

LIBERALIZATION AND SEPARATION WITH COSTLY DEMAND INFORMATION

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Liberalization and Separation with Costly Demand Information

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Abstract

We consider an industry characterized by an upstream market which is a regulated natural monopoly and an unregulated downstream market with Cournot competition and demand uncertainty. The realization of demand cannot be observed by the regulator, whilst it can be privately observed at some cost by the upstream monopolist. Information acquisition is also unobservable. We study whether it is better to allow the monopolist to operate in the downstream market (liberalization) or instead to exclude it (separation). We show that asymmetric information on demand favours separation but unobservability of information acquisition favours liberalization.

Keywords: Information acquisition, liberalization and separation.

JEL Classification:

1 Introduction

The conventional wisdom until the 1990's was that regulated networks had to be structurally separated from potentially-competitive segments. Structural reforms during the 1980's and the 1990's then lead to a separation of the transmission grid from generation in the electricity industry (England and Wales), to a divestiture of transportation service and supply of gas in the gas industry, and to a structural separation of local network from long-distance market in the telecommunications industry (A&T in USA in 1982).

However, other events have shown an opposite tendency. In the US the 1996 Telecommunication Act has removed the restrictions that kept the Regional Bell Operating Companies out of the long-distance market once sufficient competition had developed in the local market. In continental Europe it has been viewed more appropriate to leave dominant regulated firms

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integrated and to address any competition concerns through action by sectorial regulator rather than to preclude integration altogether.¹

The desirability of downstream integration of an input supplier in network industries is an issue that has long been debated in the economic literature. In the context of an upstream naturally monopolistic sector and a downstream unregulated sector, it has been shown that downstream integration can alter the performance of the industry in two opposite ways. On the one hand, when the access price is greater than the marginal cost of the input, because of the need to recover fixed costs, an integrated firm faces lower cost in the downstream market than its rivals. This generally yields a greater output in the downstream market and a higher welfare than under separation. Downstream integration can also lead to a reduction in total fixed costs due to a lower number of suppliers entering the downstream market, to efficiency gains from economies of scope and to a better coordination between investments in the upstream and downstream markets (Vickers, 1995).

On the other hand, downstream integration can make it difficult to create a level playing field in the downstream market because of the incentives of the integrated firm to increase the costs of its rivals. The firm can do this in at least two ways. First, it can exaggerate its cost of supplying the essential input in order to convince the regulator to set a higher access price (Vickers, 1995). Second, it can degrade the quality of the input it supplies for example by imposing burdensome purchasing requirements on the downstream competitors (Armstrong and Sappington, 2005).

In the present paper we highlight a new effect of integration which has been overlooked so far although it is linked to one of the most important characteristics of network industries, namely the uncertain nature of the demand for services which is subject to random and often unpredictable fluctuations. In particular, we analyze how the incentives of the upstream monopolist and of its competitors to acquire valuable information on demand under integration and under separation affect the desirability of separation in network industries.

Consider the electricity sector. As discussed by Borenstein (2002), the demand for electricity is difficult to forecast and it is almost completely insensitive to price fluctuations. One

¹This view is well summarized by the position of the UK regulator which states (OfTel 2001) "*an all encompassing prevention of vertical integration would be unjustified, since it may hamper innovation in new services, damage competition across different platform and hinder UK firms competing in world market. Rather than precluding integration altogether, it is more appropriate to address any competition concerns through action by sectorial regulator*". See also see Cowan, (2001) for a deeper discussion.

of the reasons for demand uncertainty is the weather conditions which cause large unpredictable fluctuations particularly in the demand of residential consumers. The demand for electricity also varies with the level economic growth and with the number and types of firms using electricity as an input for their production. Consumers of electricity are heterogeneous: there are consumers who require no interruption of the service and consumers who are willing to accept interruptability. All these factors make demand for electricity costly to forecast; resources are indeed needed to predict the variations in the industrial use of electricity due variations in the number of operating firms or to technological change and to investigate the distribution of consumers' types.

The importance of accurate demand estimates in the electricity industry then stems from the need to reduce the risk of bankruptcy of the entire system and from the universal service obligation (continuity of supply in time and space). As emphasized by Borenstein (2002), storage of electricity is very costly and capacity constraints on generation facilities cannot be breached for significant periods without risk. This implies that there are constraints on the amount of electricity that can be delivered at any point of time. Yet because of the properties of electricity transmission, an imbalance of supply and demand at any one location on an electricity grid can threaten the stability of the entire grid and disrupt delivery of the product.² Consider the black-out in California in 2000. An unexpected increase in demand and a shortfall of supply, made wholesale prices treble between 1999 and 2000, which bankrupted the distribution companies whose prices were capped (Newbery, 2002).

Telecommunications is another industry where the problem of accurately estimating an uncertain demand is critical for the industry performance. Twenty years ago the boundaries of the telecommunications industry were stable and well defined. Now the rapidly changing technology generates a supply of rapidly changing mix of services, which leads to high fluctuations in the demand for existing services. Information on demand is then necessary to design a network which is compatible with the services offered, and to make appropriate investment in infrastructure modernization.

In this paper we show that the problem of uncertain demand calls for vertical integration in network industries because integration strengthens the incentives of firms to acquire and

²Hence, when there is structural separation between generation of power and its distribution, even though the generating firms do not have a universal service obligation *per se*, the threat of break downs of the network puts the generating firms in a situation where they have a *de facto* obligation of continuous supply.

report valuable information on demand. To show this, we consider a stylized model with an industry characterized by an upstream market which is a regulated natural monopoly and an unregulated downstream market characterized by Cournot competition with homogenous good and demand uncertainty. The downstream demand is random and information on its realization is valuable to the regulator for the choice of the access price and it is valuable to the downstream firms for the choice of output. In this setting, we compare the performance of the two industrial structures: liberalization, where the upstream firm is integrated with a downstream firm, and separation, where the upstream firm does not operate in the downstream market. We start by considering the case where information on demand can only be acquired by the upstream firm.

As benchmark we consider the case where information on demand is costly but, once acquired, it becomes public information. In this benchmark, either liberalization or separation can be optimal, depending on the parameters but not on the problem of inducing information acquisition by the upstream firm. Instead, when information on demand is privately acquired, a novel difference between liberalization and separation emerges. This difference critically depends on whether information acquisition is observable or not. When it is observable, the issue of information acquisition favours separation. This is because of an informational externality which arises when information on demand reaches the downstream firms and which implies that a greater informative rent must be granted to the upstream firm under liberalization than under separation. Instead, when information acquisition is unobservable, the issue of information acquisition tends to favour liberalization. This is because the upstream firm has more incentives to acquire information when information can also be used to choose production in the downstream market. Thus integration strengthens the incentives of the upstream monopolist to acquire information on demand.

Our results are robust to the possibility of information acquisition by downstream firms, which reduces but does not eliminate the welfare bias against separation that arises when information acquisition is unobservable. The reason is twofold. First, the value of information for a downstream firm under separation is lower than the value of information for the upstream monopolist under liberalization. Second, information acquisition by a downstream firm is less valuable for social welfare than information acquisition by the upstream monopolist. This is because information acquired by the upstream monopolist is transmitted to the downstream firms via the regulation mechanism. Instead, information acquired by an

unregulated downstream firm is not transmitted to its rival.

Our paper is related to the literature on information acquisition on demand in unregulated contexts. Hauk and Hurkens (2000) discuss information acquisition in Cournot markets and compare the case where information acquisition is observable by the rival and when it is not. Hauk and Vulkan (2001) study the relationship between entry decisions and information gathering by potential entrants, whilst Dimitrova and Schlee (2003) analyze how potential entry affects the incentives of the incumbent monopolist to acquire information on demand. Our paper is also related to the literature on information acquisition by regulated firms under optimal regulation and under price cap regulation. See for example Cremer Khalil and Rochet, (1998) for the case of optimal regulation and Iossa and Stroffolini (2002) for the case of price cap regulation.

The rest of the paper is organized as follows. In section 2 we set up the model. In section 3 we discuss the benchmark case where information acquisition is observable and information can be made public at no additional cost. Section 4 analyzes the case where information acquisition is verifiable but the information is privately observed by the upstream monopolist. Section 5 considers the case of unobservable information acquisition. In each section we discuss and compare liberalization with separation. Section 6 concludes. All proofs missing from the text are in the appendix

2 The model

We consider an industry characterized by an upstream regulated natural monopoly and a downstream unregulated market with Cournot competition, homogenous products and demand uncertainty. The production in the downstream market requires an essential input (e.g. an essential facility), produced in the upstream market. We compare two industrial structures: liberalization (L) and separation (S). L indicates a situation where the upstream monopolist is allowed to produce, through a subsidiary, also in the downstream market while under S it is excluded. The number of firms in the downstream market is fixed and equal to two in both industrial structures; only one firm - in addition to the upstream monopolist - owns the technology required to produce the output. Thus the difference between the two industrial structures is solely that under separation the downstream firm that was subsidiary of the upstream monopolist is now an independent firm. The results of the paper would not

qualitatively change if we considered the case of an unregulated competitive fringe.

The upstream market is regulated through a transfer given to the upstream monopolist and an access price paid to the upstream monopolist by the firm(s) in the downstream market for the utilization of the essential input. The technology used to produce the downstream output is the same under L and S and it only requires the essential input. Thus, the upstream monopolist's marginal cost of production of the final good is the marginal cost of the essential input, since the access price paid by its subsidiary is just an internal transfer, while for the rival the marginal cost of production of the final good is the access price. Therefore, there is a cost advantage either for the upstream monopolist or for the rival firm in the downstream market depending on whether the regulated access price is greater or lower than the marginal cost of production of the essential input. We assume that the upstream monopolist and its rival are equally efficient in the downstream market and normalize to zero both the marginal cost and the fixed cost of production.

The downstream market is characterized by a linear inverse demand function: $P(Q, \theta) = \theta - Q + \varepsilon$, where θ , with $\theta \in [\underline{\theta}, \bar{\theta}]$, is a parameter of adverse selection; it has density function $f(\theta)$ and distribution function $F(\theta)$ satisfying the following assumption $\frac{\partial}{\partial \theta} \left(\frac{1-F(\theta)}{f(\theta)} \right) \leq 0$. $f(\theta)$ and $F(\theta)$ are common knowledge. ε is a random error with zero mean. The parameter θ can be interpreted either as the willingness to pay of consumers with preferences distributed according to $f(\theta)$ or as the level of market demand with realizations distributed according to $f(\theta)$. We denote by θ_0 and by σ^2 the mean value and the variance of the distribution of θ , respectively.

The realization of θ can be privately observed at some cost K by the upstream monopolist. In most of the paper we assume that information acquisition is prohibitively costly for the regulator and for the other firms. The regulator observes quantities and price but he cannot deduce the true value of θ because of the noise ε . The informational advantage of the upstream monopolist stems from it being the incumbent firm. In Section 6, we relax this assumption and discuss the possibility that the downstream firm that was once a subsidiary of the upstream monopolist retains the technical expertise and know-how to acquire information on θ also at cost K . In our setting information on demand serves to determine the optimal access price and the equilibrium output in the downstream market. As explained in the introduction, information on demand can also be necessary to ensure continuation of service and service disruptions have a high social cost. We model this effect in a reduced form and denote by u

the social value of information in terms of lower risk of service disruptions.

Consider now the payoff of the firms, net of the information-acquisition cost. Under L , the profit function of the upstream monopolist is given by³

$$\Pi_L^M = (\theta - Q_L)q^M + a_L q^R + T_L \quad (1)$$

where $Q_L = q^M + q^R$ and q^M and q^R denote the quantity produced by the upstream monopolist and by the rival firm in the downstream market, respectively. T_L and a_L denote the transfer received by the regulator and the access price paid by the rival. The profit function of the rival is instead

$$\Pi_L^R = (\theta - Q_L - a_L)q^R \quad (2)$$

Under S , the profit function of the upstream monopolist is given by

$$\Pi_S^M = a_S Q_S + T_S \quad (3)$$

where $Q_S = 2q_S$ and q_S denotes the quantity produced by a downstream firm. T_S and a_S denote the transfer received by the regulator and the access price paid by the downstream firms. The profit of a downstream firm is

$$\Pi_S^D = (\theta - Q_S - a_S)q_S \quad (4)$$

The objective function of the regulator is given by the social value of the net consumer surplus plus the firms' profits. Let $S(Q)$ denote the gross consumer surplus, with $S'(Q) = P(Q)$ and $S''(Q) \leq 0$, and let $\lambda > 0$ denote the shadow cost of public funds due to the use of distorsive taxation to finance the transfer to the upstream monopolist. The objective function of the regulator under L , when there is information acquisition, can then be written as

$$W_L = S(\theta, Q_L) - P(\theta, Q_L)Q_L - (1 + \lambda)T_L + \Pi_L^M + \Pi_L^R - K + u$$

Under S , when there is information acquisition, the regulator's objective function is

$$W_S = S(\theta, Q_S) - P(\theta, Q_S)Q_S - (1 + \lambda)T_S + \Pi_S^M + 2\Pi_S^D - K + u$$

The timing of the game is the following. 1) Nature chooses θ ; 2) the regulator offers the upstream monopolist the menu of contracts $\{a_L(\theta), T_L(\theta)\}$ under L and $\{a_S(\theta), T_S(\theta)\}$ under

³In the rest of this paper $\Pi(\cdot)$ indicates the expected profit with respect to ε .

S ; 3) the monopolist decides whether to acquire information on θ by investing K , and it observes θ if it does; 4) the monopolist decides whether to accept the contract offered by the regulator; the firms in the downstream market simultaneously choose their quantities; the transfer T_i and the access price a_i ($i = L, S$) are paid.

3 Costly Public Information

3.1 Liberalization

As benchmark consider the case where under L information acquisition is observable and information can be made public at no additional cost. Assuming information acquisition, the regulatory mechanism induces the upstream monopolist to acquire information and spend K , the information acquired is made public and the rival learns the realization of θ before choosing its output level. Maximization of (1) w.r.t. q^M and of (2) w.r.t. q^R yields the following first-order conditions for the choices of output in the downstream market by the upstream monopolist and the rival firm (it is immediate to show that SOC are satisfied)

$$\begin{aligned}\theta - 2q^M - q^R &= 0 \\ \theta - 2q^R - q^M - a_L &= 0\end{aligned}$$

Solving the above equations, we obtain the equilibrium variables in the downstream market as function of θ and a_L

$$q^M(\theta, a_L) = \frac{\theta + a_L}{3}; q^R(\theta, a_L) = \frac{\theta - 2a_L}{3}; Q_L(\theta, a_L) = \frac{2\theta - a_L}{3}; P_L(\theta, a_L) = \frac{\theta + a_L}{3} \quad (5)$$

Let $w_L(\theta, a_L) = S(\theta, Q_L) + \lambda P_L q^M + \lambda a_L q^R$ with Q_L, P_L, q^M and q^R given by (5). Using (1) and (2) we can rewrite the objective function of the regulator as

$$W_L(\theta, a_L, \Pi_L^M, K, u) = w_L(\theta, a_L) - \lambda \Pi_L^M - K + u \quad (6)$$

The regulator's problem then consists in setting, for each realization of θ , the couple $\{a_L(\theta), \Pi_L^M(\theta)\}$ that maximizes W^L (given by 6), subject to two constraints. The first one, $E\Pi_L^M(\theta) - K \geq 0$, ensures that the upstream monopolist finds it profitable to acquire information about θ ; the second one ensures that the upstream monopolist accepts the regulatory contract once it has observed the realization of θ . Thus, under costly public information, the

regulator's maximization program, for any given realization of θ , is given by⁴

$$\begin{aligned} \max_{a_L(\cdot), \Pi_L^M(\cdot)} \quad & W_L(\theta, a_L(\cdot), \Pi_L^M(\cdot), K, u) \\ \text{s.t.} \quad & E\Pi_L^M(\theta) - K \geq 0, \quad (\text{IRL-IA}) \\ & \Pi_L^M(\theta) \geq 0 \text{ for all } \theta \in [\underline{\theta}, \bar{\theta}] \quad (\text{IRL}) \end{aligned}$$

It is immediate that, at the solution, $E\Pi_L^M(\theta) = K$ and the access price is given by

$$a_L^*(\theta) = \frac{(5\lambda - 1)\theta}{1 + 10\lambda} \quad (7)$$

with $a_L^*(\theta)$ increasing in λ . The positive relationship between the access price and the shadow cost of public funds reflects a sort of Ramsey prices. On the one hand, the higher a_L , the lower the transfer that needs to be paid to the upstream monopolist in order to ensure its participation. Ceteris paribus, this has a positive effect on welfare because it reduces distortionary taxation. On the other hand, the higher a_L , the lower the output in the downstream market (from 5). Ceteris paribus, this reduces welfare since production in the downstream market is suboptimal. Since the first effect is increasing in λ , whilst the second one is independent of λ , a more distortionary taxation (a greater value of λ) induces a higher level of the access price and a lower level of output. For $\lambda > \frac{1}{5}$, the first effect dominates: $a_L^*(\theta)$ is positive, i.e. higher than the marginal cost in the upstream market, and it is increasing in θ . For $\lambda < \frac{1}{5}$, the second effect dominates: $a_L^*(\theta)$ is negative, i.e. lower than the marginal cost in the upstream market, and it is decreasing in θ .

In light of the above analysis let $W_L^*(\theta, K, u)$ denote the maximum value function under costly public information and information acquisition, where $W_L^*(\theta, K, u) = w_L(\theta, a_L^*(\theta)) - (1 + \lambda)K + u$. The expected welfare from information acquisition under costly public information is then

$$EW_L^*(\theta, K, u) = Ew_L(\theta, a_L^*(\theta)) - (1 + \lambda)K + u \quad (8)$$

Instead, if information acquisition does not occur, the expected welfare is given by $EW_L^*(\theta_0) = w_L^*(\theta_0)$, where $w_L^*(\theta_0) \equiv Ew_L^*(a_L^*(\theta_0), \theta)$. Taking the difference between $EW_L^*(\cdot)$ and $w_L^*(\theta_0)$ we obtain the following lemma.

Lemma 1 *Costly public information on demand is socially valuable for $K \leq K_L^*$, where*

$$K_L^* = \frac{1+8\lambda+5\lambda^2}{2(1+\lambda)(1+10\lambda)}\sigma^2 + \frac{u}{(1+\lambda)}.$$

⁴We ignore the participation constraint of the rival, which can be shown to be always satisfied in equilibrium.

Under L , public information on demand θ is socially valuable because social welfare maximization calls for a different access price for any given θ and profit maximization calls for quantities under Cournot competition to vary with θ .

3.2 Separation

As benchmark consider the case where under S information acquisition is observable and information can be made public at no additional cost. Assuming that information acquisition is welfare enhancing, the regulatory mechanism induces the upstream monopolist to acquire information about the realization of θ at cost K . The downstream firms then learn the realization of θ from the public report made by the upstream monopolist and Cournot competition yields

$$q_S(\theta, a_S) = \frac{\theta - a_S}{3}; Q_S(\theta, a_S) = \frac{2\theta - 2a_S}{3}; P_S(\theta, a_S) = \frac{\theta + 2a_S}{3} \quad (9)$$

Letting $w_S(\theta, a_S) = S(\theta, Q_S) + \lambda a_S Q_S$, with q_S, Q_S , and P_S given by (9); using (3), and (4), the objective function of the regulator can be rewritten as

$$W_S(\theta, a_S, \Pi_S^M, K, u) = w_S(\theta, a_S) - \lambda \Pi_S^M - K + u \quad (10)$$

Under costly public information, the regulator's maximization program for any given θ , is then⁵

$$\begin{aligned} \max_{a_S(\cdot), \Pi_S^M(\cdot)} \quad & W_S(\theta, a_S(\cdot), \Pi_S^M(\cdot), K, u) \\ \text{s.t.} \quad & E\Pi_S^M(\theta) - K \geq 0 \\ & \Pi_S^M(\theta) \geq 0 \text{ for all } \theta \in [\underline{\theta}, \bar{\theta}] \end{aligned} \quad (\text{IRS-IA})$$

where the first constraint ensures that the upstream monopolist finds it profitable to acquire information about θ , whilst the second one ensures that the upstream monopolist accepts the regulatory contract once it has observed the realization of θ .

It is immediate that at the solution of the above program, $E\Pi_S^M(\theta) = K$, and the optimal access price is given by

$$a_S^*(\theta) = \frac{\theta(3\lambda - 1)}{2 + 6\lambda} \quad (11)$$

⁵We disregard the participation constraints of the downstream firms, which can be shown always to hold at the optimum.

As under L the access price is increasing in λ ; in particular, for $\lambda > \frac{1}{3}$, $a_S^*(\theta)$ is positive and increasing in θ while for $\lambda < \frac{1}{3}$, $a_S^*(\theta)$ is negative and decreasing in θ . In light of the above analysis, let $W_S^*(\theta, K, u)$ denote the maximum value function under costly public information and information acquisition, with $W_S^*(\cdot) = w_S(\theta, a_S^*(\theta)) - (1 + \lambda)K + u$. Taking the expectation we obtain the expected welfare from information acquisition, as given by

$$EW_S^*(\theta, K, u) = Ew_S(\theta, a_S^*(\theta)) - (1 + \lambda)K + u \quad (12)$$

Instead, if the value of θ remains unknown, the expected welfare is given by $EW_S^*(\theta_0) = w_S^*(\theta_0)$, where $w_S^*(\theta_0) \equiv EW_S^*(a_S^*(\theta_0), \theta)$. Taking the difference between $EW_S^*(\cdot)$ and $w_S^*(\theta_0)$ we obtain the following lemma.

Lemma 2 *Costly public information on θ is socially valuable if $K \leq K_S^*$, where $K_S^* = \frac{(1+\lambda)}{2(1+3\lambda)(1+\lambda)}\sigma^2 + \frac{u}{(1+\lambda)}$*

As under L , information on demand is valuable. Provided that the cost of acquiring information is not too high, information acquisition is optimal.

3.3 Comparison

In this section we compare welfare under L and S , with costly public information.

Proposition 1 *Under costly public information, there exists a level of λ , denoted by $\lambda^* > 0$, such that (i) $W_S^*(\theta, u) \geq W_L^*(\theta, u)$ and $w_S^*(\theta_0) \geq w_L^*(\theta_0)$ for $\lambda \leq \lambda^*$; (ii) $K_S^*(\lambda, u) \geq K_L^*(\lambda, u)$ for $\lambda \leq \lambda^*$. That is for $\lambda > \lambda^*$, under L expected welfare and the value of information are greater than under separation. The opposite statement holds for $\lambda < \lambda^*$.*

Under both L and S , the regulator uses the access price to reduce the need for distortionary taxation and to affect the behaviour of the firms in the downstream market. When λ is high, reducing the level of distortionary taxation is particularly important and thus the social value of the revenue obtained by the upstream monopolist in downstream market under L is high. This effect favours L . When λ is low, reducing the level of distortionary taxation is less important and the main concern of the regulator becomes to increase production in the downstream market. This calls for a low access price and it favours S .

4 Observable information acquisition with private information

In this section we consider the case where information acquisition is observable but the information is privately observed by the upstream monopolist. In this case, the regulator can demand the upstream monopolist to incur cost K to acquire information and use a direct truthful regulatory mechanism of the form: $\{a_i(\theta), \Pi_i^M(\theta)\}$, with $i = L, S$. We assume that the regulatory mechanism is public information and so is the report $\hat{\theta}$ made by the monopolist. This is realistic, given the lack of control on the activities of regulators if we assumed otherwise.⁶

4.1 Liberalization

Under L , consider the game played in the downstream market. Given the demand parameter announced by the upstream monopolist $\hat{\theta}$ and the access price set by the regulator, $a_L(\hat{\theta})$, the upstream monopolist chooses q^M to maximize

$$\Pi_L^M(\theta, \hat{\theta}) = (\theta - q^M - q^R)q^M + a_L(\hat{\theta})q^R + T_L(\hat{\theta}) \quad (13)$$

whilst the rival chooses q^R so as to maximize

$$\Pi_L^R(\hat{\theta}) = (\hat{\theta} - q^M - q^R - a_L(\hat{\theta}))q^R$$

Since in equilibrium $\hat{\theta} = \theta$, the rival learns the realization of demand from the report of the monopolist and uses it to set its own output. Thus, there is an informational externality: the information that the upstream monopolist acquires becomes public through the regulatory mechanism; this affects the strategy of the rival and, through this, the payoff of the monopolistic firm.

From the above two equations we obtain the equilibrium quantities produced in the downstream market for any given level of $\hat{\theta}$ and $a_L(\hat{\theta})$

$$q^M(\theta, \hat{\theta}) = \frac{3\theta - \hat{\theta} + 2a_L(\hat{\theta})}{6}; \quad q^R(\hat{\theta}) = \frac{\hat{\theta} - 2a_L(\hat{\theta})}{3} \quad (14)$$

By substituting for these equilibrium quantities in the profit function of the upstream monopolist, given by (13), and using standard techniques, we obtain the following two incentive

⁶It is also possible to show that if $\hat{\theta}$ were confidential information, under plausible assumptions ensuring strict monotonicity, its value could be easily inferred from the value of $a_L(\hat{\theta})$.

compatibility conditions for truth-telling

$$IC1 : \frac{\partial \Pi_L^M(\theta)}{\partial \theta} = q^M(\theta, \hat{\theta} = \theta) = \frac{\theta + a_L(\theta)}{3} > 0 \quad (15)$$

$$IC2 : \frac{\partial^2 \Pi_L^M(\theta)}{\partial \theta \partial \hat{\theta}} = \frac{\partial a_L(\theta)}{\partial \theta} - \frac{1}{2} > 0 \quad (16)$$

From (IC1) we note that the firm has incentives to underreport the realization of θ . How strong these incentives are depends on the rival's reaction in the unregulated market which in turns depends on whether the rival is informed or not. Suppose for a moment that also the rival is informed. In this case, the profit function of the incumbent from reporting $\hat{\theta}$ would be

$$\Pi_L^M(\theta, \hat{\theta}) = (\theta - q^M(\theta, \hat{\theta}) - q^R(\theta, \hat{\theta}))q^M(\theta, \hat{\theta}) + a_L(\hat{\theta})q^R(\theta, \hat{\theta}) + T_L(\hat{\theta})$$

with $q^M(\theta, \hat{\theta}) = \frac{\theta + a(\hat{\theta})}{3}$ and $q^R(\theta, \hat{\theta}) = \frac{\theta - 2a(\hat{\theta})}{3}$, and we would have

$$\frac{\partial \Pi_L^M(\theta, \hat{\theta})}{\partial \theta} = q^M(\theta, \hat{\theta}) - \frac{\partial q^R}{\partial \theta} (q^M(\theta, \hat{\theta}) - a(\hat{\theta})) = \frac{2\theta + 5a(\hat{\theta})}{9} \quad (17)$$

Thus when also the rival is informed, the gain from underreporting θ is as follows. First, the higher θ the greater the profit that the upstream monopolist can obtain in the downstream market for any given level of output produced by the rival. This effect is positive and given by $q_M(\theta, \hat{\theta})$. Second, the higher θ the greater the output of the rival in the downstream market, which in turn generates two effects: it increases the access revenues due to greater output by the rival and it reduces the profits of the upstream monopolist in the downstream market. The sum of these two effects is negative and given by $-\frac{\partial q_r}{\partial \theta} (q_M(\theta, \hat{\theta}) - a(\hat{\theta}))$, but is more than compensated by the first effect described above. Overall, the firm gains from underreporting θ .

Now consider the case studied in this paper where the rival is uninformed and chooses its output on the basis of $\hat{\theta}$, the level of demand reported by the upstream monopolist. An informational externality affects the incumbent's incentives to underreport θ .⁷ On the one hand, by underreporting θ the upstream monopolist gains greater profits in the downstream market; this is the first effect above given by $q_M(\theta, \hat{\theta})$. However, now a higher θ does not affect the output of the rival in the downstream market, and thus the term $-\frac{\partial q_r}{\partial \theta} (q_M - a(\hat{\theta}))$

⁷This informational externality of regulation is highlighted also by Calzolari and Scarpa (2006) who consider a multiutility firm active both in a regulated and in an unregulated market, with private information about economies of scope.

disappears. The informational externality increases incentives to underreport θ and the informational rent.

Using standard techniques, from (15), we obtain the expected rent of the upstream monopolist

$$E\Pi_L^M(\theta, a_L(\theta)) = \Pi_L^M(\underline{\theta}) + \int_{\underline{\theta}}^{\bar{\theta}} \frac{\theta + a_L(\theta)}{3} \frac{1 - F(\theta)}{f(\theta)} dF(\theta) \quad (18)$$

The regulator's problem is then to determine, for each θ , the couple $(\hat{a}_L(\theta), \hat{\Pi}_L^M(\theta))$ which solves the following maximization problem (referred to as PL-1)

$$\max_{a_L(\theta), \Pi_L^M(\theta)} \int_{\underline{\theta}}^{\bar{\theta}} W_L(\theta, a_L(\theta), \Pi_L^M(\theta), K, u) dF(\theta) \quad (\text{PL-1})$$

$$s.t. : (IRL - IA), (16)$$

$$\Pi_L^M(\theta, a_L(\theta)) \equiv \Pi_L^M(\underline{\theta}) + \int_{\underline{\theta}}^{\bar{\theta}} \frac{\theta + a_L(\theta)}{3} d\theta \geq 0 \quad (\text{IRL})$$

where in $(IRL - IA)$, the expected rent is given by (18). Letting μ be the non-negative multiplier associated with the constraint $(IRL - IA)$, the following lemma obtains.

Lemma 3 *Let $\hat{K}_L^0 \equiv E\Pi_L^M(\theta, \hat{a}_L(\theta, \mu = 0))$ and $\hat{K}_L^1 \equiv E\Pi_L^M(\theta, \hat{a}_L(\theta, \mu = \lambda))$ with $\hat{K}_L^1 > \hat{K}_L^0$. Under observable information acquisition, the optimal access price schedule with liberalization is given by*

$$\hat{a}_L(\theta, \mu) \equiv \frac{\theta(5\lambda - 1) - 3(\lambda - \mu(K)) \frac{1 - F(\theta)}{f(\theta)}}{1 + 10\lambda} \quad (19)$$

where (i) for $K \leq \hat{K}_L^0$, $\mu(K) = 0$; (ii) for $K \in (\hat{K}_L^0, \hat{K}_L^1)$, $\mu(K) \in (0, \lambda)$ solves

$$E\Pi_L^M(\theta, \hat{a}_L(\theta, \mu)) = K; \quad (20)$$

with $\mu'(K) \geq 0$; and (iii) for $K \geq \hat{K}_L^1$, $\mu(K) = \lambda$.

The intuition is as follows. When K is low (i.e. $K < \hat{K}_L^0$), the expected rent (given by (18)) - evaluated at $a_L^*(\theta)$ - is greater than K . Thus the $(IRL - IA)$ constraint is slacking and we are in a standard adverse selection problem. To reduce this rent, which has a social cost of λ , the regulator introduces a downward distortion in the access-price schedule with respect to the perfect information allocation (7) for all $\theta < \bar{\theta}$. This leads to $\hat{a}_L(\theta, \mu = 0)$. As K raises, eventually it reaches a level, \hat{K}_L^0 , where the expected rent, evaluated at $\hat{a}_L(\theta, \mu = 0)$, is equal to K . From this value of K onwards, the $(IRL - IA)$ constraint starts to be binding.

Thus there is no longer a need to minimize the informative rent, and in fact, the firm needs to receive an additional transfer to help it cover the cost of acquiring information. The distortion in the access price is gradually reduced, and as K reaches the value \widehat{K}_L^1 , the access price schedule returns to its full information level, $a_L^*(\theta)$. For even higher K , the firm is compensated for the information acquisition cost with an increase in the monetary transfer.⁸

Let $\widehat{W}_L(\theta, K, u)$ denote the maximum value function under observable information acquisition, in light of Lemma 3 we have

$$E\widehat{W}_L(\theta, K, u) = w_L(\theta, \widehat{a}_L(\theta, \mu(K))) - (\lambda E\Pi_L^M(\theta, \widehat{a}_L(\theta, \mu(K))) + K) + u \quad (21)$$

$$\text{with } \frac{\partial E\widehat{W}_L(\theta, K)}{\partial K} = -(1 + \mu(K))$$

If instead there is no information acquisition, the maximum value function is given by $w_L^*(\theta_0)$. We denote by \widehat{K}_L^* the level of K such that for $K \geq \widehat{K}_L^*$ information acquisition is suboptimal. Since $E\widehat{W}_L(\cdot) \leq EW_L^*(\cdot)$, we have $\widehat{K}_L^* \leq K_L^*$.

Now consider how the unobservability of θ affects the performance of regulation. Let $\widehat{\Delta}^L(\cdot) \equiv \max\{EW_L^*(\theta, K, u), w_L^*(\theta_0)\} - \max\{E\widehat{W}_L(\theta, K, u), w_L^*(\theta_0)\}$ and without loss of generality consider the case where $\widehat{K}_L^1 \leq K_L^*$. The following lemma is then obtained.

Lemma 4 (i) $\widehat{\Delta}^L(K) > 0$; with $\frac{\partial \widehat{\Delta}^L(K)}{\partial K} = \mu(K) - \lambda < 0$ for all $K < \widehat{K}_L^1$; (ii) $\widehat{\Delta}^L(K) = 0$ for $K \geq \widehat{K}_L^1$. That is, asymmetric information reduces expected welfare under liberalization for all $K < \widehat{K}_L^1$, whilst it has no effects for $K \geq \widehat{K}_L^1$.

Lemma 4 is easily understood in light of the fact that for $K < \widehat{K}_L^1$ information acquisition is optimal but it is costly in terms of expected rent due to asymmetric information. For $K > \widehat{K}_L^1$, the expected rent due to asymmetric information is insufficient to cover information acquisition cost. The IC constraint (16) starts to slack, whilst the $(IRL - IA)$ starts to bind as under costly public information leading to $EW_L^*(\theta, K, u) = E\widehat{W}_L(\theta, K, u)$. It also follows from this that $\widehat{K}_L^* = K_L^*$ and that $\widehat{\Delta}^L$ is independent of u .

⁸Second order conditions are satisfied and the constraint (16) is satisfied provided that

$$-\frac{3}{2} + 5\lambda - 3(\lambda - \mu) \frac{\partial}{\partial \theta} \left(\frac{1 - F(\theta)}{f(\theta)} \right) \geq 0$$

4.2 Separation

Following the same reasoning as under L , consider the game played in the downstream market when the value of demand parameter announced by the upstream monopolist is $\hat{\theta}$. Anticipating that in equilibrium $\hat{\theta} = \theta$, a downstream firm chooses q_S so as to maximize

$$\Pi_S^D(\hat{\theta}) = (\hat{\theta} - 2q_S - a_S(\hat{\theta}))q_S$$

yielding $q_S(\hat{\theta}) = \frac{\hat{\theta} - a_S(\hat{\theta})}{3}$ and profit for the upstream monopolist equal to

$$\Pi_S^M(\hat{\theta}) = a_S(\hat{\theta})2q_S(\hat{\theta}) + T_S(\hat{\theta}) \quad (22)$$

It follows that $\frac{\partial \Pi_S^M(\theta)}{\partial \theta} = 0$, which implies that the upstream monopolist has no incentives to misreport the value of θ and therefore the optimal mechanism is the same as under costly public information. Intuitively, under S the profits of the upstream monopolist are equal to the access revenues which only depend on the quantities produced by the downstream firms. These quantities are in turn independent of θ : since the downstream firms are ignorant, their output decisions are taken on the basis of the reported realization of θ and not of its true realization. It follows that the profits of the upstream monopolist are independent of the true realization of θ . This explains why the informational externality generated by the regulatory mechanism, as under L , works, contrary to L , in favour of truthful reporting of θ . Indeed if the downstream firms were informed, by underreporting θ the incumbent could gain the greater access revenues corresponding to the true realization of θ . In particular, if the downstream firms were informed, we would have

$$\Pi_S^M(\theta, \hat{\theta}) = a(\hat{\theta})Q(\theta, \hat{\theta}) + T_S(\hat{\theta})$$

with $Q(\theta, \hat{\theta}) = \frac{2\theta - 2a(\hat{\theta})}{3}$ and

$$\frac{\partial \Pi_S^M(\theta, \hat{\theta})}{\partial \theta} = a(\hat{\theta}) \frac{\partial Q}{\partial \theta} > 0 \quad (23)$$

That is, with informed downstream firms, it would be more costly for the regulator to extract information about demand from the upstream monopolist because the firm would have incentives to underreport θ in order to raise its access revenues.

Let us now go back to the case analyzed in this paper and let $E\widehat{W}_S(K, u)$ denote the expected maximum value function under S when there is information acquisition and information acquisition is observable. We have

$$E\widehat{W}_S(K, u) = EW_S^*(K, u) \quad (24)$$

where $EW_S^*(K, u)$ is given by (12). For $K > \widehat{K}_S^*$ there is no information acquisition and the maximum value function is given by $w_S^*(\theta_0)$, and it follows from (24) that $\widehat{K}_S^* = K_S^*$.

Let $\widehat{\Delta}^S(\cdot) = \max\{EW_S^*(K, u), w_S^*(\theta_0)\} - \max\{\widehat{EW}_S(K, u), w_S^*(\theta_0)\}$ in light of (24) we obtain the following lemma.

Lemma 5 $\widehat{\Delta}^S = 0$ for all K and u . That is, under separation, asymmetric information has no effect on welfare.

Under observable information acquisition, asymmetric information has no effect on the efficiency of the regulatory mechanism since the monopolist has no incentives to misreport the level of demand; the optimal access price is then given by (11), and the $(IR - IA)$ constraints is binding for all $K > 0$.

4.3 Comparison

From Lemmas 4 and 5 we have seen that for all $K < \widehat{K}_L^1$ asymmetric information creates a distortion in the optimal mechanism under L but not under S , whilst for all $K \geq \widehat{K}_L^1$ under both L and S there is no distortion. The Proposition below is then obtained.

Proposition 2 (i) $\widehat{\Delta}_L(K) - \widehat{\Delta}_S > 0$ and $\frac{\partial(\widehat{\Delta}_L(K) - \widehat{\Delta}_S)}{\partial K} = \mu(K) - \lambda < 0$ for $K < \widehat{K}_L^1$, where $\mu(K)$ is defined in Lemma 4. (ii) $\widehat{\Delta}_L(K) - \widehat{\Delta}_S = 0$ for $K \geq \widehat{K}_L^1$. That is, when information acquisition is costly but observable, asymmetric information on demand generates a bias in favour of separation for all $K < \widehat{K}_L^1$, whilst it has no effect on the welfare comparison between liberalization and separation for all $K \geq \widehat{K}_L^1$. The bias in favour of separation over the range $K < \widehat{K}_L^1$ decreases with K .

5 Unobservable information acquisition

In this section we consider the case where information acquisition is unobservable.

5.1 Liberalization

Consider the case of L , when the regulator induces through the choice of the regulatory mechanism the upstream monopolist to acquire information. In this case, an additional constraint needs to be added to the regulator's maximization program (PL-1) compared to the case where information acquisition is observable. This is the incentive compatibility constraint

on information acquisition, $(IC - IA)$, which ensures that, under the optimal mechanism, the upstream monopolist prefers to incur K to become informed about the realization of θ rather than remain uninformed.

In this context, it is easy to show that with linear demand function an uninformed upstream monopolist would choose the contract corresponding to the mean of the distribution of $\theta : \{a(\theta_0), T(\theta_0)\}$. By using equations (15) and (18), the $(IC - IA)$ is then given by

$$E\Pi_L^M(\theta) - \Pi_L^M(\theta_0) = \int_{\underline{\theta}}^{\bar{\theta}} q^M(\theta)(1 - F(\theta) - \Upsilon_{\theta < \theta_0})d\theta \geq K \quad (\text{IC-IA})$$

where Υ is a dummy variable with $\Upsilon = 1$ if $\theta < \theta_0$ and $\Upsilon = 0$ if $\theta \geq \theta_0$. Let ν denote the non-negative multiplier of the $(IC - IA)$, the regulator's problem is then

$$\begin{aligned} \max_{a_L(\theta), \Pi_L^M(\theta)} \int_{\underline{\theta}}^{\bar{\theta}} W_L(\theta, a_L(\theta), \Pi_L^M(\theta), K, u)dF(\theta) \\ \text{s.t. : } (IR - IA), (IRL), (16), (IC - IA) \end{aligned}$$

We obtain the following Lemma.

Lemma 6 *Let $\tilde{K}_L = \frac{1}{6}(1 + \frac{\partial \hat{a}_L(\theta, \mu=0)}{\partial \theta})\sigma^2 < K_L^0$. Under unobservable information acquisition, the optimal access price schedule with L is given by*

$$\tilde{a}_L(\theta, \nu) = \begin{cases} \frac{\theta(5\lambda-1)-3(\lambda-\nu(K))\frac{1-F(\theta)}{f(\theta)}}{1+10\lambda} & \text{for } \theta > \theta_0 \\ \frac{\theta(5\lambda-1)-3\left(\lambda\frac{1-F(\theta)}{f(\theta)}+\nu(K)\frac{F(\theta)}{f(\theta)}\right)}{1+10\lambda} & \text{for } \theta < \theta_0 \end{cases} \quad (25)$$

where (i) $\nu(K) = 0$ for $K \leq \tilde{K}_L$, (ii) $\nu(K) \in (0, \lambda]$ and solves

$$E\Pi_L^M(\theta, \nu) - \Pi_L^M(\theta_0) = K \quad (26)$$

with $\nu'(K) > 0$ and $\nu(K) \geq \mu(K)$, for $K > \tilde{K}_L$.

Recall the constraint (IC-IA). Depending on whether θ is greater or smaller than θ_0 an increase in $a_L(\cdot)$ has one or two (opposing) effects on the value of information. An increase in $a_L(\cdot)$ increases $E\Pi_L^M(\theta)$ by $(1 - F(\theta))$ and eases the information constraint, but for $\theta \in (\underline{\theta}, \theta_0)$ a unit increase in $a_L(\cdot)$ increase also $\Pi_L^M(\theta_0)$ by a unit and makes the information constraint tighter. Therefore $\tilde{a}_L(\theta)$ is higher than $\hat{a}_L(\theta)$ for large values of θ and smaller for low θ which implies a discontinuity at θ_0 .

Let $\widetilde{W}_L(K, u)$ denote the maximum value function under unobservable information acquisition when information acquisition is induced, and let $E\widetilde{W}_L(K, u)$ denote its expectation. From Lemma 6, we have

$$E\widetilde{W}_L(K, u) = Ew_L(\theta, \widetilde{a}_L(\theta, \nu(K)) - \lambda E\Pi_L^M(\theta, \widetilde{a}_L(\theta, \nu(K)) - K + u) \\ \text{with } \frac{\partial \widetilde{W}_L(K, u)}{\partial K} = -(1 + \nu(K))$$

and there exists a $\widetilde{K}_L^*(u)$ such that for $K \leq \widetilde{K}_L^*(u)$ there is information acquisition and $E\widetilde{W}_L(K, u)$ is obtained, whilst for $K > \widetilde{K}_L^*(u)$ there is no information acquisition and the maximum value function is given by $Ew_L^*(\theta_0) = w_L^*(\theta_0)$, where it is immediate that $\widetilde{K}_L^*(u)$ is increasing in u and that $\widetilde{K}_L^*(u) \leq \widehat{K}_L^*(u)$.

Let $\widetilde{\Delta}_L(\cdot) = \max\{E\widehat{W}_L(\cdot), w_L^*(\theta_0)\} - \{E\widetilde{W}_L(\cdot), w_L^*(\theta_0)\}$, that is $\widetilde{\Delta}_L$ denotes the welfare difference under L between the case where information acquisition is observable and the case where it is not observable.

Lemma 7 *Under unobservable information acquisition, (i) $\widetilde{\Delta}_L = 0$ for $K \leq \widetilde{K}_L$; (ii) $\widetilde{\Delta}_L(K, u) > 0$, with $\frac{\partial \widetilde{\Delta}_L(K, u)}{\partial K} = \nu(K) - \mu(K)$, $\frac{\partial \widetilde{\Delta}_L(K, u)}{\partial u} \geq 0$ for $K \in (\widetilde{K}_L, \widehat{K}_L^*(u)]$, (iii) $\widetilde{\Delta}_L(K) = 0$ for $K > \widehat{K}_L^*(u)$.*

Intuitively, when K is low (case (i) in the Lemma), the unobservability of information acquisition does not induce any welfare loss since the firm has incentives to acquire information in order to gain the informational rent. However, as K increases (case (ii)) inducing information becomes costly. The $(ICL - IA)$ constraint starts to bind and the regulator starts to distort the mechanism in order to provide the firm with incentives to acquire information. When K increases even further (case (iii)) information acquisition becomes so costly that it is preferable for welfare not to induce it.

When information acquisition is observable, we have seen in section 4.1 that the informational externality has a negative social value since it increases the incentives of the upstream monopolist to underreport θ . We now show that the informational externality has also a negative social value when information acquisition is unobservable. Indeed suppose for a moment that the rival is informed; the value of information for the upstream monopolist is obtained by differentiating (17), evaluated at $\widehat{\theta} = \theta$, with respect to θ ,

$$E\Pi_L^M(\theta) - \Pi_L^M(\theta_0) = \frac{1}{2} \frac{\partial^2 \Pi_L^M(\theta)}{\partial^2 \theta} \sigma^2 = \frac{1}{18} (2 + 5 \frac{\partial a}{\partial \theta}) \sigma^2$$

It is easy to show that the above expression is greater than \tilde{K}_L , defined in Lemma 6, which is the value of information for the upstream monopolist when the rival is ignorant.⁹ This result can be understood by noticing that the gain from information acquisition is proportional to the sensitivity of the regulated access price to θ and the degree of proportionality is greater when the rival is informed with respect to the case it is ignorant. This in turn is due to access revenues being sensitive to θ when the rival is informed but not when the rival is ignorant (see 17).

5.2 Separation

Consider the value of information for the upstream monopolist under S . Recall that $\frac{\partial \Pi_S^M}{\partial \theta} = 0$, which as we have seen implies that there is no gain for the upstream monopolist from misreporting the value of the demand parameter. Whilst this is a positive result for the regulator when information acquisition is observable, it becomes problematic when information acquisition is not observable, as the lemma below emphasizes.

Lemma 8 *Under unverifiable information acquisition the upstream monopolist never acquires information under separation.*

Intuitively, since the monopolist cannot extract any informative rent from acquiring information under S , it will have no incentives to invest K in order to learn the value of θ , or to put it differently, since the monopolist does not produce in the downstream market, information revelation is a cheap talk game. It follows from the above lemma that the optimal regulatory mechanism will be given by $\{a_S^*(\theta_0), \Pi_S^*(\theta_0)\}$, leading to an expected welfare of $E\tilde{W}_S(K, u) = w_S^*(\theta_0)$. Then, letting $\tilde{\Delta}_S(\cdot) = \max\{E\tilde{W}_S(\cdot), w_S^*(\theta_0)\} - \max\{E\tilde{W}_S(\cdot), w_S^*(\theta_0)\}$, we obtain the lemma below.

Lemma 9 (i) $\tilde{\Delta}_S(K, u) > 0$, for all $K \leq K_S^*(u)$, with $\frac{\partial \tilde{\Delta}_S(K)}{\partial K} = -(1 + \lambda)$, $\frac{\partial \tilde{\Delta}_S(K, u)}{\partial u} > 0$,
 ii) $\tilde{\Delta}_S = 0$ for all $K > K_S^*(u)$.

Since there is no information acquisition under S , a welfare loss due to the unobservability of information acquisition will arise whenever information acquisition is socially desirable, i.e. whenever $K \leq K_S^*$.

⁹Indeed the difference between the above expression and \tilde{K}_L reduces to $2\frac{\partial a}{\partial \theta} - 1$ which is positive in light of (16).

When information acquisition is observable, we have seen in section 4.2 that the informational externality due to the rival not being informed has a positive social value since it eliminates the incentives of the upstream monopolist to underreport θ . However, this informational externality has a negative social value when information acquisition is unobservable, as in the case analyzed in this section. Indeed, if the unregulated downstream firms were informed, the upstream monopolist would have incentives to acquire information on θ . By differentiating (23), evaluated at $\hat{\theta} = \theta$, with respect to θ , we obtain the value of information for the upstream monopolist

$$E\Pi_S^M(\theta) - \Pi_S^M(\theta_0) = \frac{1}{2} \frac{\partial^2 \Pi_S^M(\theta)}{\partial^2 \theta} \sigma^2 = \frac{\partial a}{\partial \theta} \frac{\partial Q}{\partial \theta} \sigma^2$$

which is positive. This result is due to the monopolist's profit function becoming sensitive to θ when the downstream firms are informed with respect to the case where they are ignorant.

5.3 Comparison

We now study how the unobservability of information acquisition affects the performance of the two regimes, L and S , compared to a situation where information acquisition is observable by the regulator. The proposition below summarizes our main result.

Proposition 3 (i) If $\lambda \leq \lambda^*$, unobservability of information acquisition creates a bias in favour of liberalization (i.e., $\tilde{\Delta}_L(K, u) \leq \tilde{\Delta}_S(K, u)$) and this bias is non-increasing in K ; (ii) If $\lambda > \lambda^*$, there exists a level of K , denoted by $K^*(u)$, where $K^* \in (\tilde{K}_L, K_S^*(u))$ such that for $K \leq K^*(u)$ unobservability of information acquisition creates a bias in favour of liberalization (i.e., $\tilde{\Delta}_L(K, u) \leq \tilde{\Delta}_S(K, u)$) and this bias is non-increasing in K . For $K > K^*(u)$ unobservability of information acquisition creates a bias in favour of separation (i.e., $\tilde{\Delta}_L(K, u) > \tilde{\Delta}_S(K, u)$) and this bias is non-decreasing in K for $K \leq K_S^*(u)$.

The above proposition follows from a combination of two effects. First, as we have seen in the previous section, it is easier to induce information acquisition under L than under S . Ceteris paribus this creates a bias in favour of L . Intuitively, inducing information acquisition is easier under L than under S because information on θ is more valuable to the firm when it can use this information also to choose output in the product market (as under L) than when it cannot (as under S). This result is close to Iossa and Legros (2004) who have shown that property rights can help to increase incentives to acquire information. Second, the value

of information acquisition depends on λ . If $\lambda \leq \lambda^*$ information acquisition is more valuable under S than under L (since $K_S^* \geq K_L^*$, and $\widehat{K}_S^* \geq \widehat{K}_L^*$) and thus more is lost from lack of information under S compared to L . These two effects go in the same direction and explain point (i). Instead, if $\lambda > \lambda^*$, information acquisition is more valuable under L than under S (since $K_S^* < K_L^*$) and the two effects go in opposite direction. Then, for low K information acquisition is valuable under both L and S and a bias arises in favour of L . For high K the opposite is true. This explains point (ii).

Before concluding this section consider the effect of an increase in the social value of information, as captured by an increase in u . From Lemmas 7 and 9, we obtain.

Corollary 1 *The greater is u the more unobservability of information acquisition is likely to generate a bias in favour of liberalization.*

Intuitively, an increase in the social value of information (u) increases the welfare loss due to the unobservability of information acquisition both under L and under S ($\widetilde{\Delta}_L$ and $\widetilde{\Delta}_S$ are non-decreasing in u). However, since under S the regulatory mechanism does not provide any incentives to acquire information, an increase in the social value of information increases the welfare loss ($\frac{\widetilde{\Delta}_S}{\partial u} > 0$) whatever the cost information acquisition (K). Instead, under L , an increase in the social value of information does not affect the welfare loss due to the unobservable information acquisition for all values of K where the regulatory mechanism induces information acquisition ($\frac{\widetilde{\Delta}_L}{\partial u} = 0$ for low level of K , i.e. $K \leq \widetilde{K}_L^* \in [\widetilde{K}_L, K_L^*]$).

6 Information acquisition by the affiliate

Until now we have assumed that the upstream monopolist is the only firm that, at cost K , can acquire information on the realization of θ . However, if we take into account that one of the two downstream firms was an affiliate of the upstream monopolist before the separation, it seems possible that also this firm will have the technology and the know-how to acquire information on θ . In this section we allow for this possibility. We let the cost of information acquisition for the downstream firm be K and we assume again that information acquisition is unobservable. Since this firm is unregulated and since the downstream firms choose their output simultaneously, the other firm as well as the upstream monopolist will remain ignorant.

In this setting, the regulator's problem is to select a couple $\{a_S, \Pi_S^M\}$ which maximizes the expected welfare function taking into account the incentives of the downstream firm to acquire information on θ . Consider therefore the incentives of the downstream firm. It is easy to show that $q_S^N(\theta_0, a_S^N) = \frac{\theta_0 - a_S}{3}$ is the quantity produced by an uninformed firm when also the rival is uninformed, and that the maximum value function of the downstream firm when it acquires information and the rival is still uninformed is given by

$$\Pi_S^D(\theta, \theta_0, a_S) = \left(\frac{\theta}{2} - \frac{\theta_0}{6} - \frac{a_S}{3} \right)^2 - K$$

Denoting by $\Pi_S^D(\theta_0, a_S)$ the expected profit of the firm when it does not acquire information, we obtain the value of information for the downstream firm

$$E\Pi_S^D(\theta, \theta_0, a_S) - \Pi_S^D(\theta_0, a_S) = \frac{\partial^2 \Pi_S^D(\theta, \theta_0, a_S)}{\partial^2 \theta} \frac{\sigma^2}{2} = \frac{\sigma^2}{4} \quad (27)$$

which leads us to the following lemma.

Lemma 10 *Under unobservable information acquisition, the optimal mechanism is given by $\{a_S(\theta_0), \Pi_S^M(\theta_0)\}$; (ii) the downstream firm acquires information on θ if $K \leq \tilde{K}_S$, where $\tilde{K}_S = \frac{\sigma^2}{4} < \tilde{K}_L$.*

Due to linear demand, the value of information for the downstream firm is independent of the access price and the regulator cannot affect the incentives of the downstream firm to acquire information on demand through the access price. The optimal mechanism is therefore the same as when the downstream firm cannot acquire information, i.e. $\{a_S(\theta_0), \Pi_S^M(\theta_0)\}$. Given this mechanism and Cournot competition in the downstream market, information on demand is valuable to the downstream firm since it yields greater expected profits. For $K \leq \tilde{K}_S$ the firm will then acquire information. However, since the access price is sensitive to θ under L but not under S , we have $\tilde{K}_S < \tilde{K}_L$. That is the value of information for the upstream monopolist under L is always greater than the value of information for the downstream firm under S because the upstream monopolist can use the information on demand not just to choose output in the downstream market but also to increase access revenue.

Let $\tilde{W}_S(K, u)$ denote the maximum value function under unobservable information acquisition and let $E\tilde{W}_S(K, u)$ denote its expectation. In light of the above analysis we have

$$E\tilde{W}_S(\theta, K, u) = \int_{\underline{\theta}}^{\bar{\theta}} w_S(\theta, \theta_0) dF(\theta) - K + u \text{ with } \frac{\partial E\tilde{W}_S(\theta, K, u)}{\partial K} = -1 \text{ for } K \leq \tilde{K}_S \quad (28)$$

whilst in the absence of information acquisition, i.e. for $K > \tilde{K}_S$, the maximum value function is given by $w_S^*(\theta_0)$. The proposition below summarizes the main result of this section.

Proposition 4 *When a downstream firm can acquire information about θ , Lemma 9 and Proposition 3 continue to hold.*

Proposition 4 steams from a combination of two things. First, the incentives to acquire information of the subsidiary are suboptimal. We show in appendix that the level of K below which information acquisition by the firm is socially optimal is greater than \tilde{K}_S . This is because the firm does not internalize the effect that its information generates on consumer surplus and u . Second, when the subsidiary acquires information it does so privately: the rival does not learn the realization of θ before choosing its output. This creates a loss in welfare compared to the case of public information.

7 Conclusions

In this paper we have studied the desirability of allowing an upstream monopolist to operate in the downstream market (liberalization) rather than to exclude it (separation), in the presence of costly demand information. We have shown that asymmetric information on demand favours separation but unobservability of information acquisition favours liberalization. We have also shown that the greater the value of information about demand the more liberalization is likely to be preferable to separation. Thus liberalization may be preferable in industries such as telecommunication and electricity where demand is uncertain and lack of information on demand can generate very costly service disruptions. The case for liberalization based on the issue of demand information is instead weaker in industries where the value of information on demand is smaller.

We have focused on the case where the number of firms is the same under both liberalization and separation. An extension of our analysis could be to study how the cost of acquiring that technology may affect entry decisions.

8 Appendix

Proof of Lemma 1. Under L , information acquisition is optimal if $Ew_L^*(\theta) - w_L^*(\theta_0) + u \geq (1 + \lambda)K$. By using Taylor expansion we can rewrite

$$Ew_L^*(\theta) - w_L^*(\theta_0) = \frac{\partial^2 w_L(\theta)}{\partial^2 \theta} \frac{\sigma^2}{2} = \frac{1 + 8\lambda + 5\lambda^2}{2(1 + 10\lambda)} \sigma^2$$

leading to K_L^* . ■

Proof of Lemma 2. It follows by using the same procedure as in the proof of Lemma 1. ■

Proof of Proposition 1. (i) First note that $W_S^*(\theta, \lambda, u) = W_L^*(\theta, \lambda, u)$ at $\lambda = 0$, and $\left. \frac{dW_L^*(\theta, \lambda, u)}{d\lambda} \right|_{\lambda=0} = -\theta^2$, $\left. \frac{dW_S^*(\theta, \lambda, u)}{d\lambda} \right|_{\lambda=0} = -\frac{\theta^2}{2}$ which implies $W_S^*(\theta, \lambda, u) > W_L^*(\theta, \lambda, u)$ in a neighborhood of $\lambda = 0$. Tedious calculations then give $\frac{d^2 W_L^*(\theta, \lambda, u)}{d\lambda^2} - \frac{d^2 W_S^*(\theta, \lambda, u)}{d\lambda^2} = b$, where b is a positive constant, which implies that there exists a $\lambda^* > 0$, independent of θ , such that $W_S^*(\theta, \lambda, u) < W_L^*(\theta, \lambda, u)$ for all $\lambda > \lambda^*$, and vice versa. (ii). From (i) $EW_S^*(\theta, \lambda, u) - w_S^*(\theta_0, \lambda) = EW_L^*(\theta, \lambda, u) - w_L^*(\theta_0, \lambda)$ at $\lambda = 0$ and $\lambda = \lambda^*$, i.e. $K_S^*(\lambda, u) = K_L^*(\lambda, u)$ at $\lambda = 0, \lambda = \lambda^*$. Furthermore from the definition of $K_S^*(\lambda, u)$ and $K_L^*(\lambda, u)$ it easy to show that they are continuous non-increasing functions of λ with $\left| \frac{\partial K_S^*(\lambda, u)}{\partial \lambda} \right| < \left| \frac{\partial K_L^*(\lambda, u)}{\partial \lambda} \right|$ at $\lambda = 0$ and $\left| \frac{\partial K_S^*(\lambda, u)}{\partial \lambda} \right| > \left| \frac{\partial K_L^*(\lambda, u)}{\partial \lambda} \right|$ at $\lambda = \lambda^*$; so the result follows. ■

Proof of Lemma 3. Since the objective function of program (PL-1) is strictly concave and the constraint ($IRL - IA$) is linear in a_L and in K , the problem is convex with an unique solution. Neglecting for the moment constraint (16), maximization of the the Lagrangian of program (PL-1) w.r.t. a yields

$$-(1 + 10\lambda)\widehat{a}_L(\cdot) - \theta + 5\lambda\theta - 3(\lambda - \mu) \frac{1 - F(\theta)}{f(\theta)} = 0$$

where the SOC and constraint (16) are satisfied provided that $-\frac{3}{2} + 5\lambda - 3(\lambda - \mu) \frac{\partial}{\partial \theta} \left(\frac{1 - F(\theta)}{f(\theta)} \right) \geq 0$. Now, consider the case where ($IRL - IA$) is not binding and $\mu = 0$. Substituting for $a_L = \widehat{a}_L(\theta, \mu = 0)$ in (18) we obtain \widehat{K}_L^0 . Thus, $\mu = 0$ is the solution for $K \leq \widehat{K}_L^0$. Substituting for $a_L = \widehat{a}_L(\theta, \mu = \lambda)$ in the same equation, we obtain \widehat{K}_L^1 .

Since $W_L(\cdot)$ is strictly concave and the ($IRL - IA$) constraint is linear in a_L and in K , it follows that its value function, $E\widehat{W}_L$, is concave in K and $\mu(K) = -\frac{\partial E\widehat{W}_L(K, u)}{\partial K} - 1$. Given

the concavity of $E\widehat{W}_L$, $\mu(K)$ is a non-decreasing function of K ; for $K \leq \widehat{K}_L^0$, $\widehat{W}_L(\cdot)$ is linear in K and $\mu(K) = 0$. To see that $\mu \leq \lambda$, consider an increase dK in K ; a (suboptimal) feasible response by the regulator that would maintain all the constraints satisfied would be to increase all the transfers by dK and to keep the same access price schedule (the $IRL - IA$ and IRL would be still met). This would decrease its payoff by $(1 + \lambda)dK$. Therefore we have $E\widehat{W}_L(K + dK, u) \geq E\widehat{W}_L(K, u) - (1 + \lambda)dK$ and so $\frac{\partial E\widehat{W}_L(K, u)}{\partial K} \geq -(1 + \lambda)$. Since, for $K \geq \widehat{K}_L^1$, $\widehat{a}_L(\widetilde{\theta}, \mu = \lambda) = a_L^*(\theta)$ we have $E\widehat{W}_L(\theta, u) = EW_L^*(\theta, u)$. ■

Proof of Lemma 4. First note that $\widehat{\Delta}^L(K) > 0$ for $K \rightarrow 0$, since $E\Pi_L^M(\theta, \widehat{a}_L(\theta, \mu = 0)) > K$ and $EW_L(\theta, \widehat{a}_L(\theta, \mu = 0), u) < EW_L(\theta, a_L^*(\theta), u)$ from $a_L^*(\theta) = \arg \max EW_L(\theta, a_L(\theta), u)$ and $a_L^*(\theta) \neq \widehat{a}_L(\theta, \mu = 0)$. From (8), (21) and Lemma 3, we then have $\frac{\partial \widehat{\Delta}^L(K)}{\partial K} = -\lambda + \mu(K) \leq 0$. For $K \geq \widehat{K}_L^1$, $EW_L(\theta, \widehat{a}_L(\theta, \mu = \lambda), u) = EW_L(\theta, a_L^*(\theta), u)$, since $\widehat{a}_L(\widetilde{\theta}, \mu = \lambda) = a_L^*(\theta)$. ■

Proof of Lemma 6. Constraint ($ICL - IA$) implies that the constraint ($IRL - IA$) is automatically satisfied and therefore it can be neglected. Neglecting for the moment the constraint (16), the Lagrangian of the maximization problem becomes

$$\int_{\underline{\theta}}^{\bar{\theta}} (S(\theta, Q_L(\theta, a_L)) + \lambda P(\theta, a_L) q^M(\theta, a_L) + \lambda a_L q^R(\theta, a_L) + u - \lambda q^M(\theta, a_L) \frac{1 - F(\theta)}{f(\theta)} + \nu q^M(\theta, a_L) \frac{1 - F(\theta) - \Upsilon_{\theta < \theta_0}}{f(\theta)} - (\nu + 1)K) dF(\theta)$$

Since the function is strictly concave and the constraint ($ICL - IA$) is linear in a_L and in K , the problem is convex with an unique solution. Maximization w.r.t. a yields

$$-(1 + 10\lambda)\widetilde{a}_L(\cdot) - \theta + 5\lambda\theta - 3\lambda \frac{1 - F(\theta)}{f(\theta)} + 3\nu \frac{1 - F(\theta) - \Upsilon_{\theta < \theta_0}}{f(\theta)} = 0$$

where SOC and constraint (16) are satisfied provided that $-\frac{3}{2} + 5\lambda - 3\lambda \frac{\partial}{\partial \theta} \left(\frac{1 - F(\theta)}{f(\theta)} \right) + 3\nu \frac{\partial}{\partial \theta} \left(\frac{1 - F(\theta) - \Upsilon_{\theta < \theta_0}}{f(\theta)} \right) \geq 0$.

(i) Now, let us take the case where the ($ICL - IA$) is slacking at the solution to the maximization program, and thus $\nu(K) = 0$. From the ($IRL - IA$) and the ($ICL - IA$) it follows that ($IRL - IA$) cannot be binding. Thus when $\nu(K) = 0$, we have $\mu = 0$, and we obtain that for all $K \leq \widetilde{K}_L$, where $\widetilde{K}_L = E\widehat{\Pi}_L^M(\theta, \mu = 0) - \widehat{\Pi}_L^M(\theta_0, \mu = 0) = \frac{\partial^2 \Pi_L^M(\theta, \mu)}{\partial \theta^2} \frac{\sigma^2}{2} = \frac{1}{6} \left(1 + \frac{\partial \widehat{a}_L(\theta, \mu = 0)}{\partial \theta} \right) \sigma^2$, the optimal mechanism is the same as under observable information. Comparing \widetilde{K}_L with \widehat{K}_L^0 from Lemma 3, we have $\widetilde{K}_L < \widehat{K}_L^0$. Instead for $K > \widetilde{K}_L$ the ($ICL - IA$) constraint is binding and the ($IRL - IA$) can be neglected.

(ii) Following the same reasoning as in the proof of Lemma 3, we have $\nu(K) \leq \lambda$. We now show that $\mu(K) \leq \nu(K)$ for all $K > \tilde{K}_L$. Suppose by contradiction that there exists a $K > \tilde{K}_L$, denoted by K_0 , such that $\mu(K_0) > \nu(K_0)$. Then since $\nu(K) > \mu(K) = 0$ for $K \leq \hat{K}_L^0$, $\mu'(K), \nu'(K) \geq 0$ and $\mu''(K), \nu''(K) = 0$ for all K , it follows that $\mu(K) \geq \nu(K)$ for all $K \geq K_0$, and that the level of K such that $\mu(K) = \lambda$, is smaller than the level of K such that $\nu(K) = \lambda$. Take therefore a K where $\nu(K) < \lambda$ and $\mu(K) = \lambda$. From $(IRL - IA)$, substituting for $\hat{a}_L(\mu = \lambda)$ we have

$$\int_{\underline{\theta}}^{\bar{\theta}} \theta + \frac{\theta(5\lambda-1)}{1+10\lambda} (1-F(\theta)) d(\theta) = K,$$

whilst from $(ICL - IA)$, substituting for $\tilde{a}_L(\nu < \lambda)$

$$\int_{\underline{\theta}}^{\theta_0} -F(\theta) \frac{\theta + \frac{\theta(5\lambda-1)-3\left(\lambda \frac{1-F(\theta)}{F(\theta)} + \nu(K) \frac{F(\theta)}{F(\theta)}\right)}{1+10\lambda}}{3} d\theta + \int_{\theta_0}^{\bar{\theta}} \theta + \frac{\theta(5\lambda-1)-3(\lambda-\nu(K)) \frac{1-F(\theta)}{F(\theta)}}{1+10\lambda} (1-F(\theta)) d\theta = K$$

and it is immediate that the LHS of the $(IRL - IA)$ is greater than the LHS of $(IC - IA)$ implying that it cannot be that they are both binding for that level of K ■

Proof of Lemma 7. From Lemmas 3 and 6 we have: $E\hat{W}_L(\cdot) = E\tilde{W}_L(\cdot)$ for $K \leq \tilde{K}_L$ and $\tilde{K}_L^* \in (\tilde{K}_L, K_L^*)$. For $K \in (\tilde{K}_L, \tilde{K}_L^*)$, $\frac{\partial E\hat{W}_L(\cdot)}{\partial K} - \frac{\partial E\tilde{W}_L(\cdot)}{\partial K} = -\mu(K) + \nu(K)$, where $\mu(K) = 0$ for all $K \leq \hat{K}_L^0$, $\mu(K), \nu(K) \leq \lambda$ and $\mu(K) \leq \nu(K)$ for all K . Since $\mu(K) = \lambda$ for all $K \geq \hat{K}_L^1$, then the level of K such that $\nu(K) = \lambda$ is a $K \in (\tilde{K}_L, \hat{K}_L^1]$. From this we have

$$\frac{\partial \tilde{\Delta}_L}{\partial K} = \begin{cases} \nu(K) > 0 & \text{for } K \in (\tilde{K}_L, \hat{K}_L^0] \\ -\mu(K) + \nu(K) > 0 & \text{for } K \in (\hat{K}_L^0, \hat{K}_L^1) \\ -\lambda + \lambda = 0 & \text{for } K \in [\hat{K}_L^1, \tilde{K}_L^*) \\ -1 - \lambda & \text{for } K \in [\tilde{K}_L^*, K_L^*] \end{cases}$$

if $\tilde{K}_L^* > \hat{K}_L^1$. The remaining cases are qualitatively similar. From the definition of $\tilde{\Delta}_L$, $\frac{\partial \tilde{\Delta}_L}{\partial u} = 0$ for $K \in (\tilde{K}_L, \tilde{K}_L^*(u)]$ and $\frac{\partial \tilde{\Delta}_L}{\partial u} = 1$ for $K \in (\tilde{K}_L^*(u), K_L^*(u)]$. ■

Proof of Proposition 3 (i) From Proposition 1 $\lambda \leq \lambda^*$ implies $K_S^*(u) \geq K_L^*(u)$. Since $\hat{K}_L^* = K_L^*(u) > \tilde{K}_L$, we have that $K_S^*(u) \geq K_L^*(u)$ implies $K_S^*(u) \geq \hat{K}_L^*(u)$. Then from Lemmas 7 and 9 we have: $\tilde{\Delta}_L(K, u) - \tilde{\Delta}_S(K, u) = -\tilde{\Delta}_S(K, u) < 0$ for all $K \leq \tilde{K}_L$ and for $K \in (\hat{K}_L^*(u), K_S^*(u))$, whilst $\tilde{\Delta}_L(K, u) - \tilde{\Delta}_S(K, u) = 0$ for $K \geq K_S^*(u)$. Then, since the functions $\tilde{\Delta}_L(K, u)$ and $\tilde{\Delta}_S(K, u)$ are continuous and $\frac{\partial}{\partial K}(\tilde{\Delta}_L(K, u) - \tilde{\Delta}_S(K, u))$ is non-negative for all

$K \in (\tilde{K}_L, \hat{K}_L^*(u))$, therefore $\tilde{\Delta}_L(K(u)) - \tilde{\Delta}_S(K(u)) < 0$ for all $K \in (\tilde{K}_L, \hat{K}_L^*(u))$. (ii) Similar reasoning proves the result when $K_S^*(u) < K_L^*(u)$. ■

Proof of Lemma 10. (i) It is easy to show that total output in the downstream market is given by $Q_S(\cdot, a_S) = \frac{3\theta + \theta_0 - 4a_S}{6}$ if the downstream firm has information on θ , and by $Q_S(\cdot, a_S) = \frac{2\theta_0 - 2a_S}{3}$ if the downstream firm has no information on θ . Since output is linear in a_S and the regulator does not know θ at the time of choosing the regulatory mechanism, the result follows. (ii) It follows from (27).

Proof of Proposition 4. The proof proceeds in two steps. First, when only one downstream firm acquires information and produces $q_S(\theta, \theta_0, a_S) = \frac{\theta}{2} - \frac{\theta_0}{6} - \frac{a_S}{3}$, the social value of information is given by

$$u + Ew_S(\theta, \theta_0) - w_S^*(\theta_0) = u + \frac{\partial^2 W_S(\theta, \theta_0) \sigma^2}{\partial^2 \theta} \frac{\sigma^2}{2} = \frac{3}{8} \sigma^2$$

where $\frac{3}{8} \sigma^2 > \tilde{K}_S$. Second, consider the welfare that would obtain if the information acquired by the firm were revealed to the rival. In this case the rival would produce $q_S(\theta, a_S) = \frac{\theta - a_S}{3}$ rather than $q_S(\theta, \theta_0, a_S) = \frac{\theta}{2} - \frac{\theta_0}{6} - \frac{a_S}{3}$ and welfare would be $Ew_S(\theta) - K$. Since $Ew_S(\theta) - Ew_S(\theta, \theta_0) = \frac{5}{72} \sigma^2 > 0$, we have $\tilde{\Delta}_S > 0$ for all $K \leq K_S^*$. ■

References

- [1] Armstrong, M. and D. Sappington (2005),
- [2] Beard, R., D. Kaserman and J. Mayo (2001), Regulation, Vertical Integration, and Sabotage, *Journal of Industrial Economics*, 46 (3), 210-224.
- [3] Borenstein, S. (2002), The Trouble with Electricity Markets: Understanding California's Restructuring Disaster, *Journal of Economic Perspectives*, 16 (1), 191-211.
- [4] Calzolari, G and C. Scarpa (2006), Regulating a Multy-Utility Firm, mimeo
- [5] Cowan, S. (2001), Regulatory Reform: Lessons from the UK. Annual Forum, Trade and Industrial Policy Strategies.
- [6] Cremer, J., F.Khalil and J.C.Rochet (1998), Contracts and Productive Information Gathering, *Games and Economic Behaviour*, 25, 174-193.
- [7] Dimitrova, M and E.E. Schlee (2003), Monopoly, Competition and Information Acquisition, *International Journal of Industrial Organization*, 21 1623-1642.
- [8] Economides, N. (1998), The Incentive for Non-Price Discrimination by an Input Monopolist, *International Journal of Industrial Organization*, 16(3), 271-284.
- [9] Hauk, E and S. Hurkens (2000), Secret Information Acquisition in Cournot Markets, *Economic Theory*, 18, 661-681.
- [10] Hinton, P., J.D. Zona, R. Schmalensee and W. Taylor (1998), An Analysis of the Welfare Effects of Long-Distance Market Entry by an Integrated Access and Long-Distance Provider, *Journal of Regulatory Economics*, 13 (2),183-196.
- [11] Hurkens, S.and N. Vulkan (2001), Information Acquisition and Entry, *Journal of Economic Behaviour and Organization*, 44,467-479.
- [12] Iossa, E. and P. Legros (2004), Auditing and Property Rights, *The Rand Journal of Economics*, 35, 356-372.
- [13] Iossa, E. and F. Stroffolini (2002), Price Cap Regulation and Information Acquisition, *The International Journal of Industrial Organization*, 20(7), 1013-36.

- [14] King, S.P. (1999), Price Discrimination, Separation and Access: Protecting Competition or Protecting Competitors?, *Australian Journal of Management*, 24(1), 21-36.
- [15] Mandy, D. (2000), Killing the Goose that Laid the Golden Egg: Only the Data Know Whether Sabotage Pays, *Journal of Regulatory Economics*, 17(2), 157-172
- [16] Mandy, D. and D. Sappington (2003), Incentives for Sabotage in Vertically- Related Industries, mimeo, University of Missouri.
- [17] Newbery, D. (2002), Regulating Unbundled Network Utilities, *The Economic and Social Review*, 33 (1), 23-41.
- [18] Oftel, (2001), Open access: delivering effective competition in communications market. April available at www.oftel.gov.uk).
- [19] Raith, M.(1996), A General Model of Information Sharing in Oligopolies, *Journal of Economic Theory*, 71, 260-288.
- [20] Reiffen, D. (1998), A Regulated Firm's Incentive to Discriminate: A Revaluation and Extension of Weisman's Result, *Journal of Regulatory Economics*, 14(1), 79-86.
- [21] Reiffen, D., L. Schumann and M. Ward (1998), Discriminatory Dealing with Downstream Competitors: Evidence From the Cellular Industry, Federal Trade Commission Working Paper.
- [22] Sappington, D. (2005), Regulation in Vertically-Related industries: Myths, Facts, and Policy, unpublished.
- [23] Sibley, D. and D. Weisman (1998), Raising Rival's Costs: The Entry of an Upstream Monopolist into Downstream Markets, *Information Economics and Policy*, 10(4), 451-470.
- [24] Vickers, J. (1995), Competition and Regulation in Vertically Related Markets, *Review of Economic Studies*, 62(1), 1-17.
- [25] Weisman, D. (1995), Regulation and the Vertically Integrated Firm: The Case of RBOC Entry Into InterLATA Long Distance, *Journal of Regulatory Economics*, 8(3), 249-266.

- [26] Weisman, D. (1988), The Incentive to Discriminate by a Vertically-Integrated Firm: A Reply, *Journal of Regulatory Economics*, 14(1), 87-91
- [27] Weisman, D. and M. Williams (2001), The Costs and Benefits of Long-Distance Entry: Regulation and Non-Price Discrimination, *Review of Economic Organization*, 18(3), 275-282.