Ex-ante Regulation and Co-investment in the Transition to Next Generation Access

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December 12, 2014

Abstract

Investments in Next Generation Access Networks (NGANs) ask for a new set of regulatory remedies. This paper contributes to this debate by focusing on three issues: the migration from the legacy copper network to the NGA infrastructure, and how wholesale pricing regulation might affect this process; the introduction of differentiated wholesale remedies according to geographical differences in NGAN deployment; the impact of co-investment decisions on market outcomes and their interplay with access regulation. Using the recent economic literature, we discuss arguments and proposals for guidelines that might be useful to regulators and policy makers.

Keywords: Next generation access networks; Investment; Access regulation.

JEL Codes: L96; L51.

*We thank audiences at the Florence School of Regulation Communications & Media Conference (Florence, 2011).

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1 Introduction

Since the start of the millennium, the broadband market has been characterized by a high degree of innovation, which has led to a rapid increase in broadband adoption, and the introduction of new innovative services. While "traditional" broadband over copper or cable TV lines continues its expansion in many countries, telecommunications operators have begun to deploy so-called "next generation access networks" (NGANs), that is, fibre-optic access networks, to provide high-speed broadband services to consumers. Though the deployment of next generation access networks is still at an early stage, as recently documented in the study "Digital Agenda for Europe" (2011), many incumbent and alternative operators have planned to invest in the near future in these new broadband infrastructures.

Investment in fibre infrastructure is extremely relevant not only for the communications sector per se, but also for the overall economy given its significant potential contribution to economic growth. Many recent papers quantify the macroeconomic effects of such investments. Röller and Waverman (2001), using data from 21 OECD countries over a 20-year period, show that an increase of 10% in the broadband adoption rate leads on average to an increase of 2.8% in GDP growth. More recently, Koutroumpis (2009) shows that the average impact of broadband infrastructure on GDP is 0.63% (for the EU-15, in the period 2002-2007), that is, 17% of total growth in this period. He also shows that there are increasing returns from broadband investments, once a critical mass is reached.[1] Greenstein and McDevitt (2009) show that broadband accounted for $28 billion of US GDP in 2006, and they estimate that $20 to $22 billion of GDP were associated with household use

[1] He evaluates the critical mass at 30% of broadband penetration.

of broadband. Finally, Czernich *et al.* (2011) find that, after a country has introduced broadband, GDP per capita is 2.7 to 3.9 percent higher on average than before its introduction. In terms of subsequent diffusion, a 10 percentage point increase in broadband penetration raises annual per-capita GDP growth by 0.9 to 1.5 percentage points.

High-bandwidth infrastructure however calls for large capital expenditures, attracting regulatory concerns about third party access to these networks. Following the EU Recommendation C(2010) 6223 on regulated access to NGANs (September 2010, "NGA Recommendation"), in Europe, national regulatory authorities have been adopting a new set of regulatory rules on network access which is intended, on the one hand, to avoid re-monopolization of the market for high-speed broadband services by calling for some kind of regulated access to NGAN infrastructure, and, on the other hand, to provide enough incentives to invest in high speed infrastructures to both incumbent and entrant operators.

The aim of this paper is to contribute to this important debate by focusing on three hotly debated issues: first, the problem of migration from the legacy copper network to the NGA infrastructure, and how wholesale pricing regulation might affect this process; second, the introduction of differentiated wholesale remedies according to geographical differences that might emerge in the deployment of NGANs in a country; third, and finally, the impact of co-investment decisions on market outcomes and their interplay with access regulation. The approach is to present the main economic and regulatory problems that are emerging in the policy arena and, using recent economic literature, to provide some discussion and proposals for guidelines that might be useful to regulators and policy makers.

The rest of the paper is organized as follows. In Section 2 the economic and regulatory aspects

of migration from the legacy to the NGA networks are analyzed. In Section 3 the geographical dimension of regulatory intervention is considered, while Section 4 studies co-investment. Section 5 concludes with some policy considerations.

2 The Migration to NGAN: the Interplay between Investment Incentives and Access Pricing

The new investments in NGAN will not immediately replace the copper or cable legacy networks, suggesting that the transition from old infrastructures to new infrastructures will go slowly. Replacement will be gradual for several reasons, such as: (*i*) the regulatory constraints on copper networks, which rule out an immediate switch-off of the old network; (*ii*) the uncertainties about demand and investment costs, which call for a progressive investment strategy; and (*iii*) the financial market constraints that imply that roll-out must be phased.

This implies that, during a transition phase, two different infrastructures will operate, and presumably each type of network will be regulated with a different set of rules. The incentives to invest in NGAN infrastructures will therefore be influenced not only by the terms of access set for fibre infrastructures, but also by the terms of access set for the legacy copper networks. Hence, a new regulatory problem arises: the interplay between the (potentially different) access regulations on the existing old network and on the new networks, in the context of new infrastructure investments.

The NGA Recommendation underlines how regulatory policies during the migration phase can be fundamental in determining the incentives to invest in new infrastructures. It states that "existing obligations [..] should continue and should not be undone by changes to the existing

network architecture and technology, unless agreement is reached on an appropriate migration path between the SMP operator and operators currently enjoying access to the SMP operator's network" (Article 39).

Regulators play a distinctive role in this process. Article 40 states that "NRAs should put in place a transparent framework for the *migration from copper to fibre-based networks*. NRAs should ensure that the systems and procedures put in place by the SMP operator [...] are designed so as to facilitate the switching of alternative providers to NGA-based access products" (our emphasis). In this respect, the Recommendation not only stresses that existing regulatory tools on the legacy network should be maintained in the medium term, but also that a new set of rules should be introduced to facilitate the migration from old to new infrastructures. However, the Recommendation is completely silent about the potential interplay between the access remedies on both old and new networks. It also seems to neglect the potential impact of access regulation on the legacy network on the incentives to invest in new infrastructures, for both alternative and incumbent operators.

The migration issue has recently received considerable attention also by market specialists. In a recent report for the European Competitive Telecommunication Association (ECTA), WIK (2011) explores a network competition model calibrated with engineering cost model data.[2] Among the many results of the simulations run, one take-away is that lower access charges to legacy networks encourage incumbents to invest in NGNs, and thus allow a rapid switch-off of the copper network in places where fibre is already installed. In contrast, a high access charge for the copper network reduces incentives for fibre investments, because moving access seekers' customers to fibre cannibalizes the incumbent's existing access profits.

[2]Steffen Hoernig participated in the WIK study.

On the other hand, the report by Plum (2011) for the European (incumbent) Telecommunications Network Operators (ETNO) claims that a low access price for copper discourages NGA infrastructure investment. This is because it leads to low prices for standard broadband, which encourages retail customers to stay on copper, thereby negatively impacting the business case for fibre. Both the WIK and the Plum documents stress that the access charge for the legacy network has a major influence on the transition to NGANs, however, its impact is disputed.

A vibrant academic literature has developed around the relationship between access pricing and investment incentives.[3] More related to the migration issue, Brito *et al.* (2010) analyze the incentives of a vertically integrated firm (regulated at the wholesale level) to invest in and to give access to an upgraded wholesale technology. Brito *et al.* assume that the new technology is not subject to regulation, and analyze the regulator's decision depending on whether the innovation is drastic or non-drastic. In the presence of a non-drastic innovation (such as Ethernet connectivity, 4G mobile networks and NGAN, at least in the short run), monopolization of the industry is not a concern, and hence, the regulator can increase the entrants' competitiveness by setting a low access charge on the copper network and let them compete fiercely with the incumbent. On the other hand, if innovation is drastic in nature (NGAN and 4G connections in the long run), the incumbent can monopolize the market, and therefore the regulator should introduce specific incentives for entrant operators to invest in alternative infrastructures.

The first academic analysis of migration is provided by Bourreau, Cambini and Doğan (2011). The authors consider a model where access to the legacy copper network (in the form of local

[3]See, for example, Gans (2001 and 2007), Foros (2004), Avenali *et al.* (2010), Vareda and Hoernig (2010), Manenti and Scialà (2011). For recent comprehensive surveys of theoretical and empirical contributions in this area, see Cambini and Jiang (2009) and Bourreau, Doğan and Manant (2010).

loop unbundling) is available everywhere in a country, and an incumbent and an entrant operator compete for the provision of retail broadband services to consumers.

In their setting, the country is composed of a continuum of areas, for which the fixed cost of a new network varies. Firms sequentially decide on their investments in NGNs, with the incumbent firm as the first mover, due to its control over the legacy network and over other essential facilities such as ducts. However, the incumbent's investment generates positive spillovers: the entrant's fixed cost of investing in a new network is assumed to be lower in the areas where the incumbent has already rolled out its NGN than in those areas where an NGN is absent.[4] Access to the legacy network is regulated, while in a first step the NGAN is totally unregulated. The authors also present the case in which both operators are obliged to grant access to their rival in areas with a monopoly fibre infrastructure, and analyze the relation between the access charges on the old and the new infrastructures.

In the competition stage, three conflicting effects emerge in this setting: (i) when the access charge for the existing infrastructure is set at a high level, the entrant's opportunity cost of investment is low, which promotes infrastructure investment by the alternative operator (this corresponds to the so-called *replacement effect*[5]); (ii) in the presence of a positive investment spillovers, a higher access charge increases the incumbent's opportunity cost of investment due to the *wholesale revenue effect*: if the incumbent invests in a higher quality network, the entrant will invest in reaction, and

[4]For example, when the incumbent builds an NGN in a given area, it may have to obtain administrative authorizations, gather information on existing ducts or rights of passage, etc., which generates administrative and contractual costs. When the entrant decides to roll out its own NGN network in the same area, its investment costs are lower if it benefits from these incumbent's earlier efforts. Other potential reasons could be informational spillovers, as well as direct cost savings due to infrastructure sharing.

[5]This effect implies that, everything else held constant, a monopoly firm has lower incentives to invest in an innovation than a competitive firm, as the former "replaces" itself. See Bourreau *et al.* (2010) for a general description of this effect in the telecoms industry.

the incumbent will then lose some wholesale profits – this effect is present in WIK (2011); and finally (*iii*) when the access charge on the legacy network is low, the prices for the services which rely on this network are low, hence, in order to encourage customers to switch away from the legacy network, operators would need to make low-priced fibre offers, which is line with Plum (2011)'s main argument. This latter effect, which we refer to as the *business migration effect*, reduces the profitability of the new infrastructure, and hence, the incentives to invest in it.

The coexistence of these multiple effects creates a non-monotonic relation between the access price for copper and the investments in the new access technology (i.e., the coverage of the NGNs).

>From a social point of view, there can be conflicts between different potential objectives: (*i*) a higher access charge on the legacy network stimulates investment by entrants and sometimes (but not always) by incumbents, enhancing dynamic efficiency; (*ii*) however, a higher access charge negatively affects static efficiency due to higher retail prices in uncovered areas, and duplication of fixed costs. Using simulations, the authors show that the socially optimal access charge to the legacy network depends on the degree of investment spillovers: If the degree of spillovers is relatively small, the regulator should set the legacy access price at marginal cost; conversely, when spillovers are strong, the access charge should increase proportionally with spillovers. Intuitively, if the entrant can obtain a considerable reduction in its investment cost due to the spillover from the incumbent's investment, then the regulator should raise the access charge to the legacy network in order to favor investment. The idea is that, when there are strong spillovers, the incumbent's investment stimulates the entrant's investment. To avoid losing wholesale revenues, the incumbent has incentives to reduce its NGN investment. In this case, the entrant does not invest much either, as it faces high investment costs. This is why the regulator should increase the access price on the

legacy network in order to provide both firms with stronger investment incentives to invest and counter balance the spillover effect.

When access to both the old and the new infrastructures is regulated, the authors highlight the presence of an interplay between the two access regimes. A new feature of regulatory intervention therefore emerges: the access rules to legacy as well as the NGN infrastructures cannot be considered separately, on the contrary the ex ante rules on one infrastructure affects the ex ante rules on the other. More specifically, given that the incumbent typically manages the existing legacy network, the interplay between access pricing regimes on the existing and new infrastructures depends on which company is the "leader" in the deployment of the NGN.

The idea is that the access charge on the legacy network affects the trade-off for the regulator between setting a high access charge on the NGN, which would extend marginally the area with a monopolistic NGN, and setting a low access charge, which would limit the deadweight loss in the areas with the monopolistic infrastructure.

When the incumbent is the "leader" in the deployment of an NGA network, raising the access price on the legacy network has three effects, which all gives the incentive to the regulator to increase the access charge on the NGN. First, a higher access charge on the legacy network reduces the size of the area with a monopoly NGN infrastructure, as it intensifies the *wholesale revenue effect*, hence reducing the incumbent's investment incentives. This, in turn, reduces the deadweight associated to a high access charge on the NGN. Second, a higher access price on the legacy network reduces welfare in the areas not covered by an NGN. Hence, the regulator has an incentive to expand marginally the area covered by an NGN and to reduce the uncovered areas where retail prices tend to increase. Third, the frontier between the uncovered areas and the areas with a monopolistic

NGN becomes more sensitive to the access price on the NGN; this also gives an incentive to the regulator to increase the access charge on the NGN. All in all, when the incumbent is the "leader" in the deployment of NGN, the socially optimal access charge to the monopoly NGN comes out to be positively related to the access charge on the legacy network.

On the contrary, if the entrant invests more than the incumbent in NGN (i.e., the entrant is the "leader"), a higher access charge to the legacy network increases the entrant's investment incentives because the *replacement effect* is reduced. Since the size of the areas with a monopoly NGN increases, the regulator has an incentive to lower the access charge on the NGN to reduce the deadweight loss in these areas. At the same time, the marginal gain of rolling out an NGN in uncovered areas can either increase or decrease, which gives the incentive to the regulator to either increase or decrease the access price on the NGN. Finally, the frontier between the uncovered areas and the areas with a monopoly NGN becomes less sensitive to the access price on the NGN, which gives an incentive to the regulator to decrease the access charge on the NGN. At the end of the day, it turns out that when the access price on the legacy network increases, the regulator should either lower or increase the NGN access charge. Hence, the relation between the socially optimal access charge on the monopoly NGN and the access charge on the legacy network can be reversed, when the entrant is the "leader".

3 The Geographical Dimension of Regulatory Intervention

A complicating feature for next generation network deployment and associated regulatory interventions is that competition among high-speed networks is likely to emerge only in specific geographical

areas, such as very dense metropolitan areas, while in the rest of the country infrastructure competition will not arise. From a regulatory point of view, this implies that rules should differ across areas.

As stated in the NGA Recommendation, "the transition from copper-based to fibre-based networks may change the conditions of competition in different geographic areas and may necessitate a review of the geographical scope of markets [...] and remedies in cases where such markets or remedies have been segmented on the basis of competition from local loop unbundling (LLU)" (recital 10). The NGA Recommendation thus invites NRAs to examine differences in the degree of competition in different geographical areas in order to determine whether the definition of sub-national geographic markets or the imposition of differentiated remedies are warranted.

While this is plausible from the competition law point of view now popular in telecoms regulation,[6] there is a lack of theoretical investigations about the type and the linkage –if any– of different remedies and their impact on firms' investment decisions.

Lestage and Flacher (2010) is one of the first papers that address the issue of geographical coverage and access pricing. In their model, the incumbent operator and an entrant decide simultaneously where to roll-out a new infrastructure. In order to take into account the differences in geographical coverage, the authors assume that the investment cost in NGA networks increases as the density of population decreases. Their main result is that access regulation reduces the regions where facility-based competition is likely to emerge to the areas with the highest population density.

As shown by Nitsche and Wiethaus (2011) and Cambini and Silvestri (2011), risk sharing –

[6] Xavier and Ypsilanti (2011) analyze the implementation of geographical regulation in a few countries (including the UK, Australia, Austria, and Portugal), and highlight the complexity in practice of geographically segmented regulations.

that is, the possibility for the incumbent and the entrants to jointly undertake and share the costs of the investment– might be an alternative instrument to access price regulation, enhancing dynamic efficiency (by expanding fibre networks' coverage), consumer surplus and social welfare. Risk sharing, in fact, leads to better outcomes in terms of social efficiency than alternative modes of regulation, such as partial regulation (when ex-ante intervention applies only to the legacy network, while the NGN is left unregulated) or full regulation (where also access to NGN is regulated), especially when the entrants have a better ability to provide new broadband services.

Bourreau, Cambini and Hoernig (2011a) explicitly consider the presence of geographically differentiated NGN access regulation and analyze the impact of such rules on investments in new access networks. The authors develop a model with a continuum of areas. Two operators decide to deploy their own networks as long as the investment costs are recovered by equilibrium profits. In equilibrium, there is infrastructure competition only in a fraction of the country, while in the rest, infrastructure monopolies emerge. While all new networks are subject to third party access obligations, the access rules may differ between competitive (i.e., duopoly) and monopolistic infrastructure areas. They then revisit different regulatory regimes and analyze how each regime affects the incentives to invest in the different sub-markets. More specifically, they evaluate the impact on investment incentives of different regulatory access rules such as: cost-based access pricing, where the access charges are set at the (long run) marginal cost in each area; uniform access pricing, where the regulator sets a uniform access charge in all areas; and finally, a "light regulation" regime where access charges are set on a commercial basis, except that the regulator imposes that the NGN access price should not be too high so as to foreclose the potential entrants.

The authors show that higher NGN access charges lead to larger NGN coverage, both in the

monopoly and in the duopoly areas. This result implies that the regulator will face a dilemma between setting a lower access charge to maximize per-area welfare, hence maintaining lower retail prices, and setting a high access charge to maximize coverage. This trade-off is analyzed under different regulatory scenarios. In presence of a cost-based regulation, total coverage turns out to be lower than in the benchmark case where access is unregulated. Hence, the standard cost based regulation –that has been traditionally applied to regulate access to the legacy copper network– might deprive investment incentives in new high-speed infrastructures.

Interestingly, however, the analysis points out the presence of an interplay between the social optimal NGN access charges in the two areas, i.e., the duopoly and the monopolistic NGN zones: it emerges that the two different access charges should be positively correlated one with each other. In other words, if the regulator sets a very low access charge in the monopoly zone, it should also set a low access charge in the duopoly zone. Intuitively, if the access charge in the monopolistic area is low, per-area welfare is high in the monopoly area, and therefore the social net benefit of extending the duopoly area (over having a monopoly infrastructure in the area) is low. Therefore, the regulator should set a low access fee in the duopoly area too, and this has two positive effects: first, it increases per-area welfare in the duopoly area due to intensified competition, and second, it reduces the duopoly area. In this case, reducing the duopoly area is socially beneficial because the net social benefit of having a duopoly infrastructure instead of a monopoly infrastructure is lower, due in particular to the duplication of fixed costs.

In presence of a uniform access pricing rule, that is, when the access fee should be the same in both the duopoly and monopoly areas, the authors show that the social benefit of expanding the duopolistic NGN area depends on the degree of service differentiation among broadband operators.

If the differentiation is limited, with a uniform access charge the social gross benefit of expanding the duopoly area is lower than the duplication cost. In other words, from a social point of view, the duopoly area is too large. On the contrary, if the degree of differentiation is sufficiently high, and the access charge is also sufficiently high, then the social gross benefit of expanding the duopoly area is larger than the duplication cost. In this case, it is socially optimal to expand the duopoly infrastructure area and to socially sustain competition among facility-based NGN operators.

Finally, in presence of a light intervention for the NGN access regime, the results show that imposing as a remedy that the NGN access price should not be too high so as to foreclose the potential entrants, generates a positive effect on total coverage, that increases relatively to the case in which access to NGNs is left totally unregulated; the coverage of the duopoly area is also expanded.

In sum, it emerges that traditional cost-based access methods are no longer the best regulatory tools when new infrastructure investments should be realized, and that the degree of product differentiation should matter in the regulatory decision of raising access fees to the NGN.

4 Co-investment and Access Remedies

Since the principal barrier to entry in network markets is the cost of constructing the physical network, a logical manner to increase NGAN coverage seems to be to invite operators to invest jointly rather than individually. This approach is gaining support, and has already been adopted in metropolitan France. The main NGA-specific twist introduced there is that co-investing operators lay multiple fibre lines instead of just one, so that operators can engage in full facility-based

competition while sharing in the cost of digging as well as other lump-sum costs.

Letting network operators coordinate at the investment level naturally raises concerns that they might then attempt to collude at retail level, leading to higher retail prices and a reduction in consumer surplus. Thus access obligations are likely to be imposed, which can be taken up by existing operators or by entrants who will not invest in an own network.

Bourreau, Cambini and Hoernig (2011b) analyze the effect of cooperative investment on NGN coverage and its interplay with access obligations in a model where two operators invest in coverage and an entrant may ask for access. They address several research questions concerning coverage, the effects of collusion, and access obligations.

One question that Bourreau *et al.* address is whether the introduction of co-investment could be a feasible way of increasing overall coverage in the absence of access provisions, assuming that firms were to compete in retail markets. The answer is largely negative, unless specific circumstances apply. The reason is that the most costly regions covered in equilibrium are those where retail returns just cover the investment cost. Under competition the sum of retail returns of the (competing) co-investors are most likely below the monopoly profits. Thus, the most expensive areas will remain monopolies, which implies that their coverage is the same with and without co-investment.

The latter conclusion does not hold, though, if the sum of retail profits is larger than the monopoly profits. This would happen if the introduction of competition (and thus of more variety) leads to a strong demand expansion effect, for example because consumers' tastes are very heterogenous. In the latter case, and only in this case, the total coverage increases because of co-investment.

A different path to increasing coverage through co-investment would be through collusion in

retail price setting, i.e., the joint setting of higher retail prices by co-investing networks. While this would evidently not be desirable from the point of view of consumers already covered by a network, again the expectation of higher retail returns would encourage networks to cover more remote areas.[7] The thought of collusion of course collides head-on with the original idea for promoting co-investment, which is to increase retail competition.

The usual measure to avoid collusion and increase competition in a retail market is to facilitate entry, especially through access provisions. Obligations to give access to new NGA infrastructure have indeed been imposed in Europe, and their effects on the incentives for network coverage have been widely discussed. Bourreau *et al.* confirm this result also in the presence of co-investment. On the other hand, they consider the effect of access on the co-investment decisions themselves. They find that the outcome is quite complex and that co-investment is non-monotonic in the access price. Essentially, results are driven by the relative magnitude of returns from co-investing in one additional area or asking for access there, where the latter depends on the level of the access price and on entry.

For a very low access price, entry of access seekers will occur in all covered areas, including the most competitive ones where networks have co-invested. For a medium-range access price, entrants only enter where the other network also asks for access, but do not enter co-investment areas. This strategy increases networks' incentives for co-investment and thus the areas where the latter takes place. For high access charges entrants stay out and only installed operators ask for access to each others' covered areas. In this case, incentives for co-investments are diminished as compared to

[7] See Inderst and Peitz (2011) for related arguments in a setting where access is not regulated but access provider and seeker freely conclude "efficient" contracts. The latter invariably involve restrictions to competition in order to increase retail returns.

the previous case, since retail revenues in access areas have increased. Finally, for extremely high access charges no access requests are made and the market outcome is identical to the one without access.

Thus, in the last case the co-investment area is largest, since under access networks trade off the returns from co-investment with those from retail competition under access. Without access the latter would be zero, and therefore, any kind of access provisions reduces the incentives for co-investment. Interestingly, though, the size of the co-investment area is not monotonous in the level of the access price. In other words, it would be wrong to believe that, if the introduction of access obligations were to be taken for granted, more co-investment could only be achieved through increasing the access price. Rather, one needs to take into account the networks' incentives to ask for access themselves instead of investing, and how the latter interact with the entrants access decisions. It turns out that intermediate values of access prices lead to the largest amount of co-investment if access obligations are to be imposed.

5 Discussion and Conclusions

>From the above it has become clear that once one takes further steps beyond the much-researched question of whether access obligations harm investments into next-generation access infrastructures, a host of additional complexities arise and the picture quickly becomes blurry. In the transition from existing to new infrastructure, it is not only access to fibre that shapes incentives, but equally it is the access regime for existing copper networks that influences strongly how much interest both network owners and access seekers have in making this transition. While there is unanimity that

the effect of copper access is strong and that access to both platforms need to be coordinated in the transition phase, there are starkly contrasting results about how this coordination is to be done.

The analysis shows that the access charge on the legacy network has an ambiguous effect on investment on NGNs, which can be either positive or negative. When an access obligation on monopoly NGN infrastructure is introduced, the regulator should also set the NGN access price in relation to the access charge on the legacy network.

If the regulator imposes differentiated wholesale remedies according to geographical differences in NGAN deployment, it emerges that traditional cost-based access methods might be no longer the best regulatory tool to sustain NGN coverage, but also that regulatory decisions should be conditioned on the degree of product differentiation among operators in order to avoid an excessive duplication of fixed costs. On the contrary, a form of "light" intervention that imposes as a remedy that the NGN access price should not be too high so as to foreclose the potential entrants, generates a positive effect on total coverage, that increases relatively to the case in which access to NGNs is left totally unregulated.

Co-investment may not be an effective means to increase overall coverage, but rather to make covered areas more competitive. Its relationship with access pricing to NGAN is rather complex, since asking for access may be a viable alternative to entering a co-investment agreement. Therefore access prices have a non-monotonic relationship with the amount of co-investment and increasing the access price may lead to less co-investment.

To sum up, the deployment of NGANs calls for the implementation of new regulatory regimes, as the old regimes cannot be applied per se. These new regimes should account in particular for the competition between the "old" copper technology and the "new" fiber technology, the geographical

dimension of investments, and the need for cooperative investments. This is a complex task, and we think that further research on these topics would be helpful to understand better the relation between regulation and investment in NGNs.

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