

**THE EFFECTS OF VERTICAL
SEPARATION AND ACCESS PRICE
REGULATION ON INVESTMENT
INCENTIVES**

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The Effects of Vertical Separation and Access Price Regulation on Investment Incentives

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Abstract

We study the impact of vertical separation between an upstream firm and its subsidiary, which competes in the retail market with an independent firm, with the incentive to invest in network upgrade. This question is discussed under two alternative regimes concerning the price of the vital input sold by the upstream firm: cost orientation regulation and absence of access price regulation. We show that the investment incentive decreases with vertical separation under both regimes. However, it is not always true that the investment incentive is higher without regulation.

JEL Classification: L51, L96

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1. Introduction

In network industries vertical separation is a crucial question. In the electricity, gas, railway, telecommunications or postal sectors, for example, there is an ongoing discussion about the degree of vertical separation between the firm that owns the network (typically the incumbent firm) and the firms that use the network to pursue their activity. Vertical separation concerns not only ownership but also, more subtly, the degree of the firms' independence at decision levels. Different firms that belong to the same vertical chain may have common ownership although they have some autonomy in the decision process. In several network industries some degree of autonomy is imposed by regulatory authorities in order to create a level playing field in market segments where they is, or where the regulatory authorities want to promote, competition. Some degree of decision autonomy corresponds to what we refer as different degrees of vertical separation. Ownership separation is the strongest form of vertical separation (as the firms have complete autonomy at the decision level). Legal, functional, accounting separation are lighter forms of vertical separation.² Accounting separation is one of the lightest forms of separation as it does not require decision autonomy but only separate organization of the accounts. Vertical separation that involves some autonomy in the decision process typically is accompanied by the implementation of separate information systems and by the training of employees in order to respect "Chinese walls" built between the business units, in order to prevent the discrimination of independent firms by the vertically integrated firm. In the telecommunications sector most European countries had already implemented accounting separation, the UK implemented functional separation in 2006, Sweden and Italy have followed this policy aiming to encourage retail competition. In the electricity sector, after setting accounting unbundling of generation and retail stages from the network business (transmission and distribution), the European Commission required in 2003 legal unbundling in order to achieve competitive efficiency (Soares and Sarmiento, 2010). In postal sector, separating the delivery function, which is a natural monopoly due to extensive scale and scope economies, from the upstream activities of acceptance,

² For a detailed description of the degrees of vertical separation applied to the telecommunication industry see, for example, Cave (2006b). For a discussion of different forms of unbundling in the telecommunications and electricity sectors see Soares and Sarmiento (2010), and the references therein.

mail processing and transportation is in discussion both in the USA and Europe (Haldi and Olson, 2005).

A strong argument in favor of vertical separation is the promotion of competition by the creation of a level playing field in some market segments. Nevertheless, it is necessary to evaluate other effects of vertical separation in network industries, namely the impact on access price regulation, on sabotage³, and on investment incentives.

This paper analyzes the effects of different degrees of vertical separation on network investment incentives comparing two regulatory policies regarding access price: regulation and no regulation. We model the different degrees of vertical separation following Chikhladze and Mandy (2009). Indeed Chikhladze and Mandy's (2009) definition of vertical control corresponds to our concept of vertical integration: "*Vertical control means the extent to which the upstream monopolist can align the objective of its downstream affiliate with the objective of the overall firm*". Therefore, the extreme case of completely vertical integration corresponds to the situation where the upstream firm has complete control over the subsidiary firm's decisions, the extreme case of full vertical separation corresponds to the situation where the subsidiary firm is completely autonomous in its decisions, and between these extremes remain all the cases where there are some limitation on the decision autonomy. Foros *et al.* (2007) also use a similar specification of vertical separation in order to study the response of a vertically integrated firm to regulatory requirements of non-discrimination. However, differently from Chikhladze and Mandy (2009) and from us, Foros *et al.* (2007) assume that the vertically integrated firm does not passively accommodate the regulatory policy on vertical separation. Instead, the vertically integrated firm strategically decides how much autonomy should be given to affiliate firms and this strategy might reverse the expected results from non-discrimination regulation.

There are other recent works that also study the relationship between the degree of vertical separation and the investment incentives. Cremer *et al.* (2006) and Pakula

³ Sabotage refers to the no-price discriminatory strategies (such as raising the rivals' costs, reducing the quality of the input delivered to competitors, reducing rivals' demands) followed by the firm that sells the network access. For deep analysis of sabotage see Weisman (1998), Economides (1998), Sibley and Weisman (1998), Mandy (2000), Weisman and Kang (2001), Beard *et al.* (2001), Mandy (2007) and Chikhladze and Mandy (2009).

and Götz (2010) study the effects of different organizational structures on the network operator's incentive to invest. Höffler and Kranz (2008) compare legal unbundling with completely vertical integration and full vertical separation. However, these works analyze the different market structures independently, as they build different models for each one. On the contrary, in the approach of Chikhladze and Mandy (2009), Foros *et al.* (2007) and ours, there is a unique model that integrates all the different degrees of vertical separation. Hence, legal separation defined by Höffler and Kranz (2008) is represented in our model as an intermediate case, while completely vertical integration and full vertical separation are the extreme cases. Besides the above references our paper is also related to the literature on vertical integration, unbundling, access price regulation and investment incentives. Buehler *et al.* (2004) study the effects of vertical separation on investment incentives considering also the impact of access price regulation. Rey and Tirole (2006) provide a survey on vertical integration and foreclosure, Guthrie (2006) offer a survey on the infrastructure investment implications of different regulatory regimes. Cambini and Jiang (2009) provide a survey on the relationship between investment incentives and regulation applied to internet broadband access. Foros (2004) and Kotakorpi (2006) analyze the effects of access price regulation on the incentive to invest considering a vertical integration.

When network access is a vital input to independent firms, the relationship between vertical separation and network investment incentives must be analyzed considering access price regulation. With vertical integration it is usual to find access price regulation, as it happens, for instance, in electricity, natural gas or Internet broadband access through DSL. Regulators require the incumbent firm to give access to some parts of its network to operators that want to provide services but do not have a complete network. The regulation of the access price is an instrument to encourage the entry of new operators, increasing competition at the retail level and later on, after consolidation, the new operators might be able to build their own networks, creating competition at upstream level.⁴ However, when vertical separation is in discussion arguments contesting access price regulation usually emerge. For instance, in 2005

⁴ This is the argument of the Investment Ladder Theory (Cave and Volgelsang, 2003; Cave, 2006), which foresees that initially the entrant firms use the incumbent firm's network to deliver their products which promotes retail competition. After the initial period, the entrants invest in their own infrastructure competing with the incumbent firm also at the upstream segments of the market.

Deutsch Telecom demanded the elimination of access price regulation when it announced its investment plans to build a new generation fiber optic network (Blum, *et al.*, 2007). Also, in the USA there has been some reduction in access price regulation in some telecommunications segments, as in broadband Internet access (Bauer, 2006). With a theoretical approach Chikhladze and Mandy (2009) show that vertical separation and access price regulation might be complementary instruments of regulation. Therefore to evaluate the effects of vertical separation on network investment we consider two alternative regulatory regimes about access price: one without regulation, where the upstream firm sets the input price in order to maximize its profits and one with regulation, where the regulator sets the access price from a cost orientation perspective. Access price regulation and intervention on vertical control are tools used by the regulatory authorities, both in the USA and in many European countries, in the telecommunication or electricity industries, as documented by Chikhladze and Mandy (2009) and many other authors.⁵

Our main conclusions regarding investment incentive are that, as expected, the investment incentive decreases with vertical separation, with or without access price regulation. Additionally, we conclude that it is possible to find some situations depending on the degree of vertical separation, where regulation leads to higher investment incentives than the absence of a regulation regime. Therefore, when analyzing the relationship between access price regulation and investment the regulatory authorities must consider the degree of vertical control they demand from the vertically integrated firms.

The remainder of the paper is organized as follows: After the introductory section 2.1 that presents the main features of the model, section 2.2 describes downstream market decisions, section 2.3 explains the results under the regime without access price regulation, section 2.4 presents the results under the access price regulation regime and section 2.5 compares the two regulatory regimes. Finally, section 3 summarizes the main conclusions of the paper.

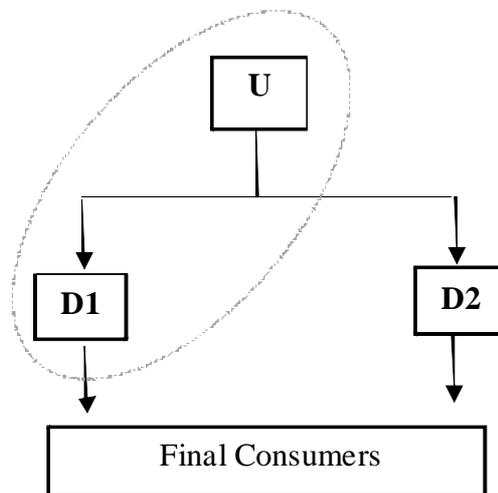
⁵ For a deeper discussion of unbundling and regulation see, Hausman and Sidack (2005), Kirsh and von Hirschhausen (2008), Tropina *et al.* (2010) and Soares and Sarmiento (2010).

2. The model

2.1 Introduction

We consider an upstream monopoly (firm U), which could be the historical incumbent firm, that sells network access to downstream firms (D_1 and D_2). The downstream market is an unregulated duopoly where firms compete for quantities of a homogenous product. The market structure is represented in Figure 1.

Figure 1 - Market Structure



The upstream monopolist undertakes an investment in network quality (denoted by I) that improves the service delivered by downstream firms and, therefore, increases the final demand. Applying this model to broadband Internet access, for example, we would say that the investment increases communication speed and reliability, which are seen by consumers as important improvements in service quality, not only because they might have access to new services that require high speed (such as interactive audio and video), but also because conventional Internet services (web-browsing and e-mail) acquire greater value (Fors, 2004; Hausman *et al.*, 2001). Then, with a better network there will be not only more consumption by the actual consumers but also the attraction of new consumers for the market. These features are represented by a parallel shift in the retail market demand function. The final consumers' demand is represented by the

linear function $p=I+\beta I-q_1-q_2$, where p is the retail price, $\beta>0$ represents the intensity of the investment effect on demand growth and q_1 and q_2 are the outputs of firms D_1 and D_2 , respectively. Notice that we assume that the investment does not affect the slope of the demand but only its intercept, ie, the investment increases the reservation price.⁶

The individual profit functions for each firm are as follows:

$$\text{Firm U: } \pi_U = (w - c)(q_1 + q_2) - \frac{I^2}{2}$$

$$\text{Firm D}_1: \pi_1 = (p - w)q_1$$

$$\text{Firm D}_2: \pi_2 = (p - w)q_2$$

where c is the constant marginal cost of the upstream activity (with $c<I$)⁷, w is the input price (with $w\geq c$) and $\frac{I^2}{2}$ is the investment cost. We assume that the cost of buying other inputs is equal for both downstream firms and normalized to zero. Also, we consider the non-existence of entry costs and the standard assumption on network industries of fixed coefficients technology.

Firms U and D_1 belong to the same economic group. Therefore, their decisions do not depend exclusively on individual profit, but also depend on the degree of vertical control. Hence, we consider the objective function for each firm, following the methodology of Chikhladze and Mandy (2009). As the upstream firm might not have full control over firm's D_1 decisions we represent the degree of control by the parameter $\lambda \in (0,1)$. The objective functions for each firm are represented as follows:

$$\text{Firm I (integrated firm): } \Pi_I = (w - c)(q_1 + q_2) + (p - w)q_2 - \frac{I^2}{2}$$

$$\text{Firm D}_1 \text{ (affiliated firm): } \Pi_A = \lambda(p - w)q_1 + (1 - \lambda) \left[(w - c)(q_1 + q_2) + (p - w)q_1 - \frac{I^2}{2} \right]$$

$$\text{Firm D}_2 \text{ (independent firm): } \Pi_2 = (p - w)q_2$$

⁶ This assumption was also used by Sarmiento and Brandão (2007).

⁷ We assume that the investment does not change marginal costs c . Höfler and Kranz (2008), Sarmiento and Brandão (2009) and Varela (2010) consider a different approach as they assume that upstream investment reduces marginal costs.

This model allows an integrated analysis of all the possible cases of vertical separation, from complete vertical integration to full vertical separation. Under complete vertical integration (represented by $\lambda=0$) firms U and D_1 have the same objective function: both maximize the integrated profit; under full vertical separation (represented by $\lambda=1$) firm U maximizes the integrated profit, while firm D_1 maximizes its individual profit from retail business. This happens when firms U and D_1 , in spite of having a common ownership, develop their businesses in an independent way.

It is worthwhile emphasizing that, as in Chikhladze and Mandy (2009), the parameter λ represents vertical control, not ownership. Also, Foros *et al.* (2007) use an analogous methodology to study vertical control, although Foros *et al.* (2007) represent the degree of vertical control directly on the downstream affiliate firm's cost function. As mentioned before, Höffler and Kranz (2008) study with separate models some market structures, which they labeled as vertical separation, ownership separation, legal unbundling and reverse legal unbundling. Vertical separation and ownership separation in the Höffler and Kranz (2008) framework are our extreme cases of full vertical separation ($\lambda=1$) and complete vertical integration ($\lambda=0$), respectively. Our intermediate cases ($0<\lambda<1$) represent different degrees of what Höffler and Kranz (2008) call reverse legal unbundling, which happen when the upstream firm maximizes a joint profit function and the downstream affiliate maximizes the individual profit. In our model the downstream objective function include the individual profit and the joint profit with variable weights (represented by λ). Our model does not contemplate what Höffler and Kranz (2008) call legal unbundling as, in this case, it is the downstream firm that maximizes the joint profit while the upstream firm maximizes the individual profit. Our model is closer to what happens in the telecommunication or electricity sectors while the legal unbundling of Höffler and Kranz (2008) is closer to what happens in the postal sector, where the essential facility is the distribution network located downstream to the firms that need the network access.

The time of the game is the following: at stage 1 the upstream firm decides the investment amount I . At stage 2 there is a decision about the access price w .⁸ We

⁸ Here we assume, as Foros (2004) that the investment decision has a longer time horizon (it refers to infrastructure investment) than the access price regulatory policy. Therefore, we assume that the regulator does not have the capacity to commit to access price regulation before the investment decision.

consider two regulatory regimes: (i) the upstream firm decides w in order to maximize its profits (no access price regulation regime) or (ii) the regulatory authority decides the uniform access price with a cost-orientation perspective (access price regulation regime). Finally, at stage 3, firms D_1 and D_2 simultaneously decide quantities à la Cournot.

The game is solved by backward induction and the equilibrium concept is subgame perfection.

2.2 Downstream market

In the retail market both firms choose the quantities that maximize their objective functions (stage 3). The optimal quantities, conditional on w , I and the parameters β , λ and c , are:

$$q_1(w, I; \beta, \lambda, c) = \frac{1 + \beta I + w - 2c}{3} - 2\lambda \frac{w - c}{3}$$

$$q_2(w, I; \beta, \lambda, c) = \frac{1 + \beta I + c - 2w}{3} + \lambda \frac{w - c}{3}$$

From these expressions some important conclusions emerge. First, if the regulator set $w=c$, the degree of vertical separation has no effect on the optimal quantities.⁹ Therefore, we restrict our analysis to $w>c$, so that the incumbent firm obtains revenue to cover also part of the investment costs. Second, for $w>c$ and taking w as given, the affiliated firm D_1 produces more than the independent firm D_2 , and this difference is increasing with w and decreasing with λ . These conclusions were already pointed out by Chikhladze and Mandy (2009) and Foros *et al.* (2007), and result from the affiliated firm's cost advantage that exists with vertical control. In the extreme case of complete vertical control ($\lambda=0$) the affiliated firm has an "effective" marginal cost of $2c-w$ while firm D_2 has an effective marginal cost of $2w-c$. With full vertical separation ($\lambda=1$), both downstream firms have an effective marginal cost of w , and therefore, they produce equal quantities. In the intermediate cases ($0<\lambda<1$) the affiliated firm has an effective marginal cost of $2c-w+2\lambda(w-c)$ and the independent firm has an effective

⁹ This result was first pointed by Chikhladze and Mandy (2009).

marginal cost of $2w-c-\lambda(w-c)$. The difference between marginal costs, which results from the partial elimination of double marginalization, is decreasing with λ . Third, taking w and I as given, the total quantity is decreasing with λ . This means that with full vertical control the total quantity offer in the market is higher, and this is due to the partial elimination of double marginalization, as firm D_1 has marginal cost of c . Only regarding firm D_2 are there two margins as $w > c$.

2.3 Absence of Access Price Regulation

Under this regime the regulator does not impose any constraint on the access price. Then, firm U chooses the access price that maximizes its objective function,

which is $w^{noreg}(I; \beta, \lambda, c) = \frac{5(1 + \beta I + c) - \lambda(1 + \beta I + c) + 4c\lambda^2}{10 - 4\lambda + 4\lambda^2}$. Here it is

important to note that with some vertical separation (ie, with $\lambda > 0$) firm D_2 is not foreclosed as it happens with vertical integration. With $\lambda = 0$ (full vertical integration),

the value of w that maximizes firm's U objective function 1 ($w(I; \beta, I, c) = \frac{1 + \beta I + c}{2}$)

does not allow a positive profit for firm 2 (this is a well known result from the vertical integration literature).¹⁰ When $\lambda > 0$ firm's D_2 profit is given by

$$\pi_2(I; \beta, I, c) = \frac{1}{4} \lambda^2 (1 + \lambda)^2 \frac{(1 + \beta I - c)^2}{(2\lambda^2 - 2\lambda + 5)^2}.$$

Considering the investment decision (stage 1) and using the above access price $w^{noreg}(I; \beta, I, c)$, the investment amount that maximizes firm's U objective function

$$\text{is } I^{noreg}(\beta, \lambda, c) = \frac{\beta(1-c)(5-2\lambda I + \lambda^2)}{x}, \text{ with } x = 10 - 4\lambda - 5\beta^2 + 4\lambda^2 - \beta^2\lambda^2 + 2\beta^2\lambda.$$

In order to ensure that the optimal investment is positive for all possible values of λ we restrict our analysis to cases where $\beta < 1,4142$. This constraint on the parameter that represents the effect of investment on demand is necessary as we consider that the cost of the investment increases exponentially while the benefit of the investment is linear. Assumption 1 synthesizes the above restriction on β .

Assumption 1: Assume $\beta < 1,4142$.

¹⁰ See, for instance, Rey and Tirole (2007).

It is worthwhile to mention that, as expected, the optimal investment is decreasing with vertical separation.¹¹ If the integrated firm exerts a tight control over the decisions of its subsidiary (small λ) then there is a high incentive to invest.

From the optimal investment value and by substitution we calculate the equilibrium values of the access price (w^{noreg}) and quantities (q_1^{noreg} , q_2^{noreg} , Q^{noreg}):

$$w^{noreg}(\beta, \lambda, c) = \frac{c(\beta^2 - 4)\lambda^2 + (1 + 3c - 2c\beta^2)\lambda - 5(1 + c - c\beta^2)}{x}$$

$$q_1^{noreg}(\beta, \lambda, c) = \frac{(1 - c)(2\lambda^2 - 5\lambda + 5)}{x}$$

$$q_2^{noreg}(\beta, \lambda, c) = \frac{\lambda(1 + \lambda)(1 - c)}{x}$$

$$Q^{noreg}(\beta, \lambda, c) = \frac{(1 - c)(3\lambda^2 - 4\lambda + 5)}{x}$$

Notice that under assumption 1 the access price without regulation is above the marginal cost c for all values of λ .

From these expressions it is straight forward to verify that the output of the subsidiary firm $q_1^{noreg}(\beta, \lambda, c)$ is decreasing with vertical separation. This is the expected result since with an increase in vertical separation the real costs of the downstream firms get closer. Following this reasoning we could expect that the independent firm's output $q_2^{noreg}(\beta, \lambda, c)$ increases with vertical separation, however, this does not happen when β and λ are relatively high (more precisely, when $\beta > 1.354$ and $\lambda > \lambda_2$ with $\lambda_2 = \frac{5\beta^2 - \sqrt{10}\sqrt{18 - 17\beta^2 + 4\beta^4} + 10}{3\beta^2 - 8}$). This result is due to the effect

of vertical separation on demand, through the investment. With a high degree of vertical separation there is a low incentive to invest, that affects negatively the demand growth and so the independent firm's output. Therefore, there is a tradeoff regarding the effects of vertical separation on $q_2^{noreg}(\beta, \lambda, c)$. When the investment effect on demand is strong $q_2^{noreg}(\beta, \lambda, c)$ decreases but, in the opposite case, the effect of vertical separation on the creation of a level playing field dominates and $q_2^{noreg}(\beta, \lambda, c)$

¹¹ This result is consistent with the main conclusions of Buehler *et al.* (2004).

increases. Also, the subsidiary's output is higher than the independent's output, except when there is full vertical separation. This is the expected result as more vertical control increases the cost advantage of the subsidiary firm.

Concerning the effects of vertical control on total output (and on consumer welfare as here the consumer welfare is given by $CS = \frac{Q^2}{2}$), we conclude that an increase in vertical separation decreases consumer welfare except when the vertical separation is already very high ($\lambda > \lambda_1$ with $\lambda_1 = \frac{5\beta^2 + \sqrt{5}\sqrt{9-10\beta^2+4\beta^4} - 5}{2 + \beta^2}$) and β is low ($\beta < 0.70711$). Once again, this result is due to the effect of vertical separation on demand, through the investment. An increase in vertical separation decreases the incentive to invest and, if β is not too low, the demand expansion is narrow. For low values of β the link between investment and demand is weak, and so the effect of vertical separation on consumer welfare varies with the degree of vertical separation. When vertical separation is low we have the same effect as with high β , however, when vertical separation is high a further increased in vertical separation produces positive effects on consumer welfare. This is explained by the positive effect of vertical separation on the promotion of retail competition that overcomes the negative effects. The above results are very relevant to policies that defend vertical separation arguing for the promotion of retail competition and the creation of a level playing field in the retail market, neglecting the important effects on investment incentive and efficiency. Foros *et al.* (2007) already claim the attention for this feature of non-discrimination policies, as they may increase consumer prices.

2.4 Access Price Regulation

Under this regime the regulator adopts a cost-based perspective, setting the access price as the marginal cost of providing the access (c) plus a fraction (α) of the investment total cost, that is, $w = c + \alpha C(I)$, with $\alpha < 1$.¹² With this regulatory policy firm U shares the cost of the investment with the downstream firms. To simplify the calculus we assumed $\alpha = \frac{1}{I}$. Then, the access price is equal to the marginal cost of providing the

¹² We follow the definition of cost based regulation described in Sarmiento and Brandão (2007).

access plus the average cost of the investment. This means that the independent firm bears a fraction of the investment cost undertaken by the upstream firm in order to expand the demand. Both downstream firms benefit from the investment and this justifies an access price above marginal cost (this is consistent with the observation of an access price above marginal cost in order to cover fixed costs of the upstream firm, as for instance, the Long Run Incremental Cost (LRIC) used by regulators).

Considering now stage 1 of the game, we calculate the investment that maximizes the firm's U objective function, which is $I^{reg}(\beta, \lambda, c) = \frac{(1-c)(5+4\beta-\lambda)}{y}$, with $y = 23 - 10\beta - 2\lambda - 4\beta^2 + 2\lambda^2 + 2\beta\lambda$. Assumption 1 ensures that the optimal investment is positive for all possible values of λ .

As expected, the optimal investment is decreasing with the degree of vertical separation. If the integrated firm exerts a tight control over the decisions of its subsidiary there is a high incentive to invest.

Substituting the optimal investment value we calculate the equilibrium values of the access price (w^{reg}) and quantities (q_1^{reg} , q_2^{reg} , Q^{reg}):

$$w^{reg}(\beta, \lambda, c) = c + \frac{(1-c)(5+4\beta-\lambda)}{2y}$$

$$q_1^{reg}(\beta, \lambda, c) = \frac{(1-c)(2\lambda^2 - 2\beta - 5\lambda - 2\beta\lambda + 17)}{2y}$$

$$q_2^{reg}(\beta, \lambda, c) = \frac{(1-c)(\lambda - 6\beta + \lambda^2 + 2\beta\lambda + 12)}{2y}$$

$$Q^{reg}(\beta, \lambda, c) = \frac{(1-c)(29 - 8\beta - 4\lambda + 3\lambda^2)}{2y}$$

It is straight forward to verify that, as expected, the access price with regulation is lower than without regulation.

From the optimal quantities we verify that the output of the subsidiary firm is decreasing with vertical separation. For the independent's firm output we find a similar result as without regulation: it is decreasing with vertical separation except for high values of β and λ (in this case for $\beta > 1.2096$ and $\lambda > \lambda_I$ with

$\lambda_1 = \frac{2\beta - 4\beta^2 + 3\sqrt{10\beta - 4\beta^2 - 8\beta^3 + 21}}{2\beta + 4}$. Also, we find that the subsidiary's firm

output is higher than the independent's firm output, except in the extreme case of full vertical separation ($\lambda=0$) where both firms produce the same output.

Regarding the effect of vertical control on consumer welfare (measured by the value of total output) we conclude that an increase on vertical separation always has a negative effect on consumer welfare. This is a different result from what we obtained without regulation, where we found some cases where consumer welfare increases as a response to more vertical separation. With access price regulation a deeper vertical separation not only has negative effects on investment but also on consumer welfare.

2.5. Comparison of the Two Regimes

The main objective of the paper is to evaluate the effects of vertical separation on the incentives to invest considering two different regimes concerning the access price. We conclude that the investment is higher without regulation for any degree of vertical separation as long as the impact of the investment on demand growth is significant ($\beta > 1.25$). For intermediate values of β ($0.9736 < \beta < 1.25$) the investment can be high without regulation depending on the degree of vertical separation: for low levels of vertical separation the investment is higher without regulation, but for high levels of vertical separation we have the opposite result. Finally, when β is low ($\beta < 0.97367$) the access price regulation allows a higher investment than no regulation, for any degree of vertical separation. This last result is unexpected. The aim of access price regulation is to protect the independent firms; however, the negative impact on investment is traditionally pointed as one crucial drawback of this regulatory policy. Here we show that it is very important to consider vertical separation in order to evaluate the relationship between investment incentive and access price regulation. Considering vertical separation we show that it is not always true that access price regulation lowers investment incentives.

The above results are aligned with Chikhladze and Mandy (2009) conclusions. In their study of sabotage incentives, these authors conclude that when access price is above marginal cost, strong vertical control decreases sabotage incentives. Therefore, it might be optimal to have access price regulation and vertical integration (indeed,

Chikhladze and Mandy (2009) conclude that access price regulation and vertical control policy can be complements). Here we conclude that vertical separation implemented with access price regulation decreases investment incentives and in some cases can also decrease consumer surplus. Hence, it is necessary a careful analyzes of regulatory policies on networks that advocate strong vertical separation simultaneously with access price regulation.

4. Conclusions

We conclude that under both regimes concerning access price definition the impact of vertical separation on the independent firm's market position depends on the intensity of investment effect on demand. This is so because there is a trade-off between the low increase in demand (caused by low investment) and the creation of a level playing field in the downstream market.

Regarding the effect of vertical separation on consumer surplus we find two different results: without regulation vertical separation not always reduces consumer welfare while with access price regulation vertical separation always reduces consumer welfare. These results call for the attention of regulatory bodies when evaluating the possibility of maintaining access price regulation and simultaneously demanding deeper vertical separation from incumbent firms. The argument for vertical separation lies in the promotion of retail competition, but this might be achieved at consumer surplus expenses.

Concerning the investment, we conclude that the optimal level is decreasing with vertical separation with or without access price regulation. However, when comparing the optimal investment values that result from the two regimes we conclude that it is possible to find some situations where regulation leads to higher investment incentives. Therefore, in the relationship between regulation and investment is crucial to consider the vertical degree of control.

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