarding the latter, as in most other papers, differentiation is key. If goods are sufficiently differentiated the sum of gross profits of two active firms may despite increased competition be larger than the profit of a monopolist. When this effect is sufficiently strong to balance the likely increase in investment cost, an increase in total coverage might theoretically be possible when introducing the co-investment option (even when introducing only the possibility of duplication). In addition, it is shown that when the probability of low demand increases, not only both monopoly and duopoly coverages are reduced but also the difference between the two, meaning that a co-investment scheme would also reduce coverage risk.

When instead traditional regulated ex-post[68] access (uniform linear usage based fee both in monopoly and duopoly areas) is also granted and demand is high, partners would ask for access outside of co-invested areas, i.e. in all areas where only single infrastructure is deployed. It is assumed that access is not asked for in case demand is low and that then profits would be the same as under no access. Here, it is assumed that also downstream entrant can enter on the retail market based on access regulation (both in single as well as co-invested areas) but also only in case of high demand. In such a case it is shown that usually an increase in the access charge increases both single and co-invested coverage. Then with respect to the no access case regulated access usually undermines investment incentives (total coverage) unless the regulated access charge is high and product differentiation too. Secondly, the introduction of regulated access is now an alternative to the co-investment creating an opportunity cost for a co-investors which reduce co-investment coverage (in the extreme case of access at marginal cost, there wouldn't be any incentive to co-invest anymore independently of the investment cost). When deciding on whether to provide regulated access (instead of no access) to co-investors the regulator therefore has to trade-off enhancing competition in single infrastructure areas with a reduction of incentives for co-investments, reducing infrastructure competition. The authors argue that a solution could be that regulated access is not provided to co-investment partners (only to downstream entrants), but this may not be feasible from a legal and practical point of view.

Finally, investment incentives are analysed under voluntary access, where in co-invested areas due to infrastructure competition access prices are fully deregulated (regional regulation) while traditional regulation remains in place in single infrastructure areas. In this case the co-investors will allow local access only when profitable, thereby weakly increasing their local profits. Co-investment coverage therefore increases with respect to both the no access as well as the regulated access scenario (while voluntary access has usually no effect on total coverage as regulation in monopoly areas remains in place). This effect is essentially due to the fact that investors here have full flexibility to maximise their profits.

Voluntary access for co-investments is, however, not necessarily socially optimal, as it may lead to higher retail prices. The authors show that such deregulation of co-investments only provides higher welfare than no access in case services are sufficiently differentiated. Also, compared to regulated access, voluntary access only leads to higher welfare when services are highly differentiated and the compared access charge under regulation is high. The first result is obtained as the introduction of a freely and jointly profit maximising access charge by the co-investors may be used to soften downstream competition[69]. This may increase the co-investors total profits even in presence of a new entrant when compared to no access implying, however, less welfare. In the case where instead goods are highly differentiated, there would be no such negative competitive effects of deregulation and welfare would be enhanced. The welfare effects of voluntary access compared to regulated

[67] PON allows to passively bundle the traffic of multiple fibre lines on one single backhaul line, reducing feeder costs, but potentially limiting flexibility.
[68] i.e. access is asked for after the investment is sunk and demand uncertainty has resolved
[69] This is also described in BEREC(2012), where it is stated that compensatory mechanisms after the investment which imply effective above marginal cost access prices can be strategically used to reduce in the market.

access are then straightforward. Given sufficient differentiation (negative effect of co-investment on competition is weak) and a high enough access charge under regulation, local welfare in a deregulated co-investment area is higher than in a regulated single infrastructure area. Also, as has been shown, voluntary access would increase co-investment coverage. Therefore, only when differentiation is strong and the compared regulated access charges high may deregulation of co-investments be a socially better choice than traditional access regulation. The French authority seems to share this view as it has actually not only regulated co-investment access conditions but also ex-post access conditions to the infrastructure. Under the current regulatory framework, it may propose to lift this part of regulation when the co-investment grants sufficient competition therefore limiting negative effects on welfare.

3.3.2. Co-investment models as an alternative to NGN regulation

While the rest of the literature does not take geographical aspects explicitly into account, different aspects of the preceding model are also analysed when considering the presence of a legacy network on a whole considered, possibly urban area and upgrade investments which, depending on their size and the ability of the operators to sell quality services, may unlock additional willingness to pay.

Overall modelling approaches in the rest of the literature vary strongly. For instance, Nietsche Wiethaus 2011, Cambini and Silvestri (2012) and Cambini and Silvestri (2013) compare different exogenous risk sharing agreement options (traditional joint-ventures and basic sharing) to - alternative - traditional NGN regulation options (LRIC, FDC, marginal cost, free market, no access). Unlike Bourreau, Cambini, Hoernig (2013) these authors consider an incumbent with an existing copper network to which all players have non-discriminatory access at marginal cost (regulated). Except for Cambini and Silvestri (2013), these papers take into account uncertainty. We will now review the rest of the literature, considering the following broad category of models: Presence of uncertainty, differing ability of partners to sell NGN based products and the presence of outsiders. Subsequently the access innovation literature is analysed where access conditions between the incumbent and the co-investor may differ and the NGN investment has no quality effect exclusively reducing access cost. Then, the literature on long term access regimes is reviewed under which the incumbent continues to fully control the network, while still being able in some cases to share risk. Finally, the empirical literature on co-investments is described.

a) Certainty

The simplest overall setting is provided by Cambini and Silvestri (2013) which consider a given roll-out area under certainty. Consumers' willingness to pay for NGN depends on the amount of investments and the two considered possible incumbents are equally good in transforming quality investments in willingness to pay. They then rank market outcomes regarding investment, competition and welfare for the traditional joint venture case, the basic sharing case as well as the traditional regulated monopoly case. Cambini and Silvestri (2012) introduce also uncertainty making similar but more detailed conclusions considering in addition the case where NGN is left unregulated, while the legacy network is continued to be regulated. Nietsche and Wiethaus (2011) consider a similar model under uncertainty comparing the basic sharing case to specific regulation such as LRIC or FDC.

In Cambini and Silvestri (2013), a downstream competitor has the possibility to enter a basic sharing agreement with the incumbent before the investment (ex-post access in case of agreement is granted for free for the partners, having to pay only their marginal costs for NGN). Duplication is therefore excluded. Investment costs as well as possible wholesale profits are as usual equally divided. Consumers are here having demand for basic broadband which can also be offered based on the legacy network and one for value added services based on NGN as in Foros (2004) and Katz and

Shapiro (1985). How much the NGN investment increases the consumers' willingness to pay depends on the industry's ability to transform input quality improvement into output.

Essentially, two scenarios are analysed. One where all operators are part of the co-investment agreement and one where there are outsiders asking for usage based access ex-post. In the regulated scenario, Cambini and Silvestri (2013) assume that no type of investment sharing option exists and that the regulator sets the welfare maximising access price to the incumbents infrastructure (ex-post and linear usage based) for all access seekers. It is shown that in this case the optimal NGN access price is set at marginal cost (as for copper). The investment extent would then depend on the willingness to pay for NGN services and investment costs and it would decrease with the number of outsiders using access, as these would compete and reduce industry profits (Cournot). In equilibrium in the basic sharing scenario, instead, when all firms participate in it, industry profits and investment incentives are increased compared to the regulatory scenario as now also NGN profits generated by the co-investing (former downstream) competitor can be taken into account when making the investment decision. In this case the whole spill-over of the investment on the competitor can be considered when deciding on investment. Typically any other form of collaboration (e.g. ex-post access, especially when regulated) would reduce the amount of rent that can be extracted from the competitor reducing investment incentives as will also be shown in Inderst and Peitz (2013). Finally, in case of a traditional joint-venture, when firms are also free to choose the access price to the co-invested network, competition can also be softened increasing profits and investment incentives even further.

Equilibrium output it is shown to be highest under basic sharing. Firstly, it is higher than under joint venture, where partners may set a high access price to dampen downstream competition restricting output[70]. Secondly it is higher than under regulated access, even though access prices to the network are identical in equilibrium (marginal cost), as investment and therefore demand are increased under basic sharing. Finally, output under joint venture in equilibrium would usually be higher than under regulation (at least when willingness to pay for quality investments is sufficiently high and costs sufficiently low)[71].

It is also shown that the ranking with respect to total welfare in this model is identical. Increasing both investment and competition, basic sharing is superior to access regulation (similar conclusions will be described in Nietsche Wiethaus (2011) and Cambini and Silvestri (2013)). By contrast, a joint venture with freely chosen access charges is a combination between strongest investment incentives and strongest restriction of competition. Again, when willingness to pay for quality investments is sufficiently high and costs sufficiently low it is shown to be superior to regulation as in this case investment is having more welfare value. Finally, a joint venture option is shown to always generate less welfare than basic sharing as the increase in investment incentives in this model with an exponential cost function and Cournot competition can never compensate the loss in terms of competition.

b) Uncertainty

Nietsche and Wiethaus (2011) and Cambini and Silvestri (2012) introduce uncertainty such that willingness to pay is enhanced only in case of success. Conversely in the case of failure willingness to pay is not enhanced. The binary nature of success allows to introduce the element of uncertainty without unduly extending the complexity of the model. In Cambini and Silvestri (2012) differently to Cambini and Silvestri (2013) and Nietsche and Wiethaus (2011) and following more closely Foros

[70] . As stakeholders will be redistributed 50% of the JVs profits the access price would only have a financial impact on an operator when its use of the infrastructure would be different than 50%/50%; this is not the case in this symmetric and certain environment. However, otherwise a JV is vehicle for internal transfers (similar to full compensation payments in the Swiss case under loose cooperation agreements).

[71] The ranking in terms of consumer welfare is identical.

(2004) the willingness to pay for quality of consumers may vary across firms. The results found under uncertainty are not in contrast with the results found in Cambini and Silvestri (2013) under certainty.

Differing ability to increase willingness to pay of consumers across firms

In Cambini and Silvestri (2012) again an incumbent with access to a legacy infrastructure has an option to invest in NGN under different possible exogenous regulatory regimes or a sharing option with a competitor. Demand is revealed only in the retail competition phase. Similarly to Cambini and Silvestri (2013) three access regimes are considered: Basic investment sharing, NGN regulation, and free NGN market. In all cases there a regulated copper option continues to be available.

The incumbent and possibly the alternative operator in case of co-investment must decide on when to invest in a given (supposedly urban) area under consideration (investment extent is supposed to be 100%). Investment costs are assumed to decrease over time[72] meaning that the investment is becoming more profitable over time and that at some point investment would take place. Practically, an exponential discount factor (between 0 and 1) is applied to a (quadratic) investment cost as in Bourreau and Dogan (2005) and Riordan (1992), depending on the adoption date of the new technology. The earlier the investment takes places the higher the discount factor, and consequently, the investment costs that need to be incurred to upgrade the network[73]. The investor will decide therefore on the investment timing, which will determine the investment costs. Until the moment of adoption the incumbent makes profits based on its legacy copper network. The NGN generates profits afterwards. The regulator in this model sets access prices ex-ante, but access prices can be conditional (i.e. higher in case demand turns out to be high). In this model, it is mostly assumed that the entrant has to commit to an access regime and cannot switch back to copper after demand is revealed. It therefore bears risk as well.

Under traditional NGN access regulation, it is shown that when the incumbent is much more efficient in creating willingness to pay for NGN services compared to the competitor, the regulator would set an expected welfare maximising price excluding the competitor from the NGN. This case is, however, assumed to be unrealistic. When the ability of the competitor increases slightly but the incumbent is still better than the competitor, the regulator would set an above marginal cost fibre access charge making its entry viable. Finally, when the ability of the competitor further increases and is only slightly lower than the ability of the incumbent, and when it is even higher, the regulator would set a negative access charge in case of success in order to incentivize the alternative operator to offer NGN based products, given that only its presence may unlock (quality) competition and possibly increased willingness to pay for NGN downstream. Negative access charges are, however, excluded and it is assumed that in such cases the fibre access charge would be set at marginal cost as copper. The authors also show that a situation where the regulator cannot set conditional access prices would be suboptimal, as the alternative operator could be inefficiently forced out of the NGN market in case of failure. This as above marginal cost NGN prices would be valid also in the case of failure and could imply that profits would be lower than with copper. Finally, the incumbent decides on the investment timing. The authors find that the better the competitor is on the fibre market the later the incumbent would invest (as in Foros (2004)). This occurs when the NGN access price is set at marginal cost, meaning that the investment is pure spill-over but also in the case of above marginal cost NGN access prices. Also, when the probability of success increases, the investment is undertaken earlier and the incumbents' incentives to invest decrease less strongly with the ability of the competitor.

In the case of full deregulation of NGN a simple take-it-or-leave it offer is considered as opposed to Nash bargaining considered below by Nitsche and Wiethaus (2011). Moreover, it is assumed that in case of failure, the access price would be set at marginal cost. It turns out that the incumbent would set the NGN access price in case of success such that

[72] This means that in this model there is always investment at some point.
[73] When investment takes place in period 0 the investment cost is not reduced at all. When taking place in period three it would be reduced by around 99%.

i) when the competitor is significantly less efficient in offering value-added services, it is excluded from the market
ii) when the competitors' ability increases but not up to a point where he would be significantly better than the incumbent, the incumbent will charge above marginal cost prices which just allow the alternative player to enter the NGN market.
iii) when the competitor is considerably better, access is granted fully extracting the willingness to pay the incumbent would be unable to generate himself (monopoly prices).

These conclusions differ from Foros (2004), where the outside option is market exit (instead of copper) and the incumbent would charge an unconstrained NGN access prices excluding the entrant, whenever the competitor has a lower ability to sell NGN services. Here, the cases of exclusions are reduced as to make entry of the competitor viable even if it is (to some extent) less efficient than the incumbent. This is due to the trade-off that if it would not allow the entrant on the NGN it would continue to compete for basic services over the legacy network at regulated marginal cost access prices, which is creating an opportunity cost for the incumbent. Granting NGN access, the incumbent can at least earn some upstream profits, which if would not earn in case the competitor would continue to use the copper network. Lifting copper regulation would therefore substantially weaken the competitor's position. Finally, in case of deregulation of NGN the authors find that the better the competitor is on the fibre market the earlier the incumbent would invest as here the incumbent can always capture part of the rent of the competitor.

Under basic investment sharing, the two firms choose the investment time to maximize their joint expected profits. In equilibrium, when at the start the competitor is better than the incumbent (or when the incumbent is better but not too much), the investment is undertaken earlier when the competitor becomes better in selling NGN. Conversely when the incumbent is considerably better than the competitor an increase in the competitors ability would delay the moment of investment. This scenario is therefore representing an intermediate solution with respect to deregulation of NGN and regulation as it internalises the effects of retail competition.

The authors conclude as the rest of the literature that basic sharing leads to more (or the same level of) competition and output than in case of NGN regulation (but also than NGN deregulation).The equilibrium in terms of time of investment depends on NGN access conditions and therefore on the firms respective abilities to sell NGN in the retail market. The investment is undertaken earliest in case of deregulation, while the ranking between NGN regulation and basic sharing depends on the parameters. When the regulated NGN access price is set to zero (marginal cost), the investment is undertaken later than under basic sharing as in this case investment costs can be shared. When the regulated NGN access price is positive instead, the relationship is ambiguous. Intuitively, while in case of investment the competitor may always profit from some spill-over effect, the incumbent may in case of deregulation also capture a part of this rent via the upstream market. In case of NGN regulation instead – if the incumbent has not a considerably higher ability to increase willingness to pay for NGN - the regulator would set prices at marginal cost decreasing the incumbents' wholesale profits to zero. Investment incentives are therefore reduced and investments take place later. Finally, when the success probability increases the investments are in all scenarios anticipated. Uncertainty is therefore a major source for suboptimal investment.

The interpretation in terms of total welfare of this model is unclear. When the competitor is better than the incumbent in providing NGN services (and a regulator would consequently set the NGN access price to zero), basic sharing is always the socially optimal choice. Even though investment incentives are lower than under NGN deregulation basic sharing more than compensates this in with the intensity of competition. Also, NGN deregulation is more efficient than regulation in this case. When instead the incumbent is better (but with the competitors' ability not so low to be excluded) NGN regulation continues to yield lowest welfare, while the ranking of basic sharing and NGN deregulation is unclear. When the ability of the competitor is further reduced, the incumbent excludes it from the NGN market

in case of NGN deregulation. In this case basic sharing is better than NGN regulation from a welfare point of view, while the relationship between NGN deregulation and basic sharing is ambiguous.

Equal ability to increase willingness to pay of consumer across firms

Nietsche and Wiethaus (2011) use a similar but simpler model as Cambini and Silvestri (2012). The factor which transforms quality investments in willingness to pay in case of success is assumed to be one for both the incumbent and the competitor. When access to NGN is granted, both players are therefore supposed to be equally good at selling NGN products. Again the outside option is regulated copper access. The regulatory options considered are now detailed regulatory regimes. Under LRIC, the access price is considered to be an average investment cost per unit (marginal costs such as the cost of production and distribution are again sustained in addition by both the incumbent and the competitor). It is assumed, however, that if the investment is unsuccessful and no additional willingness to pay is created by the NGN investment, the NGN LRIC access price is set to zero. Therefore, only in case of success can the incumbent pass-on investment costs to the competitor under LRIC. In case of failure, the willingness to pay of consumers is not increased and the incumbent would continue to sell copper products under conditions as before and could not recoup its investment cost. Under fully distributed costs (FDC), instead, access prices are also defined as investment cost per unit. But here the incumbent is allowed to recoup costs also in case of failure (i.e. positive regulated NGN access charge also in case of failure). The form in which investment costs are recouped in case of failure can be by a forced full switch to fibre or by continued parallel services, whereby, however, copper based products have to contribute to cover the NGN investment cost. Finally, a basic sharing agreement is considered as well as a deregulated NGN environment. In the case of NGN deregulation negotiation for access to the network in case of success is modelled differently to Cambini and Silvestri (2012) as a Nash bargaining solution is assumed, meaning that rent extraction by the incumbent is more limited.

Overall the authors show that in case of success competition is strongest in case of basic sharing where implicit access prices are lowest (in particular when compared to LRIC). As the equilibrium outputs in case of failure would be the same, overall expected quantities are increased with basic sharing. Moreover it is shown that LRIC leads to higher expected output than FDC, as the outcomes in case of success are equivalent, but as FDC would increase access costs for the competitor also in case of failure leading to lower output in this case. Finally, it is also shown that basic sharing generates more output than NGN deregulation as the latter leads to positive transfers in case of success.

When looking at investment, given that output in this setting is always symmetric, with LRIC in case of success investment costs are effectively reduced by 50%. With FDC the entrant bears this share also in case of failure. Under basic risk sharing instead all investment costs are entirely sunk and do not allow any allocation of investments as second stage marginal access costs leading to a high level of retail competition and consequently limited investment incentives[74]. Basic sharing therefore induces less investment than both FDC and full NGN deregulation. The ranking between basic sharing and LRIC, however, is not entirely clear. As under LRIC the incumbent has to share the benefits of the network in case of success, but it cannot recoup or share investment costs in case of failure, the investment incentives strongly depend on the probability of success. In case of certainty for instance LRIC would provide better investment incentives than risk sharing. In case the probability of success is low enough (under 85%), however, basic sharing, turns out to induce more investments as it allows to share not only benefits but also investment costs upfront.

The authors finally compare the performance of these regulatory options in terms of consumer welfare. It turns out that risk sharing is superior to LRIC both in terms of competition than in terms of

[74] The authors, however, admit that risk sharing may also have other forms allowing for such transaction and improving this trade-off.

investment incentives. This is, however, not always the case with respect to other regulatory options such as deregulation and FDC. In a numerical example, the authors show that usually expected consumer surplus for a large range of parameters (probability of success lower than 90%) is highest for risk sharing, followed by FDC, deregulation, and LRIC. The high performance of risk sharing is due to its property of leading to a very high intensity of competition, but at the same time giving reasonable investment incentives allowing sharing of both benefits and costs in all cases. It should be noted that risk sharing remains optimal even if the probability of success is above 90% and in a certain environment. In this case only the ranking between NGN deregulation and LRIC becomes unclear. Interestingly FDC dominates both NGN deregulation as well as LRIC. Apparently the higher investment incentives more than compensate lower competitive intensity. Furthermore, with some uncertainty even NGN deregulation appears to dominate LRIC (for a large set of parameters). This final result depends on the particular form of access prices under deregulation (Nash bargaining) and the hypothesis of competition.

c) Outsiders

The only paper next to Bourreau, Cambini and Hoernig (2013) to consider ex-post outsiders in case of co-investment is Cambini and Silvestri (2013). In this case the insiders are able to set a (usage based) access price for outsiders which is potentially different from the insider fee. Results are however, not directly comparable as in Cambini and Silvestri (2013), as for the presence of a regulated legacy network option which changes the model fundamentally. Similarly, though the presence of an outsider undermines investment incentives, in particular in case of regulation.

When an outsider is considered, in the basic sharing case the partners continue to access the infrastructure at marginal cost while the outsider has to pay a higher NGN access fee. The outsider also has the alternative possibility to use the copper network at regulated marginal cost prices (same as NGN) or to not enter at all. Given the demand structure, the more the partners invest in quality the less attractive is providing copper services for the outsiders. Depending on the extent of investment, the outsider may therefore be fully excluded from the market even though access to copper is regulated. In equilibrium the authors show that when willingness to pay for quality investments is sufficiently high and costs sufficiently low, the partners set an external access fee so high, that the entrant is excluded from the NGN network. Intuitively when the competitive advantage from fibre over copper services is large the temptation to exclude the entrant from the NGN is higher for the partners as profits in such a situation increase. It is also shown that under the same circumstances the partners choose an investment extent in the preceding stage which is high enough to exclude the entrant also from entering via copper (even though access is regulated at marginal cost), in which case the investment level is identical to the one under no access. When willingness to pay for quality investments is instead sufficiently low and costs sufficiently high, the partners set an above marginal cost access price which makes entry viable. One of the reasons the entrant is not excluded in this case is that it is simply not fully excludable when regulated copper access is granted at marginal cost and the willingness to pay cannot be significantly enhanced at reasonable cost. Once the entrant is not excludable, access can also be granted to the NGN, where more rent can be extracted.

In the joint-venture case the partners instead choose the internal as well as the external access fee freely. When the willingness to pay for quality investments is sufficiently high and costs sufficiently low, the partners again exclude the outsider from the NGN via its access charge. In this case they would set their internal access charge at marginal cost in order to be able to compete at best on NGN base with the copper-based competitor. As before, however, in equilibrium the entrant is excluded also from copper based via investment extent when it is excluded from NGN based entry. In the converse case, the partners would set an outsider fee above marginal cost which would make NGN based entry for the competitor viable as well as an identical internal fee to overall soften (NGN) competition. The regulators intervention may here in both cases prevent discrimination and possibly foreclosure. It would again choose marginal cost access for all operators (insiders and outsiders), in which case the equilibrium investment under joint-venture would be the same as under basic sharing. French

regulation is largely in line with this observation as it foresees ex-post access for outsiders but includes a risk premium.

Under a joint-venture the partners are again able to increase profits by reducing downstream competition. With outsiders, however, also under basic sharing some dampening of competition via the outsiders' access fee is possible. This means that for a given investment extent output is highest and investment level lowest under regulation (uniform regulation at marginal cost). Also output under basic sharing is higher than under joint-venture. The rankings compared to the no outsider case is now different as the presence of an outsider implies that the insider fee is set low by the partners. In equilibrium Cambini and Silvestri (2013) show that with an outsider, sharing agreements increase investments incentives (even more under joint-venture than under basic sharing) over regulation but dampen competition further and lead more likely to exclusion. However, the benefits are such that total welfare is always enhanced by sharing models over the regulated case. The exact ranking between basic sharing and joint venture is unclear and depends again on the willingness to pay for NGN and investment costs. It seems therefore that notwithstanding the fact that sharing agreements can lead to a reduction of competition and potential foreclosure of outsiders this can be socially optimal when compared to a situation with NGN regulation at marginal cost which would reduce industry profits with every outside entrant. Regulators fears of a reduction of competition are therefore well founded when outsiders are present. Nevertheless they should consider that such regulation can reduce investment incentives to a point where welfare is decreased.

3.3.3. Access innovation

Some interesting insights can be obtained from the literature on cooperative access innovation. Mizuno (2009) considers access innovation representing investments with the effect of exclusively reducing network access costs[75]. While two firms compete à la Cournot with horizontally differentiated goods at the retail stage, in the investment stage, two exogenous options are considered. On one hand a non-cooperative regime in which the first moving incumbent alone determines the investment level maximizing its profits, and on the other hand a cooperative access innovation regime (joint venture) whereby the investment is chosen that maximizes joint profits of the incumbent and an entrant while sharing the fixed cost somehow and continuing to compete downstream. Unlike all other articles considered, the access fee the competitor has to pay ex-post is different from the one the incumbent bears. It has to continue to pay a usage based (linear) access fee which is set by the regulator.

Under uncertainty in a benchmark scenario an unconditional regulated access price is considered which does not adjust to realized costs and is fixed. In this case, the investment incentives for access innovation are higher in case of no cooperation, as the entrant does not have any spill-over from the access innovation (results are reported in Table 4). Even worse for the entrant, the access innovation will lead to increased competitiveness of the incumbent reducing its market share and profits. In a more realistic scenario where the regulator imposes a conditional cost-based access pricing rule, the access charge is a fixed multiple (usually above 1) of the realized access cost ex-post (e.g. adding common non-traffic dependent cost elements as a fixed percentage of the access cost on top). Expenditure for access innovation investment may be also included in this perspective. Under any such access rule now access innovation and cost reductions by the incumbent also have a positive spill-over effect on the entrant as a reduction of the access cost also reduces the access charge and therefore the entrants marginal costs.

When the spill-over effect (and access charge) is very small, the entrants' access costs are reduced much less than the incumbents, leading to a strong competitive imbalance, given that the entrants' costs increase relatively to the incumbents'. In this case the entrant overall does not benefit from access innovation and access charge reduction and it would in case of cooperation work to reduce

[75] For simplicity it is assumed that the incumbents' marginal costs are equal to average costs.

investments in innovation. A non-cooperative investment by the incumbent would therefore lead to higher investments. When the spill-over effect becomes high enough, the entrant also benefits sufficiently from access innovation and cooperative investment can increase investment over non-cooperative investment. Finally, when the spill-over effect becomes very high, the entrant benefits more from the access innovation than the incumbent, whose overall benefits from access innovation may become negative due to competitive effects. No investment would then be undertaken as the entrant is supposed to be unable to invest alone. Access charges that are too high, therefore, contrary to intuition, do here not incentivize investment in access innovation but deteriorate it. This is however, only the case because of the particular regulated access price structure (fixed access rule). When the access charge is not a multiple of the access cost, but instead is set as a two part tariff, where non-traffic related costs are set separately as a fixed "set up" fee in addition to usage based charges, the scheme would represent a mix between a fix committed price and a marginal access cost rule implying that the limitation of investment incentives under the non-cooperative scheme are limited. The author suggests that regulators should therefore take care when structuring regulatory access products as incentives for both non-cooperative and cooperative access innovation can be distorted. Regarding the cooperation scheme per se it is not always effective but in case of a regulated (cost) conditional access charge it allows overall to enhance investment incentives. Also, given the above an increase in competition (goods becoming closer substitutes) reduces the range of regulated access charges (and spillover effects) for which cooperation is viable.

	Cooperative access innovation	**Non-Cooperative access innovation**
Fixed usage based access charge	Lower investment incentives	Higher investment incentives
Linear ex-post contracts with high spillovers	Higher investment incentives	Lower investment incentives
Linear ex-post contracts with low spillovers	Lower investment incentives	Higher investment incentives
Standard LRIC	Higher investment incentives (Higher total welfare)	Lower investment incentives (Lower total welfare)

Table 4 – Investment incentives from non-cooperative and cooperative access innovation

In the rest of the paper, the authors conclude that the usage based regulated access charge, considered the only instrument of the regulator, should be set below marginal cost in order to compensate for presumed market power at retail level both in the non-cooperative and cooperative regime. When the access pricing rule is such that the access charge is equal to realized incremental access costs (e.g. LRIC) the level of spill-overs are shown to be "large". It is then shown that such an access pricing regime would not only imply that cooperation leads to more investment incentives with respect to a non-cooperative regime, but also that under cooperation total welfare would be higher. In case of a two part tariff, it is shown that it might lead to higher investment incentives under the non cooperative scheme but also that it would not be welfare optimal in this context.

3.3.4. Long term access agreements

a) Certainty

The co-investment options considered in the rest of this survey foresee joint profit maximisation. There are however, also possibilities to share investment risk without joint control. This is in particular the case with long term access agreements where a competitor may reach an agreement with the incumbent which foresees, for instance, a fixed unconditional ex-ante investment contribution in exchange for favourable ex-post access. Inderst and Peitz (2012a) as well as Inderst, Kühling, Neumann and Peitz (2012) analyse the effects of different access options including ex-ante long term access agreements to NGA in a certain environment. They derive critical levels of investments below which investment is undertaken under different access options. The outside option is again represented by regulated copper access at marginal cost.

Two operators are supposed to fully control a hinterland of particularly loyal customers beyond reach for the competitor and served exclusively. In addition, non-captive consumers are located on a Hotelling line with uniformly distributed customers and products are located at the two endpoints. In such a setting it is shown that the equilibrium price difference of the two products increases with differences in consumers' gross utilities (or willingness to pay), marginal costs or the extent of hinterlands. It is, however, assumed that customers' gross utilities only differ between the firms when they use different technologies. With given fixed, price independent hinterlands - and therefore industry demand - the authors note also that the property that firms can only set a uniform price for all customers (captive and non-captive), means that firms with a larger hinterland are less aggressive in the competitive segment holding a lower market share in this segment. In this analysis, however, symmetric hinterlands are assumed. Analogously equilibrium conditions are derived for the case when demand in the monopoly hinterland segments is price dependent (as well as consequently industry demand). The NGN investment decision takes place consisting in a 0-1 decision in a regional market (the incumbent deciding first on investment). In the following the different network access scenarios for the competitor are analysed under certainty (for a summary see Table 5).

	Investment incentives (total coverage)	**Investment incentives (duplication)**
No access possibility	Lowest	Maximum
Ex-post: Linear access charge	Intermediate	None
Ex-post: Nonlinear access charge (full bargaining power with investor)	Maximum	Maximum
Ex-post: Nonlinear access charge (not full bargaining power with investor)	Intermediate (equal or higher than with linear access charge)	Intermediate
Ex-ante contract option (co-investment)	Higher than corresponding ex-post option	None

Table 5 - Effect of access options under certainty (case of price independent demand)

When no access possibility for the competitors exists, duplication may occur if investment requirements are very low. In the other extreme case, investment requirements are so high that not even a single operators' investment is viable. In the intermediate case, only one of both firms' investments is viable and only one firm invests in equilibrium. As a second option traditional ex-post access is considered. It is first assumed that access fees take the form of a linear charge per subscriber to recoup the investment and that the investor has full bargaining power.

When industry demand is price independent, an increase in linear access prices above marginal cost is shown for the competitor to work like an increase in its marginal costs and leads to an equivalent increase in the retail price in equilibrium (see De Bijl and Peitz (2006)) as the whole marginal cost increase can be passed on one-to-one in equilibrium. The entrants profit remains therefore unchanged with changes in the level of the access charge. It is further shown that in equilibrium the same is true for the incumbents' prices via opportunity costs.
The incumbent would therefore be the only firm benefiting from this access price increase being able to extract rent from the entrant via higher wholesale profits. Foreclosure never happens in this case as the investor is able to always increase its profits through access, extracting rent generated by the entrant (competitors' hinterland). Total coverage is therefore increased with an access possibility. Investment incentives are, however, not efficient here as the linear access charge determines jointly the level of industry profits and their distribution between the access seeker and the investor. Under this scheme the competitors' net profits from access are the profits generated in duopoly at retail level (above wholesale cost). Duplication and a possible reduction of the competitors' access cost to

marginal network costs[76] would not impact the retail profits of the two firms, most importantly leaving the competitors' total profits unchanged. Duplication at any positive investment cost is therefore never possible in such an environment. In addition, a change in the distribution of bargaining power has here no effects as the competitor is indifferent about the level of the access charge.
When ex-post non-linear access prices are considered, for instance, not only a usage based charge has to be paid by the access seeker, but also a fixed charge. Compared to the linear access charge, more rent extraction would then be possible. As in a joint-venture, the usage-based access charge would then be chosen high enough to set marginal cost conditions such to maximise industry profits (monopoly outcome), while the fixed fee would allow the participants to divide the profits according to bargaining power between the two firms (in case of full bargaining power, extracting the entire additional profit, being largely equivalent to a joint venture). A two part tariff option therefore increases the investment cost that can be borne by the investor and investment incentives for total coverage when compared to standard linear access charges. When a shift in bargaining power is considered, it has no direct effect on the market outcome, but on the distribution of rents (and indirectly on level of investment). When not all of the bargaining power is with the investor, rent extraction and total coverage are lower. Regarding duplication, when the entrant does not invest on its own and uses access it has zero profits under nonlinear access in case of full rent extraction. The decision on when to invest in duplication is for the entrant then equivalent to the case when no access is possible. The probability of duplication is therefore the same. It is however, reduced when the incumbent has not full bargaining power. In the extreme case where the incumbent has no bargaining power no duplication takes place. The fixed charge is then zero and the resulting contract equivalent to an ex-post linear access contract. Overall, non linear contract types are therefore a useful instrument as they allow separating objectives maximising investment incentives.

When industry demand instead is price dependent an increase in the linear access price leads to higher retail prices but also a decrease of demand for the access seeking firm and the investor. There is therefore no one-to-one pass through anymore creating an asymmetry between the firms as the investor in its hinterland incurs only its marginal network cost and not an (above marginal cost) opportunity costs. The incumbent will therefore charge a lower uniform price than the competitor and have a relatively higher market share in the competitive segment (partial foreclosure). This outcome is therefore different to the outcome an integrated monopolist (joint-venture) would prefer creating allocative inefficiency and reducing overall rent extraction. As a consequence, duplication can now occur as the competitors' profits under duplication may be higher than under access given that lower marginal costs would now allow the entrant to increase its demand, especially in its own hinterland. When the access seeking firm increases its bargaining power, finally, the contracted linear access price will be reduced, leading to lower retail prices of both firms and a relatively higher market share of the access seeker. With non-linear access prices instead, again, higher investment incentives can be achieved. Setting a fixed charge, the incumbent can reduce the variable access fee returning to a more allocatively efficient and symmetric solution, while not being able to reach the joint venture allocation (as the incumbent cannot control the access conditions for both firms)[77]. An optimal allocation without necessitating a joint-venture allowing still full rent extraction could possibly be reached with an even more complex tariff foreseeing next to the fixed fee also the distribution of an adequately chosen ex-post lump sum transfer according market shares (similar to the "compensation mechanism" proposed by some Swiss operators).

Finally, when a linear or non-linear binding contract is instead signed ex-ante the competitor may commit to a usage-based and possibly also a fixed charge for access. When ex-ante negotiations break down, the outside profits depend on the outside option scenario (no access or linear or non-linear ex-post NGN access). Under ex-post contracts, as shown, a hold-up problem may arise, where

[76] both operators would then face this access cost instead of the access price and there would be no wholesale market anymore
[77] Changes in the bargaining power would here again not change the allocation.

not the entire rent can be extracted from the competitor in case the incumbent does not have full bargaining power. For the incumbent, the investment is then already sunk at the time of negotiation. It will therefore not be considered during an ex-post bargaining stage (e.g. Nash bargaining), the outside option being that only the incumbent offers NGN based products. When ex-ante contracts are used instead, investment costs are not sunk at the time of negotiation and the hold-up problem can be mitigated (and it even disappears with sufficiently complex contracts). Investment cost can therefore be shared somehow with the entrant. The option for an ex-ante contract correspondingly increases the incumbents' profits under price independent demand, (weakly) increasing the range of investment costs that it can sustain and therefore total coverage when compared to the corresponding ex-post contracts. Also, duplication can be avoided, as under this ex-ante contract ex-post the fixed charge is already sunk not creating any incentive for duplication for the competitor. Under price dependent demand, this result does not necessarily hold, as a reduction of the access cost from building own duplicated infrastructure can lead to an increase in the competitors' demand, which may potentially be profit enhancing. In case where a fixed contribution is sunk, this reduces, however, such incentives also in this case. Duplication is therefore in any case more limited under ex-ante contracts. Overall, compared to ex-post contracts (and no access), ex-ante contracts in general provide higher investment incentives (for total coverage) while minimizing duplication and dampening competition if the regulator does not put in place safeguards. This even occurs without considering uncertainty or risk aversion due to bargaining advantages.

b) Uncertainty

Inderst and Peitz (2013) consider a similar model as Inderst and Peitz (2012a), introducing uncertainty about the success of the investment. In addition, the effects of risk aversion and investment timing are analysed. Differently to Inderst and Peitz (2012a), however, duplication is a priori assumed to be not economically feasible facilitating the analysis.

Uncertainty is here introduced by assuming that the NGN gross utility is drawn from a distribution function with values equal to (fail) or higher than the gross utility derived from copper (success to the extent of the utility difference). When both operators use the NGN with respect to the situation where copper is used, an increase in the gross utility of the NGN does affect price and profits only under price dependent demand.

Table 6 summarizes the predicted effects of different access options on investment incentives under uncertainty and risk neutrality, assuming that granting access generates value (net increase in industry profits), i.e. that there is sufficient expansion of total demand and/or lessening of competition so that foreclosure is not an optimal strategy for the incumbent.

	Hold-up problem	Usage of NGN by competitor in all cases	Competitors' outside option	Overall NGN investment incentives
Fixed access charges unconditional on NGN gross utility				
1) - Ex-ante contract - Non-optional fixed charge unconditional on demand	Efficient	No	- Incumbent NGN/copper - Competitor copper	Intermediate
2) - Ex-post contract (before realisation of demand) - Optional fixed charge unconditional on demand	Inefficient	No	- Incumbent NGN - Competitor copper	Low
Fixed access charges conditional on realisation of NGN gross utility				
3) - Ex-post contract (after realisation) - Optional fixed charge conditional on demand	Inefficient	Yes	- Incumbent NGN - Competitor copper	Intermediate (maximum with full bargaining power)
4) - Ex-ante contract - Optional fixed charge conditional on demand	Efficient	Yes	- Incumbent NGN - Competitor copper	Maximum
5) - No fixed charge - Linear usage based charge	Inefficient	Yes	- Incumbent NGN - Competitor copper	Intermediate (but higher than unconditional fixed fee)
6) - No fixed charge - Nonlinear usage based charge	Inefficient	Yes	- Incumbent NGN - Competitor copper	Lower than than linear usage based charges

Table 6 - Effects of different access options on investment incentives under uncertainty and risk neutrality

Under **non-optional fixed fees,** the access seeker enters a binding **ex-ante** agreement on an access charge plan and there is no opt out possibility. It is assumed that after signing the contract a fixed charge (investment contribution) has to be paid by the competitor in any case and usage based access will be granted ex-post at marginal cost (as in all other cases below when a fixed charge is considered). The access seeker is, however, free to buy zero quantity after realization of demand, meaning that only the fixed charge is non-optional. The allocation on the retail market would then be the same as under duplication (symmetric) as both competitors would enjoy marginal costs access ex-post. The fixed contribution can have two effects on coverage. In case the incumbents' investment would be viable also without it (when the competitor would continue to use copper), total coverage is not affected. Access is still granted in this case as long as it creates added value for the industry (extension of total demand and/or lessening of competition). In cases when the investment without the investment contribution of the competitor is not viable, coverage is, instead, extended when compared to no NGN access. The operators will in this case be able to agree on an ex-ante fixed fee as long as industry profits under NGN (both firms) exceed industry profits under copper (both firms) by more than the investment cost (via extension of total demand and/or lessening of competition). Such a scheme does, however, not provide for maximum investment incentives as differently to optional plans described below the outside option for the competitor is in one scenario for the incumbent based on copper reducing the incumbents bargaining power and extractable rents[78].

[78] It is also shown as an example that the access option of setting the non-optional ex-ante fixed charge at the investment cost multiplied by the expected market share of the competitor would not necessarily satisfy the participation constraint in the case when a single investment is not profitable but a co-investment is. There may

Under an optional unconditional fixed fee, the competitor has the possibility to seek access signing an access contract ex-post or also ex-ante, while it can then also opt out of the contract after uncertainty has resolved and it is known whether demand is high or low. The competitor will accept to pay the agreed fixed fee in case demand (gross utility under NGN) turns out to be sufficiently high. In this case, in fact, its copper based profits would otherwise be too importantly reduced by customers switching to the incumbents NGN products. Conversely, when demand turns out to be sufficiently low, the competitor will continue to use regulated copper access, which is socially inefficient, reducing competition and not allowing any rent extraction for the incumbent. When demand turns out to be higher than the level to make the competitors' entry via NGN access viable, the competitor makes positive profits, which can, in addition, not be extracted by the incumbent with an unconditioned fee. The investor then receives the fixed contribution with the probability that demand realizes sufficiently high to make the NGN access contract viable for the competitor. If such a probability is low, the investor would have to increase the investment contribution to obtain a given fraction of the investment. But then again the level of demand necessary to sustain such a charge for the competitor increases, reducing the probability of success, and so on. In other terms, it may be impossible for the incumbent to extract sufficient rent to sustain the investment with an unconditional charge. In addition, this scheme could (at least ex-post) not efficiently address a hold-up problem when the incumbent has not full bargaining power.

The shortcomings of optional contracts can be overcome by conditioning the fixed charge on the realization of demand. When negotiations take place ex-post and after realization of demand for instance, the level of demand (NGN gross utility) can be observed and taken into account at the contracting stage, allowing an efficient adaption to market conditions and efficient surplus extraction. When the incumbent has full bargaining power it can extract the entire profits the competitor generates from upgrading to NGN under any realization of demand. NGN access is therefore here always provided as long as industry profits increase with the introduction of NGN as assumed initially. When considering full bargaining power rent extraction and efficiency is enhanced when compared to an ex-ante unconditional access option where in one scenario the outside option is copper not only for the competitor but also for the incumbent. Under conditional (ex-post) contracts, instead, the outside option is always NGN for the incumbent, who has always already invested[79], and copper for the competitor, putting the competitor in a weaker position. The extractable gross profit from access for the competitor is therefore higher under conditional optional contracts.

As shown under certainty in Inderst and Peitz (2012a) with ex-post contracts the investment incentives for the investor are, however, reduced when it does not dispose of full bargaining power. Ex-ante contracts may solve also this hold-up problem. The same is true under uncertainty. Also, ex-post contracts were shown to be an efficient tool to extract rent as they can be fully conditioned on the actual realization of demand. In principle, it is possible to combine both schemes introducing flexible ex-ante contracts depending on demand realization (as long as the level contracted upon is not only observable but also verifiable ex-post). An optimal access option could therefore be an optional ex-ante contract conditioned on realised demand. In such a case, however, from a practical point of view a series of access prices would need to be defined ex-ante for all possible outcomes. Even though the negotiation here takes place ex-ante, the outside option considered is never that of no investment (where both firms use copper), as the situations defined in the ex-ante contract apply only to situations when the investment would have already been undertaken. In this case the same efficiency as with ex-post contracts can be achieved with ex-ante contracts, while addressing in addition a possible hold-up problem. Compared to a non-optional ex-ante fee where in some cases the outside option consists in no investment by the incumbent and therefore relatively higher profits for the competitor when remaining on copper, the rent possibly extracted by the incumbent is therefore increased. When the outcome can be perfectly observed and verified an ex-ante conditional optional fee would therefore

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therefore be cases where benefits and therefore the investment contribution would need to be distributed differently.

[79] Or is foreseen to have invested.

provide the same investment incentives as an ex-post optional fee under full bargaining power. When instead the incumbent does not have full bargaining power the ex-ante optional conditional fixed charge is the most efficient tool to promote investment incentives, as it also addresses the hold-up problem. As will be seen in the next section, such an access scheme undermines, however, one of the main functions of a co-investment, which is to reduce the investors' risk, as the investor would in this case need to bear a larger share of the investment cost when demand turns out to be low. In this scenario under risk neutrality this effect needs not to be considered.

Inderst and Peitz (2013) also compare linear usage based charges, assuming that the fixed charge is zero. In this case, any access plan is optional as the competitor could always opt-out by buying zero quantity. As shown under certainty, when demand is price dependent, usage based charges introduce inefficient allocative asymmetries. Nevertheless, investment incentives compared to unconditional fixed fees with equivalent wholesale revenues are shown to be usually enhanced as usage based charges provide conditional wholesale revenues by construction. Also, corresponding non-linear usage based access charges can be considered. When still considering an access scheme that implies the same level of wholesale revenues than under the unconditional optional fixed charge and the linear usage based charge, a non-linear charge such as quantity discount leads to relatively lower access prices when demand is high and relatively higher access charges when demand is low. This has two effects. On one hand, this creates an incentive for both firms to increase outputs when they use NGN, reducing deadweight loss and enhancing competition compared to the linear charge. This usually would lead to lower profits and investment incentives though. On the other hand, when demand is realized to be low, access charges increase relatively, meaning that the likelihood that NGN is used by the competitor is reduced and that usage is less efficient. Overall, investment incentives seem to be lower in case of risk neutrality than with a corresponding linear usage based charge. In addition, negative quantity discounts could also be considered. This is for instance the case with capacity limits, where once reached, higher per unit access costs need to be paid. The conclusions are similar to positive quantity discounts. Capacity constraints could therefore be efficient to increase investment incentives. The authors finally consider a combined fixed and usage based charge under uncertainty. They propose a standard case of a non-optional fixed ex-ante fee and an ex-post optional usage based access fee. The usage based fee can as shown under certainty be used to relax competition in the retail market, increasing investment incentives, while the ex-ante non-optional fixed fee may be used to distribute rents especially when the incumbent does not have full bargaining power. However, with respect to the joint-venture outcome in case of price dependent demand, there continues to exist an allocative inefficiency.

Risk averse firms consider profits less valuable when they are uncertain. The two competitors may also have different levels of risk aversion, for instance resulting from their varying ability to access the capital market. Inderst and Peitz (2013) then consider an ex-ante non-optional fixed fee (with the usual marginal cost usage based charge) and alternatively a linear usage based charge (above marginal cost) generating a priori the same wholesale revenues. In this case, when demand turns out to be high, it is shown that the investor has higher total profits under the usage based charge than under the fixed charge. Also, when demand turns out to be low, the investor would have lower profits under the usage based charge. The profit function of the incumbent under a usage based charge is therefore rotated with respect to profits under the fixed charge. The investors' profits with a fixed charge over all possible outcomes of demand are therefore less risky than under usage based charge. The latter therefore shift more risk to the investor. Conversely, the risk the competitor would bear with a non-optional fixed fee would be the same as the investors'. If regulation aims at balancing risks between market participants such an access option could therefore be desirable[80] and depending on the extent of risk adversity of the incumbent this could increase investment incentives accordingly. When considering (unconditional) optional fixed charges instead the risk profiles changes radically. In this case when demand turns out to be low the competitor would opt not to ask for access. From a certain

[80] Abstracting from a possible foreclosure or late entrant problem.

level of demand, it would ask for access and pay the fixed fee. The investors profit function is therefore shown to have a discontinuity (increase) at some level of realised NGN gross utility. The level of the discontinuity depends on the level of competition. When there is weak competition (strong horizontal differentiation) the discontinuity corresponds nearly to the fixed charge implying a large revenue risk for the investor.

Finally, Inderst and Peitz (2013) also introduce a dynamic model, where demand for NGN in the market is expected to exogenously grow over time, meaning that operators may prefer waiting some time before investing. Investment can in a basic scenario be seen as an initial decision causing a number of periods of profits depending on the realisations of demand for NGN. Also, from the moment the competitor asks for access, it is supposed to need to pay a corresponding fixed charge also in each following period to access the network. This setting implies that there is an optimal moment for the competitor to invest and adopt NGN via access, the moment being determined by the paths of the access charges and gross profits. Introducing uncertainty about the NGN gross utility means that waiting is becoming an even more attractive option. But, as the NGN already exists, waiting is not socially optimal. Therefore, the fixed charge should be set low initially and rise over time. This could then be an efficient access option for ensuring earliest possible NGN adoption by the competitor while maximising investment incentives. In an additional scenario when the investor is allowed to dilute its investment over time and when cumulative investments are assumed to increases the likelihood of high NGN gross utility realisations, there may – under uncertainty - also be value of waiting for the investor, especially for risk averse investors. Comparing a fixed to a linear usage based fee in this context, it is shown that the latter may have an efficiency advantage over the former as it would increase with the competitors' subscribers over time while fixed revenues would remain constant. For a given level of investment contribution, the usage based fee may, therefore, lead to relatively quicker investments and more efficiency.

3.3.5. Empirical literature

Empirical data on the effectiveness on new regulatory options such as co-investments is by definition not available. Krämer & Vogelsang (2012) provide, however, a laboratory experiment on the effects of a co-investment option in the market which can be empirically analysed. In their model two firms determine the coverage of their NGN networks in a Greenfield in three areas: metropolitan, urban and rural (respectively increasing in investment costs per household). Depending on the scenario a firm can roll-out independently or (partially) cooperatively. In subsequent ten stages firms compete repeatedly à la Bertrand in a retail market with homogeneous goods in all areas where they have own infrastructure or access (at a geographically uniform price). When the price of two operators is the same, customers are supposed to have a higher probability to choose the incumbent (75%). Access regulation (LRIC[81]) is exogenous and assumed to be in effect wherever only one firm is present. In the scenario without a co-investment option the incumbent first and then the entrant decide on their independent coverage. When instead a co-investments option is admitted, the two firms can, in a prior stage, agree bindingly on the area they will cover by co-investment (basic investment sharing, where the total investment cost for the infrastructure is assumed to remain unchanged). After agreeing on a co-investment, the operators again choose their independent coverage. Under these model settings in the last stage prices would in equilibrium be competed down to marginal costs and the market would be split. In a finitely repeated setting the unique equilibrium of the whole retail game is equivalent. The marginal cost to which prices are competed down includes, however, not only the average marginal cost for access on the other operators network but also the opportunity cost in form of an own (average) access price (represented by the average marginal cost for access for the other operator). This is the case, as giving up a customer implies that the operator does not have to pay an (average) access fee anymore, but that in turn it will receive an (average) access fee. Regarding the investment stage, under the independent investment scheme the authors find that the first mover advantage of

[81] Including a return on investment

the incumbent leads to an equilibrium such that it would cover all possibly profitable areas with own infrastructure anticipating that uncovered profitable areas would otherwise be covered by the entrant (in which case its overall profits would decrease as it would have to pay a positive ROI to the entrant for access). It is also found that the entrant having the same cost structure would find it unprofitable to invest in additional areas and that duplication is not feasible as the entrant would need to pay investment costs in own infrastructure without being able to obtain any additional profits (no wholesale profits and retail profits are always zero). In equilibrium, therefore, the incumbent rolls out as far as profitable alone and the entrant asks for access. In the investment stage under the scheme which foresees the possibility for co-investment the equilibrium outcome is surprisingly shown to be identical. As a co-investor, the entrant would have access to the infrastructure at marginal costs not needing to pay any ROI to the incumbent via an access charge. When deciding for co-investment, however, wholesale profits are the only real benefit of investment as retail prices are competed down to marginal cost. Any extent of co-investment would therefore reduce the overall profitability of the infrastructure. Thus, co-investment is fully avoided in equilibrium. After unsuccessful co-investment talks, the equilibrium outcome would then be the same as under independent investment with the incumbent covering all profitable areas and the entrant asking for regulated access.

In a laboratory experiment the authors then tried to evaluate differences between these scenarios. In addition to the scenarios described the participants in the experiment were also exposed to an outside scenario under independent investment with communication where similar to the co-investment scenario they could communicate before the investment stage (but not make a co-investment contract). Such a scheme is unlikely to exist in reality. In both cases, however, participants could not communicate about prices (Chinese wall). In a first empirical model, a mixed-effects linear regression is used to test for differences in total coverage and collusion across different scenarios (Table 7).

	Investment (total coverage)	**Intensity of Competition**
Co-investment option	Intermediate	Lowest
Independent networks investment option	Intermediate	Intermediate
Independent networks investment option – with limited communication possibility	Maximum	Intermediate

Table 7 – Experimental results, effect of availability of options on competition and investment

In a first econometric analysis, it is found that in an artificial scenario with independent investment, the possibility of communication leads to highest total coverage. The co-investment option scheme leads to less but not statistically significantly different total coverage, when compared to the standard independent investment scenario. Interestingly, even though not an equilibrium outcome under the co-investment option, 56% of duopolies chose to co-invest. This could be motivated by the second result. The authors also use the model to test for differences in the average level of price collusion (over ten periods) in form of a simple Lerner index and a variant of the Lerner index measuring the deviation from average costs. The result shows that collusion is significantly higher in the scenario with a co-investment option present when compared to the other scenarios. Finally, a three level model is estimated considering single periods. These regressions show that tacit collusion decreases towards the end of the game. The authors suspect, however, that this is due to the finite nature of the game. More importantly, it is shown that collusion increases from round to round. Therefore, the longer the participants are in the market, the more they learn to collude.

In a second econometric analysis, the influence of actual market outcomes such as the share of co-investment coverage (rather than differences in scenarios) on total coverage, prices and consumer welfare is estimated. The authors state that they did not impose any demand or cost shocks, meaning that differences in prices or total coverage could be caused only by the conduct of the firms (collusion and investment levels). They assume therefore the absence of any endogeneity problem and use

simple regressions where the explanatory variables are treated as exogenous. Such a fully exogenous setting is unlikely to be realistic and results could be unstable. The most important results seem however to broadly support to preceding analysis that the possibility of communication per se significantly increases coverage. Moreover, the share of co-investment coverage (excluding effects related to communication) would not increase total coverage. Regarding collusion it is found that the share of duplication as expected reduces the level of collusion while co-investment increases it (even net of communications effects). The authors see the latter effect as a mystery and speculate about a psychological result from a stronger bond between the two firms in the case of co-investment. Overall they show that consumer welfare can be increased via co-investment when regulators are able to hold these collusive effects somehow in check.

3.4. Conclusion

In this section the conclusions holding throughout the literature and possible future work in this field are described. Directly comparing the results of the theoretical literature is a complex task, as fundamentally different market models and co-investment agreement details are considered. Despite these differences, however, the conclusions and recommendations offered by the literature are surprisingly consistent.

Generally, co-investment agreements are shown to always increase investment incentives in duopoly coverage when compared to no access, while usually not having an impact on total coverage. Total coverage can, however, be affected too with co-investment agreements when compared to the outside option, as they can be used to reduce downstream competition (via internal and/or external access prices, by communication or other means), to extract more rent from access seekers, to extend total demand or in case of risk averse operators to share risks. The fine details of such agreements as well as of the considered outside options therefore matter.

- Cambini and Silvestri (2013) show that under certainty and without outsiders, basic sharing is superior to NGN access regulation at marginal cost in terms of welfare, increasing both investment levels and competition, as the competitors' profits may also be taken into account in the investment decision, thereby expanding network coverage at unchanged access conditions. These results remain valid when outsiders are considered even though co-investment schemes can then lead to foreclosure.

- Under uncertainty, without outsiders, when there is differing ability to increase willingness to pay of consumers across firms, this result remains substantially valid according to Cambini and Silvestri (2012). Basic sharing would still provide maximum output while investment incentives are reduced. When the regulator would set the access price at marginal cost, however, basic sharing would continue to provide also higher investment incentives. When the competitor is slightly better than the incumbent in selling NGN services (a regulator would then set the access price to zero), basic sharing continues overall to be the socially optimal choice. When instead the incumbent is (slightly) better, basic sharing is still a better choice than traditional regulation (but not necessarily than deregulation). Nietsche and Wiethaus (2011) find that with equal ability to increase willingness to pay of consumers across firms in terms of consumer welfare, this conclusion remains valid for different forms of access regulation such as LRIC or FDC.

These different authors seem to agree that basic sharing may represent a valid alternative to traditional access regulation. A basic sharing option could in practice be implemented by imposing regulated conditions to NGA joint-ventures, which includes the imposition of an internal ex-post access fees and the split of investment costs. In substance, this is the regulatory scheme implemented in France. The question then arises, however, whether a solution where ex-post regulated NGN access to the infrastructure is continued in parallel to such regulation would not be an even better solution.

- From the literature only few conclusions can be obtained regarding co-investment schemes under a traditional usage based NGN access regulation environment. Bourreau, Cambini and Hoernig (2013) analyse such a setting, however, and conclude that with uncertainty and outsiders deregulation of basic sharing agreements (i.e. no ex-post regulation of the outsider access price) may be socially preferable to access regulation only when services are highly differentiated and the access charge under regulation would be high. This is the case because with outsiders dampening of competition takes place also under basic sharing. Nevertheless, there are some specific circumstances under which deregulation can be a welfare optimal solution in presence of such a co-investment scheme.

Regulators should therefore consider the possibility of deregulation of co-investments and articulate ex-ante which detailed forms of co-investments would warrant which type of deregulation and under which external circumstances. In light of the above result it seems, however, likely that the introduction of a regulated co-investment option should usually be accompanied by continued traditional NGN regulation to hold excessive negative competitive effects due to the presence of outsiders in check[82]. This is also the approach the French NRA has chosen.

- Regarding long-term access options Inderst and Peitz (2012a) show, under certainty, with price independent demand and full bargaining power that non-linear ex-post access fees can increase rent extraction over linear access prices to the point to reach investment incentives under monopoly (joint-venture). This is the case because under price-independent demand, no allocative inefficiencies from access arise. When instead industry demand is price dependent, there is an inherent allocative inefficiency, implying that under any form of (long term) access, investment incentives are reduced. Under these circumstances, a highly complex contract with lump-sum compensation payments based on ex-post market shares can possibly achieve replication of the monopoly outcome under full bargaining power and certainty. Finally, ex-ante contracts increase investment incentives for any tariff plan when the incumbent does not have full bargaining power, making rent extraction always more efficient.

- Under uncertainty instead, Inderst and Peitz (2013) show that the above is no longer true and that fixed unconditional fees are inefficient as when demand turns out to be low the competitor would continue to use the copper network. Competition as well as investment incentives could, however, be enhanced when it would be given access at reasonable terms. Conditional fees are therefore more efficient in this case. Conditional fees can also be defined ex-ante (describing all possible outcomes), additionally addressing a possible hold-up problem. Ex-ante optional conditional fixed fees are therefore the most efficient (fixed only) access option to promote investment incentives under risk neutrality. Finally, with risk aversion, it is shown that profits are less valuable when they are uncertain. When the investor is known to be risk averse and regulation aims at balancing risks between market participants a largely non-optional ex-ante fee becomes again an interesting access option promoting investments.

- The empirical literature is still limited. In Krämer & Vogelsang (2012) co-investment is not taking place in equilibrium due to unrealistically aggressive downstream retail competition assumptions when compared to the rest of the literature. Unsurprisingly, their experimental results suggest that such an equilibrium would not arise in reality and that operators may use co-investments as a means to increase collusion - even when the internal access fee is fixed at marginal cost and in presence of Chinese walls limiting communication.

[82] It should be noted here that Cambini and Silvestri (2013) show that when considering basic sharing as an alternative to traditional regulation with outsiders, basic sharing would be preferable for regulators to access regulation (at marginal cost) even though this may imply foreclosure.

To conclude, also on the subject of co-investments many issues still remain to be explored. The most important flaw when comparing theoretical literature with applied regulation seems that multifibre has not yet received attention in academic research. Given the attention this roll-out option has received from regulators as well as Governments and the European Commission, future co-investment models should try to incorporate multifibre options. The main properties of multifibre, which could allow integration in existing models, are that it allows more flexibility and independence via IRUs when compared to traditional networks, that it enables consumers to purchase services from multiple providers simultaneously and that switching costs are reduced. More concretely, multifibre may allow physical infrastructure competition between the partners. In the existing literature usually under joint-ventures a common access price to the infrastructure for outsiders is chosen by the partners jointly and under long-term access an incumbent is setting this price (alone). With multifibre instead both types of outsider access charges could be set independently by the two partners. In addition, another form of access debated by regulators has not yet received attention. Participation in a co-investment agreement could also be possible ex-post. Such a scenario seems particularly relevant in the multifibre case, where for instance in Switzerland two dedicated fibres (out of four) are today usually left unused. Also, the co-investment compensation mechanism described in the section on regulatory practice has been only broadly explored by Inderst and Peitz (2013). It should be analysed in more detail in a fully fledged model. Finally, there is yet no common framework to date that allows for instance a direct comparison of the Dutch co-investment case (joint-venture) to the predominant Swiss co-investment case (long-term access agreements).

4. Concluding remarks

This chapter integrates themes which have appeared throughout the text.

- The review of practical cases has shown that by the end of 2013, European regulators continued to lack clarity on how to handle co-investment agreements and geographic regulation. At the time of writing, a wide variety of regulations were being applied. Their ultimate success will not be evident until several years after their implementation. To cite only the most extreme cases which have been reviewed:

    - While nearly all regulatory authorities continue to apply uniform access prices, the Dutch regulator imposes regional access prices varying with the extent of investment cost.
    - Regarding co-investment, on one hand, the Swiss regulator leaves full freedom to co-investors to shape their NGN risk sharing agreements (as long as compatible with cartel law). On the other hand, the French regulator regulates all important clauses of such agreements (share of investment cost to bear, access price for insiders and outsiders, location of distribution point).

- To date, there do not appear to be strong initiatives to address these issues at the European level. It is possible that this is the case as regulators, BEREC and the European Commission do not yet have a clear vision on these issues. This is understandable, to some extent, as for example the analysed effects of co-investment schemes depend on the fine details of such agreements and often also on market parameters such as the willingness to pay, investment requirements or potential industry demand expansion. While the economic literature on these topics is still limited, it seems, however, to clearly show that co-investment agreements with the right clauses can enhance welfare over traditional regulation at least in some cases and that exclusively uniform usage based access pricing may no longer be optimal. Future literature will likely further build on this and provide more stable insights. Nevertheless, it seems that regulators are now in a position to start to reflect on how to introduce and implement regional access prices and to promote co-investments.

Annex

Table 8 - Theoretical analyses – geographic segmentation of remedies and geographic aspects of regulation

	Main Assumptions									Main results
	Geographic difference in cost and competition considered	**Geographically differentiated retail prices allowed**	**Allow for geographically differentiated access prices (cost)**	**Allow for geographically differentiated access prices (competition)**	**Type of retail competition**	**Entry**	**Presence of old technology**	**Remedies considered**	**Case of free wholesale market**	
Bourreau, Cambini, & Hoernig (2012b)	Yes	Yes	Yes	Yes, number of firms	Bertrand, horizontally differentiated good	Two potential incumbents and potential downstream entrants	No	-Access price regulation -Access obligation	Yes. Bertrand, no differentia-tion (at same prices access providing firm is chosen randomly)	Cost-based geographic access prices lead to suboptimal roll-out and duplication and uniform pricing to too much duplication. The paper analyzes geographic regulatory instruments able to achieve the social optimum, e.g. geographically differentiated prices or remedies.
De Matos & Ferreira (2011)	Yes	Yes	Yes	No (assumed to be competitive when investment costs are such to allow infrastructure competition)	Cournot, horizontally differentiated good	Endogenous (simulation)	No	Access price regulation	No	Different market outcomes with different access rates are simulated. Low access prices erode profitability of infrastructure providers. When regional markets interact, deregulation of more competitive areas may trigger a monopoly situation in an adjacent market.
Flacher & Jennequin (2012)	Yes	No	No	No	Cournot, vertically and horizontally differentiated good	One potential infrastructure entrant, one potential downstream entrant (no duplication)	Yes	-Access price regulation -Coverage obligation	Yes	Show that regulation for maximize total coverage (full deregulation) is not optimal, as well as cost-based regulation to maximize static efficiency. Suggests that setting access prices and coverage obligations is optimal.
Lestage & Flacher (2010)	Yes	Yes	No	No	Bertrand, vertically differentiated good	Two potential incumbents	Yes	- Access price regulation	Yes	A low access price may lead to areas having two equilibria, where it is not clear which operator would invest. It is then uncertain whether there will be investment. If the quality advantage of firm A is sufficient this problem disappears.

Table 9 – Theoretical analyses – NGN co-investments

		Main assumptions						Main results
Cooperation type	**Paper**	**Fixed investment contribution (share of investment cost)**	**Usage based access charges for insiders**	**Usage based access charges for outsiders**	**Uncertainty**	**Presence of legacy technology**	**Effect of NGN**	
Joint-venture (JV)	Cambini & Silvestri (2013)	Yes, equal shares	Yes (free choice)	Yes, positive and higher than insider fee	No	Yes	NGN increases willingness to pay (same for both firms) depending on investment extent	Cambini and Silvestri (2013) show that without outsiders, basic sharing is superior to NGN access regulation at marginal cost in terms of welfare, increasing both investment levels and competition, as the competitors profits may also be taken into account in the investment decision, thereby expanding network coverage at unchanged access conditions. These results remain valid when outsiders are considered even though co-investment schemes can then lead to foreclosure.
	Cambini & Silvestri (2012)	Yes, variable shares.	Yes (free choice)	-	Yes	Yes	Chance that NGN investment increases willingness to pay (by same amount for both firms)	Under uncertainty, without outsiders, when there is differing ability to increase willingness to pay of consumers across firms basic sharing always leads to more competition and output than with regulation or deregulation, while full deregulation induces the highest investments. From a welfare point of view, when the competitor is better than the incumbent in providing NGN services (and the regulator would consequently set the NGN access price under full regulation to zero) basic sharing is always optimal. When instead the incumbent is better, the ranking is less clear. Basic sharing usually continues to be optimal.
Basic investment sharing (particular form of JV)	Cambini & Silvestri (2013)	(see above)	Yes, marginal cost	(see above)	(see above)	(see above)	(see above)	(see above)
	Nietsche & Wiethaus (2011)	Yes, equal shares	Yes, marginal cost	-	Yes	Yes	Chance that NGN investment increases willingness to pay (by same amount for both firms)	Risk sharing (basic sharing) is shown to lead to maximum output and competition as well as to maximum consumer welfare, when compared to LRIC, FDC or deregulation, for its strong competitive effects and reasonable investment incentives allowing the operators to share benefits and costs upfront - even if ex-post the investment fails.
	Bourreau, Cambini & Hoernig (2013)	Yes, equal shares	Yes, marginal cost	Yes, same as insider fee	Yes	No	Demand for NGN can be high or low (same willingness to pay across firms)	With uncertainty and outsiders deregulation of basic sharing agreements (i.e. no ex-post regulation of the outsider access price) may be socially preferable to access regulation only when services are highly differentiated and the access charge under regulation would be high. This is the case because with outsiders dampening of competition takes place also under basic sharing. Nevertheless, there are some circumstances under which deregulation can be a welfare optimal solution in presence of such a co-investment scheme.
	Krämer & Vogelsang (2012)	Yes, 75% incumbent / 50% competitor (according to demand share)	Yes, marginal cost	-	No	No	No quality effect, willingness to pay is identical for both firms	Basic sharing is not taking place in equilibrium due to aggressive downstream retail competition assumptions when compared to the rest of the literature. Experimental results suggest that such equilibrium would not arise in reality and that operators may use co-investments here as a means to increase collusion - even when the access fee is fixed at marginal cost and

								in presence of Chinese walls limiting communication. Overall the regulator can ensure positive effects on consumer welfare when the introduction of a co-investment option is accompanied by measures preventing collusion.
Access innovation joint-venture	Mizuno (2009)	Yes, variable	Incumbent has access at marginal cost. Competitor has access at regulated prices (fixed multiple of marginal cost)	-	No	No	NGN investments have no effect on quality but can reduce marginal costs	Under a regulated (usage) cost based access pricing rule when positive spill-overs from access innovation on the entrant (via a high access charge) are sufficiently high, the entrant also benefits from a reduction in access costs. In this case the negative effects from competition (in this range the incumbents marginal costs decrease more than the entrants') are sufficiently balanced. Then the entrant may participate in a cooperative investment scheme increasing overall investment incentives. The author moreover shows that in case of standard LRIC cooperation is enhancing total welfare. Finally he shows that investment incentives under no cooperation can be enhanced with a two-part tariff but that this would not be welfare optimal.
Long term access	Inderst & Peitz (2012a)	-	Incumbent has access at marginal cost. Competitor has access at possibly above marginal oost prices.	-	No	Yes	NGN increases consumers' gross utility of the service (same amount for both operators).	Under certainty, with price independent demand and full bargaining power that non-linear ex-post access fees can increase rent extraction over linear access prices to the point to reach investment incentives under monopoly (joint-venture). This is the case because under price-independent demand, no allocative inefficiencies from access arise. When instead industry demand is price dependent, there is an inherent allocative inefficiency, implying that under any form of (long term) access, investment incentives are reduced. Under these circumstances, a highly complex contract with lump-sum compensation payments based on ex-post market shares can possibly achieve replication of the monopoly outcome under full bargaining power and certainty. Finally, ex-ante contracts increase investment incentives for any tariff plan when the incumbent does not have full bargaining power, making rent extraction always more efficient.
	Inderst & Peitz (2013)	-	Incumbent has access at marginal cost. Competitor has access at possibly different access options.	-	Yes	Yes	NGN increases consumers' gross utility of the service (same amount for both operators).	Under uncertainty instead conclusions of Inderst and Peitz (2012a) are no longer true and fixed unconditional fees are inefficient. When demand turns out to be low the competitor would continue to use the copper network. Competition as well as investment incentives could, however, be enhanced when it would be given access at reasonable terms. Conditional fees are therefore more efficient in this case. Conditional fees can also be defined ex-ante (describing all possible outcomes), additionally addressing a possible hold-up problem. Ex-ante optional conditional fixed fees (with subsequent access at marginal cost) are therefore the most efficient access option to promote investment incentives under risk neutrality. Finally, with risk aversion, it is shown that profits are less valuable when they are uncertain. When the investor is known to be risk averse and regulation aims at balancing risks between market participants a largely non-optional ex-ante fee becomes again an interesting access option promoting investments.

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