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# Next Generation Access Networks: The Effects of Vertical Spillovers on Access and Innovation

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## Abstract

The model that we develop here considers that an upstream firm sells a vital input to downstream firms. There are vertical spillovers and two different regulatory policies of the input price: cost oriented regulation and no-regulation. We also admit two alternative market structures: vertical integration and vertical separation. With this setting we study the effects of the spillovers on foreclosure and on the investment of the upstream firm with and without access price regulation in the two market structures. We conclude that in this setting foreclosure is not a necessary outcome and that the investment of the upstream firm depends on the values of the spillovers of each firm. The increase of the investment with regulation is more likely with vertical separation but it can also happen with vertical integration although this is not a typical result.

*JEL Classification:* L51, L96

*Keywords:* access price regulation, vertical integration

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# 1 Introduction

Around the world many incumbent firms and other operators in the electronic communications sector are planning, and in some cases already implementing, huge investments in Next Generation Networks (NGN). NGNs "are broadband networks that allow integrated data, voice and video services through the deployment of Internet Protocols" (Cohen, 2007). NGNs can be developed using several technologies, including fibre, cable, fixed, mobile wireless and others. The more important features of NGNs is that they are packet-based, Internet Protocol-based and allow the provision of multiple services (Cohen, 2007). The Next Generation Access Networks (NGANs) are independent from services and allow the provision of different services, as TV, internet access, voice and others. At the access level it is expected platform competition between fixed lines, cable, mobile, wireless and satellite (European Telecommunications Platform, 2006) but this requires the development of new technologies (fibre in the fixed network, for instance) in the access networks. There is the expectation that the investment in NGNs will improve the quality of communications (in particular due to an increase in access speeds), will deepen technological convergence, will allow the use of a single network to deliver different forms of traffic and, quite importantly, will allow the reduction of the operators costs (Ruhle and Reichl, 2007; Marcus and Elixmann, 2007).

From a regulatory point of view the NGANs place new challenges but also rise out old discussions. The European incumbent firms are asking a new regulatory framework that will allow them to recover the investments in NGANs. The increase in competition between different platforms reinforces their argument in favor of lighter regulation. However, regulators are concerned that the new infrastructures can create new monopolies at the access level (Amendola and Pupillo, 2007). In this context several authors (for instance Waverman and Dasgupta, 2006 and Amendola and Pupillo, 2007) propose a geographically differentiation of the access regulatory policy. The authors argue that in markets where competition is feasible, forbearance is appropriate, but in markets where competition is not expected it might be prudent to maintain access regulation in order to avoid bottleneck in the same way it currently happen on local loop and broadband access. However, asymmetric

access regulation imposed on incumbents to strength competition, discourages the investment in infrastructure and in innovation.

In this paper we discuss the above questions introducing an additional issue: the effects of vertical spillovers from investment in NGNs on the regulatory policy about access. When the benefits of the networks investment spread out to the firms that use the network, these effects should be considered in the access regulation discussion.

Building in a model inspired on d'Aspremont and Jacquemin (1988) we analyze the effects of vertical spillovers on access regulation. We consider a framework with no competition between networks, so our analysis applies to the geographical markets identified by Amendola and Pupillo (2007) where competition between networks is not expected in the near future.

We contemplate a market with an incumbent firm that will undertake an investment in network upgrade. The incumbent firm provides network access to downstream firms that offer services to final consumers. The investment undertaken by the incumbent firm allows the downstream firms to reduce their costs. The magnitude of the cost reductions depends on the ability of the downstream firms to take advantage of the network upgrade. Therefore, the vertical spillovers depend on the downstream firms absorptive capacity (Kamien and Zang, 2000; Grunfeld, 2003) to explore the NGN new functionalities. Downstream firms can have different absorptive capacity due to past development of internal competencies. The market structure can be one of two types: under the first scenario, the incumbent firm is vertically integrated and owns one of the downstream firms. The independent downstream firm has to buy network access from the incumbent firm. Under the second scenario there are vertical separation and the upstream firm sells access to both downstream firms.

Additionally, we study two alternative ways of defining the access price that correspond to two different regulatory approaches in discussion. Under the first regulatory policy we assume a forbearance policy, that is, we assume that the regulator does not impose any rule on the access price. The objective of this policy is to encourage NGN investments. In fact this policy is demanded by several incumbent firms. For instance, in 2005 Deutsche Telekom demands no regulation on pricing

or third party access as a condition to invest in new generation broadband fiber network (Blum et al., 2007). The second regulatory policy is the regulation of the access price with a cost orientation perspective. This second approach represents a policy that is an extension of current wholesale regulation on local loop unbundling and on broadband access.

To compare the results from the two regulatory policies we developed a model using the game theory approach in order to point out the interdependence between investment and regulatory decisions. Therefore, and for both market structures, we assume that first the incumbent firm has to decide about the amount of investment in the network. Then, at a second step, we consider two alternative ways of defining the access price: one is to let the incumbent firm define the access price that maximizes its profit, the other is to consider the cost orientation regulation of the access price. Finally, firms decide the quantities in the downstream market. Then, it is possible to know the equilibrium price and profits.

Our results show that in the case of vertical integration if the independent firm has a greater capacity to absorb the network update than the subsidiary firm the foreclosure result does not appear even when there is no regulation. This means that the independent firm is able to obtain a positive profit and then access regulation is not necessary to guarantee downstream competition. Note that this result contradicts the vertical integration literature. Actually without spillovers foreclosure appears as the expected behavior of the incumbent firm.

We also conclude that the investment of the incumbent firm depends on the value of the spillovers and on the relation between the absorptive ability of the two firms. In the case of vertical integration the investment of the incumbent firm will decrease with regulation except for enough small values of the spillovers of the subsidiary firm. With vertical separation regulation will increase the investment if the values of the spillovers for the two firms together are not very high. However, if spillovers are significant, regulation can harm the investment of the incumbent firm and this recommends careful foresight in the definition of access regulation policy in this case.

## 2 The model

We consider an upstream monopoly, which could be the historical incumbent firm, which sells network access to downstream firms. The retail market is an unregulated duopoly market with two firms that compete on quantities.

The upstream monopolist undertakes an investment in network upgrade by the amount of  $x$ . This investment leads to a reduction on the upstream firm's cost and also allows a cost reduction for the downstream firm's depending on their ability to absorb the innovation. The vertical spillovers, which translate these abilities, are represented by the reduction of the downstream costs by  $\beta_1 x$  and  $\beta_2 x$ , respectively for downstream firms 1 and 2. We assume that  $0 < \beta_1 \leq 1$  and  $0 < \beta_2 \leq 1$ , i.e., there are positive spillovers for both firms. If  $\beta_1 \neq \beta_2$  firms have different absorptive capacity to translate the networks upgrades into cost reductions. For simplicity, we assume that the production of one unit of the final service requires one unit of the input (fixed coefficients technology). Also, we assume that the quality of the access sold by the monopolist is the same whether it is sold to firm 1 or firm 2 (non-price discrimination) and we consider a homogenous final product.

The final consumers demand is represented by the linear function  $p = 1 - q_1 - q_2$ .

The time of the game is the following: in stage 1 the upstream firm decides the investment amount of  $x$ . Then, in stage 2, there is a decision about the access price  $w$ . We consider two hypothesis: (i) the upstream firm decides the price in order to maximize its profits (forbearance hypothesis) or (ii) the regulatory authority decides the access price with a cost-orientation perspective (access regulation hypothesis), i.e., fixing  $w$  equal to the marginal cost of the upstream activity. Finally, in stage 3, firms decide the quantities.

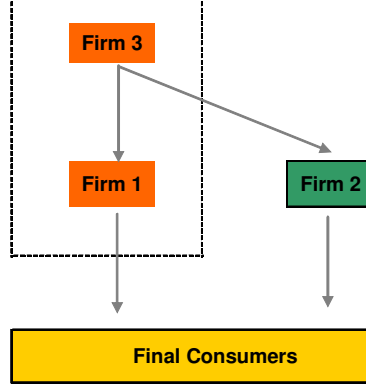
The game is solved by backward induction, considering separately two scenarios for market structure: vertical integration and vertical separation.

### 2.1 The game with vertical integration

Vertical integration implies that the upstream firm (firm 3) and one of the downstream firms (firm 1, for instance) belong to the same economic group and coordinate their decisions. Hence they have a joint profit function. The market structure is

represented in figure 1.

Figure 1 - Vertical Integration



The profit function of the vertically integrated firm is:

$$\pi_{1+3} = (p - w + \beta_1 x)q_1 + (w - c + x)(q_1 + q_2) - \frac{x^2}{2}$$

which is equivalent to

$$\pi_{1+3} = (p - c + x + \beta_1 x)q_1 + (w - c + x)q_2 - \frac{x^2}{2}$$

where  $c$  is the marginal cost of the upstream activity with  $c < 1$ ,  $w$  is the access price (with  $w \geq c$ ) and  $\frac{x^2}{2}$  is the investment cost.

The profit function of the independent downstream firm 2 is:

$$\pi_2 = (p - w + \beta_2 x)q_2$$

For simplicity, it is assumed that the cost of buying other inputs is equal for both downstream firms and normalized to zero.

In the downstream market firms choose the quantities that maximize their profits considering the rival quantity as constant (Cournot competition). Then, the optimal quantities conditional on  $w$  and  $x$  are  $q_1 = \frac{1-2c+w+2x+2x\beta_1-x\beta_2}{3}$  and  $q_2 = \frac{1+c-2w-x-x\beta_1+2x\beta_2}{3}$ .

We analyze two different cases for the definition of the access price: forbearance and regulation.

### Forbearance

Under this case the regulator does not impose any constraint on the access price. Then, the integrated firm chooses the price that maximizes its profit, obtaining  $w = \frac{5+5c-5x+x\beta_1+4x\beta_2}{10}$ . Using this result, the investment amount that maximizes the incumbent firm profit is  $x^{VIF} = \frac{5(1-c)(1+\beta_1)}{8\beta_1\beta_2-10\beta_1-9\beta_1^2-4\beta_2^2+5}$ .



To guarantee that  $x^{VIF}$  is always positive we consider assumption 1 about the relation between  $\beta_1$  and  $\beta_2$ .

**Assumption 1:** Assume  $\beta_2 < \beta_2^{\max}$  with  $\beta_2^{\max} = \beta_1 + \frac{1}{2}\sqrt{5}\sqrt{1 - \beta_1^2 - 2\beta_1}$ . The value of  $\beta_2^{\max}$  is defined for  $\beta_1 \leq 0.41421$ .

Assumption 1 requires that the absorptive capacity of firm 2 is higher than the one of firm 1, but can not exceed it by more than a certain amount.

Considering  $x^{VIF}$ , the equilibrium values under vertical integration and forbearance are the following:

$$\begin{aligned} q_1^{VIF} &= \frac{(1-c)(3\beta_1\beta_2 + \beta_1 - \beta_1^2 - 2\beta_2^2 + 5 - \beta_2)}{y} & q_2^{VIF} &= \frac{2(1-c)(1+\beta_1)(\beta_2 - \beta_1)}{y} \\ p^{VIF} &= \frac{1}{2}(1+c) + \frac{(1-c)(5+8\beta_1+2\beta_2+2\beta_1\beta_2+3\beta_1^2)}{2y} & \pi_2^{VIF} &= q_2^2 \\ w^{VIF} &= \frac{1}{2}(1+c) + \frac{(1-c)(4\beta_2-4\beta_1-5+4\beta_1\beta_2+\beta_1^2)}{2y} & x^{VIF} &= \frac{5(1-c)(1+\beta_1)}{y} \end{aligned}$$

where  $y = 8\beta_1\beta_2 - 10\beta_1 - 9\beta_1^2 - 4\beta_2^2 + 5$ .

**Proposition 1:** Under assumption 1 and if  $\beta_2 > \beta_1$  the output and profits of firm 2 are positive under the forbearance regime.

Then, under the vertical integration hypothesis, foreclosure is not a necessary outcome when the access is not regulated. This means that, even with a monopoly at the upstream level, the access regulation is not necessary to allow the presence of the independent firm at the downstream market as long as the independent firm has a greater capacity to translate the network updates into cost reductions than its rival.

This result draws the attention to the effect of asymmetric absorptive capacity between downstream firms on the access regulation policy. When the independent firm has a greater absorptive capacity the standard result from vertical integration literature – foreclosure - does not appear.<sup>1</sup> Consequently, this is an argument in favor of the forbearance regime.

### Regulation

In this case the regulator sets the access price equal to the marginal cost of the upstream activity,  $w = c$ . The investment level that maximizes the vertically

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<sup>1</sup>For a detail analysis of vertical foreclosure and its relation with access regulation see Rey and Tirole (2007).

integrated firm profit is  $x^{VIR} = \frac{(1-c)(4\beta_1-2\beta_2+7)}{8\beta_1\beta_2-10\beta_1-4\beta_2-8\beta_1^2-2\beta_2^2+7}$ . Under assumption 1  $x^{VIR}$  is always positive.

Considering  $x^{VIR}$  the equilibrium values for the regulation case are the following:

$$q_1^{VIR} = \frac{1-c}{z}(5\beta_2-4\beta_1-7) \quad q_2^{VIR} = \frac{1-c}{z}(7\beta_1-4\beta_2-6\beta_1\beta_2+4\beta_1^2+2\beta_2^2)$$

$$p^{VIR} = \frac{1}{3}(1+2c) + \frac{(1-c)(7+11\beta_1+5\beta_2+2\beta_1\beta_2+4\beta_1^2-2\beta_2^2)}{3z}$$

Where  $z = 8\beta_1\beta_2 - 10\beta_1 - 4\beta_2 - 8\beta_1^2 - 2\beta_2^2 + 7$ . By assumption 1  $z$  is always positive.

### Comparison of the results

**Proposition 2:**  $x^{VIF} > x^{VIR}$  if  $\beta_1 > \beta_1^c$ , with  $\beta_1^c = \frac{3}{4}\beta_2 + \frac{1}{8}\sqrt{4\beta_2^2 - 52\beta_2 + 49} - \frac{7}{8}$ .

Under the vertical integration hypothesis we found that the equilibrium value of the investment is higher without regulation than with regulation, as it would be expected, except for a small interval of values for  $\beta_1$  and  $\beta_2$ . Comparing the equilibrium values of the investment under both cases we conclude that forbearance leads to a higher investment if  $\beta_1 > \frac{3}{4}\beta_2 + \frac{1}{8}\sqrt{4\beta_2^2 - 52\beta_2 + 49} - \frac{7}{8}$ .

Then, as long the absorptive capacity of the subsidiary firm is not too distant from the absorptive capacity of the independent firm, the forbearance regime leads to higher investment than access price regulation.

Notice that an unexpected result is possible. When the independent firm has a higher capacity of translating the investment into cost reduction relatively to its rival firm, the access price regulation regime stimulates more the investment than the forbearance regime. Our intuition for this situation is the following. Access price regulation benefits the independent firm. The independent firm has a relatively high capacity to translate the investment into cost reduction. Then the investment leads to significant firm's 2 cost reduction which implies a decrease in the final price, and a higher output for both firms. Hence, firm 1 has a greater incentive to invest because it benefits from firm's 2 reduction cost, although it does not have profits with the upstream activity.

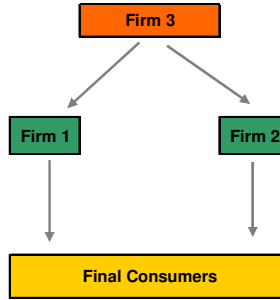
In order to illustrate this situation we compute the equilibrium values for a particular case:  $\beta_2 = 0.6$  and  $c = 0.1$ . For these values the investment under forbearance is below the investment under regulation as long as  $\beta_1 < 0.12329$ . Lets assume  $\beta_1 = 0.1$ , for instance <sup>2</sup>. Naturally, in this situation the vertically integrated firm maintains a higher profit under the forbearance case.

An important point of this result is that spillovers might change the standard conclusions about the incentive to invest. If there were no spillovers the forbearance hypothesis always leads to a higher investment than regulation (Sarmiento and Brandão, 2007). With spillovers it is possible to have the reverse result.

## 2.2 The game with vertical separation

In this section we consider a different market organization characterized by vertical separation. Then there are three independent firms. The upstream firm (firm 3) sells the access as an input to independent firms (firms 1 and 2) that operate in the retail market. The market structure is represented in figure 3:

Figure 3 - Vertical Separation



The profit functions are the following:

$$\pi_3 = (w - c + x)q_3 - \frac{x^2}{2}$$

$$\pi_1 = (p - w + \beta_1 x)q_1$$

$$\pi_2 = (p - w + \beta_2 x)q_2$$

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<sup>2</sup>For this example the equilibrium values without regulation are:  $x^{VIF} = 1.6780$  ;  $w^{VIF} = 0.13051$  ;  $q_1^{VIF} = 1.2051$  ;  $q_2^{VIF} = 0.33559$ . The equilibrium values with access price regulation are:  $x^{VIR} = 1.7012$  ;  $q_1^{VIR} = 1.2073$  ;  $q_2^{VIR} = 0.35671$ .

As in the previous case we assume that in the downstream market the firms choose the quantities that maximize their profits considering the rival quantity as constant (Cournot competition). Then, the optimal quantities for firms 1 and 2 conditional on the values of  $w$  and  $x$  are  $q_1 = \frac{1-w+2x\beta_1-x\beta_2}{3}$  and  $q_2 = \frac{1-w+2x\beta_2-x\beta_1}{3}$ . Firms 3's quantity is  $q_3 = q_1 + q_2$ .

As before, we analyze two different cases for the access price definition: forbearance and cost oriented regulation.

### Forbearance

From the first order conditions of firms' 1 and 2 maximization problems we derive the inverse demand function for firm 3:  $w = \frac{x\beta_1-3q_3+x\beta_2+2}{2}$ . Considering this expression and solving the profit maximization problem of firm 3 we immediately have the access price choose by firm 3, as a function of  $x$ ,  $w = \frac{1+c-x}{2} + \frac{\beta_1+\beta_2}{4}x$ .

Then, using this result we calculate the investment level that maximizes firm's 3 profit,  $x^{VSF} = \frac{2(1-c)(2+\beta_1+\beta_2)}{8-4\beta_1-4\beta_2-2\beta_1\beta_2-\beta_1^2-\beta_2^2}$ .

In order to have a positive value for  $x^{VSF}$  it is necessary that  $8 - 4\beta_1 - 4\beta_2 - 2\beta_1\beta_2 - \beta_1^2 - \beta_2^2 > 0$ . This condition is true as long as  $\beta_1 + \beta_2 < 1.464$ , and this is always verified as  $\beta_2 \leq 1$  and, by assumption 1,  $\beta_1 \leq 0.41421$ .

Considering  $x^{VSF}$  the final results for the forbearance case are the following:

$$q_1^{VSF} = \frac{1-c}{r}(2-2\beta_2+2\beta_1+\beta_1^2-\beta_2^2) \quad q_2^{VSF} = \frac{1-c}{r}(2-2\beta_1+2\beta_2-\beta_1^2+\beta_2^2)$$

$$p^{VSF} = \frac{1}{3}(2+c) - \frac{(1-c)(4+4\beta_1+4\beta_2+2\beta_1\beta_2+\beta_1^2+\beta_2^2)}{3r} \quad w^{VSF} = \frac{1}{2}(1+c) - \frac{(1-c)(4-2\beta_1\beta_2-\beta_1^2-\beta_2^2)}{2r}$$

$$\text{Where } r = 8 - 4\beta_1 - 4\beta_2 - 2\beta_1\beta_2 - \beta_1^2 - \beta_2^2.$$

Notice that, in the downstream market, the quantities of both firms are positive. The upstream firm does not have any incentive to drive out the market none of the downstream firms.

### Regulation

Under this case the regulator sets the access price equal to the marginal cost of the upstream activity, then  $w = c$ . The investment level that maximizes firm's 3 profit is  $x^{VSR} = \frac{2(1-c)}{3-2\beta_1-2\beta_2}$  that is always positive.

Considering  $x^{VSR}$  the final results for the forbearance case are the following:

$$q_1^{VSR} = \frac{1}{3}(1-c)\left(\frac{3+2\beta_1-4\beta_2}{3-2\beta_1-2\beta_2}\right) \quad q_2^{VSR} = \frac{1}{3}(1-c)\left(\frac{3+2\beta_2-4\beta_1}{3-2\beta_2-2\beta_1}\right) \quad p^{VSR} = \frac{1}{3}(1+2c) - \frac{2(1-c)(\beta_1+\beta_2)}{9-6(\beta_1+\beta_2)}$$

### Comparison of the results

**Proposition 3:** If  $\beta_1+\beta_2 < 1$  then  $x^{VSF} < x^{VSR}$ .

Comparing the investment equilibrium values for both regimes - forbearance ( $x^{VSF}$ ) and regulation ( $x^{VSR}$ ) - we conclude that, as long as the joint absorptive capacity of downstream firms assume reasonable values (meaning  $\beta_1 + \beta_2 < 1$ ), the forbearance regime leads to lower investment than access regulation.

Notice that having  $\beta_1 + \beta_2 > 1$  is not likely, considering the significance of the parameters  $\beta_1$  and  $\beta_2$ . Therefore, if there is vertical separation and the downstream firms jointly do not have a high absorptive capacity, access regulation is necessary to encourage investment.

## 3 Conclusions

We conclude that, differently from the standard results, foreclosure is not a necessary outcome with vertical integration when there is no regulation of the vital input price. If spillovers are significant and if the independent firm has greater absorptive capacity than the integrated firm, the integrated firm does not drive out the market the independent firm. In this scenario both firms obtain positive profits.

We also conclude that with vertical spillovers the effects of regulation of the access price on the investment of the incumbent firm differ as we consider the cases of vertical integration or vertical separation. In the case of vertical integration and except for some special values of the spillovers the investment of the incumbent firm will probably decrease with access price regulation. When we consider vertical separation the likely result for the more realistic values of the spillovers is the contrary, i.e., the investment of the incumbent firm is greater with regulation. Then since this kind of spillovers is important in the development of the next generation networks these results suggest that regulation will be more necessary in the cases of vertical separation.

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