"Build or Buy" Strategies in the Local Loop*

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Abstract

We provide a dynamic model to study how the presence of the option to "buy" the incumbent local exchange carrier's (ILEC) facilities via local loop unbundling affects the competitive local exchange carriers' (CLECs) incentives to "build" alternative infrastructures. We show that an unregulated incumbent sets a rental path for its local loop which delays technology adoption compared to the case in which there is no unbundling. We also characterize the equilibrium rental path set by the unregulated incumbent; it is prohibitively high at the initial phases when there is no effective threat of entry with alternative technologies, and it is decreasing over time in later phases. The decrease in the rental price follows the rise of the entrant's opportunity cost of leasing lines.

We also argue that neither allowing higher prices for unbundled elements over time nor setting a sunset clause would suffice to induce facility-based competition. By studying the unregulated ILECs decision regarding unbundling, we challenge the implicit assumption behind the sunset clauses, which is that the ILEC would either deny unbundling or charge too high a price for its network elements in the absence of regulation. We claim that the ILECs that initially resist unbundling requirements would tend to charge attractive access prices (relative to the entrants' alternatives) for their infrastructure, which become *less essential* over time.

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1 Introduction

The nature of competition in local access telecommunications networks is shaped by the "build or buy" decisions of the competitive local exchange carriers (CLECs). Facility-based competition takes place when a CLEC "builds" its own infrastructure (e.g., wireless local loop, cable network, fiber-optic network, satellite network), whereas service-based competition takes place when a CLEC "buys" some network elements from the incumbent local exchange carrier (ILEC). Two main ways to achieve service-based competition is through resale and local loop unbundling.[1]

Many policy makers consider facility-based competition as an important component of a deregulated competitive telecommunications industry.[2] Therefore, any regulatory policy promoting service-based competition has to be be concerned with not undermining the incentives for facility-based entry. A number of studies have claimed that mandatory local loop unbundling has precisely that effect,[3] and this idea has also received some empirical support.[4] Basing their arguments on concerns of this sort, Jerry A. Hausman and J. Gregory Sidak (2004) suggest that regulators should allow the prices for fixed unbundled elements to increase over time in order to achieve transition to facility-based competition, while Thomas Jorde, J. Gregory Sidak and David Teece (2000) suggest that mandatory unbundling should sunset after the passage of two years or upon the entry of a facility-based competitor.

In this paper, we challenge the implicit assumption behind sunset clauses,[5] namely that the ILEC would either deny unbundling or charge too high a price for its network elements in the absence of regulation. We do this by considering an unregulated environment and focusing on an unregulated ILEC's decision regarding unbundling. We model a dynamic setting in which an unregulated ILEC faces a single potential CLEC, and sets a rental path for its loops. The CLEC then decides whether to lease loops or to build its own infrastructure. It has the option to lease the incumbent's local loop prior to building its infrastructure. Similar to Riordan (1992), we consider an access technology for which the cost of building the infrastructure declines over time.[6] We show that the unregulated incumbent sets a rental path for its local loop which delays facility-based

[1] Local loop unbundling refers to a series of regulatory offers which aims at providing the CLECs with access to the local loop (the twisted pair of copper wires that connect the customers' telephones at homes and businesses to the incumbent's central office) without any obligation to purchase other services (e.g., switching) from the ILEC.

[2] In the words of the EC decision on unbundling the local loop:

> "Pricing rules for local loops should foster fair and sustainable competition, bearing in mind the need for investment in alternative structures, and ensure that there is no distortion of competition, in particular no margin squeeze between prices of wholesale and retail services of the notified operator" (EC Regulation No. 2887/2000).

See Laffont and Tirole (2000) for a discussion on unbundling-based entry and facility-based entry.

[3] See, for example, Crandall et al. (2004) and Jorde et al. (2000). Mandatory unbundling may also distort the investment incentives of the incumbent to upgrade its network. However, this is not the focus of our paper. See Pindyck (2004) and Pindyck (2005) for this argument.

[4] Crandall et al (2004) show that unbundling decreases facility-based competition in the short run; the authors find that the share of facility-based lines owned by the entrants in the US is lower in the states where the rental rates are lower relative to cost of building infrastructure. An earlier study by Eisner and Lehman (2001) also finds less facilities-based competition in states with lower rental prices.

[5] Sunset clauses specify ex ante a period of time after which the ILEC's facilities are no longer regulated.

[6] Riordan (1992) studies how price and entry regulations affect the pattern and timing of technology adoption. Two firms decide if and when to adopt a new technology in a setting where adoption cost declines over time and profit flows change with adoption patterns. He shows that price and entry regulations tend to slow down technology adoption as they make preemption strategies less attractive. Differently, we consider the CLEC as the only firm, that decides to adopt the new technology. This situation can be interpreted as 'one-sided entry regulation' in Riordan, except that we consider a single market in which ILEC's existing and CLECs new infrastructure compete.

entry compared to the case in which there is no unbundling. The equilibrium rental path set by the unregulated incumbent is prohibitively high in the initial phases when there is no effective threat of facility-based entry, and it is decreasing over time during the later phases following the rise of the entrant's opportunity cost of leasing lines.

An important question for policy analysis is whether the delay in facility-based competition induced by unbundling is *suboptimal* from the social welfare point of view. We state the general conditions under which the date of facility-based entry in an unregulated environment can be suboptimally late (and suboptimally early), and give two examples of demand specifications which lead to suboptimally late facility-based competition.

We argue that neither allowing higher prices for unbundled elements over time nor setting a sunset clause would suffice to induce facility-based competition. Since the ILEC's infrastructure becomes *less essential* over time (given our assumption that the cost of building it declines), ILECs that initially resist unbundling requirements will eventually tend to charge attractive access prices (relative to the CLECs' alternatives) for their infrastructure. Therefore, the appopriate policy for regulators is to commit to ban unbundled access when facility-based entry becomes feasible and socially desirable.

In a related paper (Bourreau and Doğan 2005),[7] we showed that an ILEC may use the rental price as a strategic tool to delay facility-based competition and set a rental price which is too low from a social welfare perspective to achieve that end. This result is obtained under the assumption that the incumbent commits to a *constant* rental price over time. The present paper departs from Bourreau and Doğan (2005) in two important ways. First, we allow the ILEC to vary its rental price over time. This enables us to analyze how the regulatory policies should change over time as well. Second, we do not specify any particular competitive setting, and hence, provide a more general analysis.

This paper is also closely related to the literature on strategic licensing. In particular, the ILEC's decision to unbundle is similar to that of an innovator's ex post decision to license its technology. A patent holder (essential facility owner) may strategically license (lease) its technology to a competitor. For example, Gallini (1984) shows that an incumbent may license its technology in order to reduce the potential entrant's incentives for R&D investment, thereby preventing the latter from developing its own–and possibly superior–technology.[8]

The rest of the paper is organized as follows. We begin by describing the model in Section 2. In Section 3, we solve for the equilibrium rental path and the date of facility-based entry in the unregulated environment. In Section 4 we characterize the socially optimal date of facility-based entry and the rental path. We also argue that sunset clauses are ineffective as a regulatory tool to achieve the socially desirable date of facility-based entry. Finally, we conclude.

2 The Model

We consider an unregulated environment in which an incumbent, facing a single entrant, determines the rental path for its local loop. Setting a prohibitively high rental price is equivalent to denying access to the loops. Entry can take one of the two following forms. Service-based entry takes place when the entrant leases loops, that is, when the entrant *buys* the necessary infrastructure for the

[7] See also Bourreau and Doğan (2004).

[8] An innovator may act in a similar way if it expects that its technology could be imitated at reasonable costs. Among others, see also Katz and Shapiro (1985a), Gilbert and Newbery (1982), Reinganum (1983).

provision of broadband services. Facility-based entry takes place when the entrant *builds* its own infrastructure. The entrant can compete on the basis of services by leasing loops prior to building its own infrastructure.

Firms The incumbent (I) and the entrant (E) have a constant marginal cost of providing broadband services, which is normalized to zero. The incumbent commits to a rental path r_t, where t designates time, and receives a marginal revenue of r_t per line if the entrant decides to lease lines. The marginal cost of the loops is constant and is normalized to zero. To simplify the analysis, we assume that the fixed cost of unbundling for the entrant is zero.[9] Finally, time is continuous and the time horizon is infinite, and firms maximize their discounted profits.

Profit Flows At any time, the industry structure is characterized by either monopoly, service-based competition, or facility-based competition. Let π_i^j denote the profit flow of firm $i = I, E$ and where $j = M, F, S$ stand for monopoly, facility-based competition and service-based competition, respectively. The net discounted profits are denoted by Π_i^j.

Assumption 1. During the phase of service-based competition, the profit flows are characterized with the following.

i. for all r, $\partial \pi_E^S(r)/\partial r \leq 0$,

ii. there exists $\overline{r}$ such that for all $r \geq \overline{r}$, $\pi_E^S(r) = 0$, and for all $r < \overline{r}$, $\pi_E^S(r) > 0$.

iii. $\pi_I^S(r)$ is concave.

The entrant's profit flow with service-based competition is non-increasing with the rental price and is positive only if the rental price is sufficiently low. A higher rental price implies a higher perceived marginal cost for the entrant in providing broadband services, whereas the marginal cost of the incumbent remains unchanged. We also assume concavity for the incumbent's profit flows.

Assumption 2. For all r,

i. $\pi_I^M > \pi_I^S(r) > \pi_I^F$,

ii. $\pi_E^S(r) < \pi_E^F$.

Assumption 2 implies that, at a given date, the incumbent prefers service-based competition to facility-based competition. There are at least three reasons why this might be true. First, the entrant's access technology may bring a superior quality of service compared to the existing one.[10] Second, the incumbent obtains rental revenues from the lease of its infrastructure, which are non existent in facility-based competition. Third, when the CLEC relies on the ILEC's infrastructure

[9] In reality, entrants incur a positive entry cost which is due to co-location and order handling. However, these costs are negligible when compared to the cost of building a new infrastructure.

[10] For instance, the maximum bandwidth available with the DSL copper-based technology today is around 50 Mbps, while digital signals can be transmitted over a single wavelength of fibre at 40 Gbps.

the ILEC can engage in "sabotage", that is, it can strategically degrade the quality of service provided by the CLEC.[11]

In the Appendix we provide two examples of competitive settings that satisfy Assumptions 1 and 2.

Cost of building an infrastructure The cost of building the new infrastructure is denoted by $A(\Delta)$, where $\Delta \in [0,1)$ is the discount factor determined by the facility-based entry date. Here we use the same notation and interpretation as Riordan (1992); $\Delta = \exp(-\delta t)$, where t is time, and δ is a discount rate, which is normalized to 1. Throughout the paper we will refer to Δ as a "date". Note that a higher Δ corresponds to an earlier time.

Assumption 3.

i. $A(0) = 0$, $A'(\Delta) \geq 0$, and $A''(\Delta) > 0$,

ii. $A(1)$ is sufficiently large so that facility-based entry never happens at $\Delta = 1$ (that is, at time zero).

Since we are interested in studying how the entrant's decision to build an infrastructure is affected by the terms of service-based competition, we assume away immediate facility-based entry with assumption 3.ii.

Assumptions 2.ii. and 3.i. together imply that the entrant always ends up by building its own infrastructure. This follows as $A(\Delta) \to 0$ when $\Delta \to 0$, and the entrant's profit flows are higher under facility-based competition.

The Timing At the beginning of the game, the incumbent commits[12] to a time dependent rental path $r(\Delta)$ for its loops. At each time, the entrant decides whether to lease loops and compete on the basis of services, or to build its infrastructure, or to wait.

3 The Equilibrium

We begin by solving the equilibrium in the unregulated environment. In Section 4 we introduce a social welfare maximizing regulator, and analyze the relevant regulatory policies for achieving socially desirable outcomes.

The timing of the facility-based entry changes with the entrant's incentives to lease loops, and hence, with the rental path. We show that when the entrant leases loops prior to building its infrastructure, the date of facility-based entry is retarded compared to the case in which the local loop is not available for lease (or is too expensive). This result hinges on the 'replacement effect' which has been introduced by Arrow (1962) in the R&D literature; an incumbent firm has less

[11] See Beard et al (2001) and Economides (1998) in favor of this argument. Also, Economides (1999) mentions that in telecommunication markets "large customers prefer to buy from an owner rather than a reseller." If this is true, facility-based competition, i.e., competition between "two owners", would be less preferred to service-based competition from the incumbent's point of view.

[12] Since we do not consider any fixed cost for unbundling, there is no commitment problem. We discuss this issue when we determine the optimal rental path for the incumbent.

incentives to invest in R&D, because by increasing its R&D investment, it hastens its replacement. The replacement effect in our model is very similar to the one considered in the licensing literature.[13]

We begin by computing the optimal date of facility-based entry when there is no unbundling. Then, we characterize the entrant's entry strategy when there is unbundling and solve for the equilibrium rental path.

Case 1. No Unbundling of the Local Loop The entrant maximizes its net discounted profit,

$$\Pi_E^F(\Delta) = \Delta\pi_E^F - A(\Delta) \tag{1}$$

with respect to the facility-based entry date, Δ. Since the second-order condition, $-A'' < 0$, is satisfied, the optimal facility-based entry date is determined by the first order condition and is

$$\Delta_{nu}^* = (A')^{-1}\left(\pi_E^F\right).$$

Since $A'' > 0$, we have Δ_{nu}^* increasing with π_E^F; a higher profit flow from facility-based competition implies an earlier date of facility-based entry.

Case 2. Unbundling of the Local Loop If the entrant never leases loops, the facility-based entry date is as defined in Case 1. Let Π_E^{S+F} denote the entrant's net discounted profits when it leases loops prior to building its infrastructure. Suppose that at date $\Delta \in [0,1]$, the entrant has not yet built its infrastructure, and that it leases lines from the date Δ on and builds its infrastructure at $\widehat{\Delta} \leq \Delta$. Then, we have

$$\Pi_E^{S+F}\left(\Delta, \widehat{\Delta}\right) = \int_{\widehat{\Delta}}^{\Delta} \pi_E^S(r(x))dx + \widehat{\Delta}\pi_E^F - A(\widehat{\Delta}). \tag{2}$$

The optimal date of facility-based entry is found by solving

$$\max_{\widehat{\Delta}\leq\Delta} \Pi_E^{S+F}\left(\Delta, \widehat{\Delta}\right). \tag{3}$$

The solution to this problem, denoted by $\widehat{\Delta}^*$, is either a corner solution ($\widehat{\Delta}^* = \Delta$), or an interior solution ($\widehat{\Delta}^* \in (0, \Delta)$), which is defined by the first order condition

$$\pi_E^F - \pi_E^S\left(r(\widehat{\Delta})\right) = A'\left(\widehat{\Delta}\right). \tag{4}$$

Notice that when $\widehat{\Delta}^*$ is an interior solution, it is independent of Δ. We assume that the second order condition to this problem holds whenever (4) holds.

Let $\underline{\Delta}$ be the facility-based entry date when the rental price equals marginal cost (zero). We have

$$\underline{\Delta} = (A')^{-1}\left(\pi_E^F - \pi_E^S(0)\right).$$

The entrant's entry strategy can be studied separately for the following three phases.

[13] See, for example, Gallini (1984); the incumbent firms reduce the entrants' incentives to innovate by licensing their technologies.

Phase 1 to Δ^*_{nu}: This is the initial phase with respect to the time line. The only entry option is via leasing loops; this is because we have $\widehat{\Delta}^* \leq \Delta^*_{nu}$. If $\widehat{\Delta}^* = \Delta$ this is true since otherwise the entrant could increase its profit by delaying facility-based entry, if $\widehat{\Delta}^* \in (0, \Delta)$ this is also true as $(A')^{-1}$ is an increasing function and as $\pi_E^F - \pi_E^S \left(r(\widehat{\Delta}^*) \right) \leq \pi_E^F$. Therefore, during this phase, the entrant leases loops if $\pi_E^S(r(\Delta)) > 0$ (if $r(\Delta) < \overline{r}$), and does not enter in the market otherwise.

Phase Δ^*_{nu} to $\underline{\Delta}$: The entry decision depends on the rental path set by the incumbent. During this phase, the entrant leases loops if

$$\Pi_E^{S+F} \left(\Delta, \widehat{\Delta}^* \right) \geq \Pi_E^F (\Delta), \tag{5}$$

and builds its infrastructure immediately otherwise.

Phase $\underline{\Delta}$ to 0: We have $\widehat{\Delta}^* = \underline{\Delta}$, that is, the entrant builds its infrastructure immediately, as $\partial \Pi_E^{S+F} / \partial \, \widehat{\Delta} > 0$ for $\widehat{\Delta} < \underline{\Delta}$.

Having described the entrant's equilibrium entry strategy, we can now study the equilibrium rental path set by the incumbent.

Equilibrium Rental Path Let Δ^*_u be the optimal date of facility-based entry for the entrant when it leases loops. At any time prior to the facility-based competition, the incumbent obtains either monopoly or service-based competition profit flows, therefore, the discounted profit function of the incumbent is

$$\Pi_I^{S+F} = \underbrace{\int_{\Delta^*_{nu}}^{1} \pi_I(r(x))dx}_{\text{(I)}} + \underbrace{\int_{\Delta^*_u}^{\Delta^*_{nu}} \pi_I(r(x))dx + \Delta^*_u \pi_I^F}_{\text{(II)}}, \tag{6}$$

with

$$\pi_I(r(x)) = \begin{cases} \pi_I^M & \text{for } r \geq \overline{r} \\ \pi_I^S(r) & \text{for } r < \overline{r} \end{cases}$$

Since the rental path during the phase 1 to Δ^*_{nu} does not affect neither Δ^*_{nu} nor Δ^*_u, the incumbent's decision can be studied separately for the following phases.

Phase 1 **to** Δ^*_{nu}**:** The incumbent sets a rental path so as to maximize term (I) in (6). Since the rental path does not affect Δ^*_{nu}, and since $\pi_I^M > \pi_I^S(r)$, the incumbent sets $r(\Delta) \geq \overline{r}$. The entrant does not lease lines and the incumbent obtains monopoly profit flows.

Phase Δ^*_{nu} to 0**:** The incumbent sets a rental path so as to maximize term (II) in (6). Since $\pi_I(r) \geq \pi_I^F$, the incumbent would like to retard facility-based entry as much as possible (i.e., induce $\Delta^*_u = \underline{\Delta}$). Therefore, the optimal rental path is such that at each date, it maximizes $\pi_I(r)$, subject to (5). We assume that the entrant leases loops when it is indifferent between the two alternatives.

Lemma 1 *If there exists an optimal rental path for phase Δ^*_{nu} to $\underline{\Delta}$, then at each date Δ during this phase, it satisfies*

$$\pi_E^S(r(\Delta)) = \pi_E^F - A'(\Delta). \tag{7}$$

Proof. Since $\partial\pi_E^S(r)/\partial r < 0$, if there exists an optimal rental path, it is such that, at each date Δ, (5) is binding, i.e.,

$$\int_{\widehat{\Delta}^*}^{\Delta} \pi_E^S(r(x))dx + \widehat{\Delta}^*\pi_E^F - A(\widehat{\Delta}^*) = \Delta\pi_E^F - A(\Delta). \tag{8}$$

Assume that there exists such a rental path $r(\Delta)$. We have $\widehat{\Delta}^* < \Delta$ as the entrant leases loops. Then, derivating the two sides of (8) with respect to Δ yields (7). Replacing $\pi_E^S(r(\Delta))$ defined in (7) into (8) shows that (7) implies (8). Therefore, any solution to (7) is also a solution to (8). ■

Proposition 1 *The equilibrium rental price decreases over time.*

Proof. The right hand side of (7) is decreasing with Δ, hence, the left hand side is also decreasing with Δ. Since π_E^S is decreasing with r, it follows that r^* is increasing with Δ. ■

The incumbent's equilibrium strategy can be summarized as follows. With an incentive to protect its monopoly profits, the incumbent charges a prohibitively high rental price $(r(\Delta) \geq \overline{r})$ during the phase in which there is no threat of facility-based entry. The incumbent anticipates the entrant to build its infrastructure at Δ_{nu}^* if the rental price remains prohibitively high. Therefore, from date Δ_{nu}^* on, the incumbent sets a rental price which is decreasing over time (following the decrease in the cost of building infrastructure).

Proposition 2 *Unbundling delays facility-based competition.*

Proof. Following the unregulated rental path determined in (7) the entrant builds its infrastructure at

$$\Delta_u^* = \underline{\Delta} = (A')^{-1}\left(\pi_E^F - \pi_E^S(0)\right)$$

as opposed to

$$\Delta_{nu}^* = (A')^{-1}\left(\pi_E^F\right)$$

when there is no unbundling. Since $(A')^{-1}$ is an increasing function, and since $\pi_E^F - \pi_E^S(0) < \pi_E^F$, it is straightforward to conclude that $\Delta_u^* < \Delta_{nu}^*$. ■

There are at least two points worth a brief discussion at this instant. The first one concerns *credibility*. To show that there are no credibility issues for setting the rental path which is described in Proposition 1, we verify that there are no profitable deviations from this path at any date. Let's begin with the initial phase. At any date $\Delta \in (\Delta_{nu}^*, 1]$, the incumbent has no interest in decreasing the price below $\overline{r}$, as there is no threat of facility-based entry during this phase. Now consider the last phase. The rental path during the last phase (that is, for $\Delta \in [0, \underline{\Delta}]$) is irrelevant, as at $\underline{\Delta}$ the entrant builds its infrastructure whatever the rental price is (assuming a non-negative rental price). Finally, credibility of the incumbent in committing the rental path determined in (7) for the intermediary phase (that is, for $\Delta \in [\underline{\Delta}, \Delta_{nu}^*]$) is not an issue, since in this phase the optimal rental path is determined such that at any date the entrant is indifferent between leasing the loops and building its infrastructure. Assume that at $\Delta \in [\underline{\Delta}, \Delta_{nu}^*]$ the entrant has not yet built its infrastructure, and that the incumbent slightly increases its price. Then the entrant builds its infrastructure at Δ, and competition is facility-based from date Δ on. This is clearly not a profitable deviation for the incumbent as it gets higher profit flows when it competes on the basis of services. The incumbent also has no incentive to reduce its price as it will reduce its rental revenues, and hence its profit flows. Now assume that the entrant has built its infrastructure at some date before Δ. Then deviating from the optimal rental path at Δ is irrelevant, as we assume that once the entrant builds its infrastructure it provides its services with its own facility.

The second point is on *below cost pricing*. Although for the sake of expositional simplicity we have normalized marginal cost of providing loops, c, to zero, the analysis could easily be extended for $c > 0$. In such a case, one could show that the incumbent could charge a rental rate $r < c$ during a phase after date Δ_u^*. This is because $\underline{\Delta}$ is defined by the minimum non-negative rental price such that the incumbent prefers service-based competition to facility-based competition (in our basic setting $r = c = 0$). With $c > 0$ the incumbent might be willing to incur losses in order to retard facility-based entry further, that is to induce a lower $\underline{\Delta}$ (a later facility-based entry date).

The equilibrium strategy of the unregulated incumbent can be summarized as follows. The incumbent would like to maintain its monopoly by charging too high a rental price for (or denying access to) its loops during the period of time for which there is no effective facility-based entry threat. The threat of entry changes the incumbent's unbundling strategy; the incumbent then charges a rental price which is decrasing over time which delays facility-based competition as a consequence. We have not yet argued, however, whether if the delay is socially undesirable. We wish to illuminate this issue in the next section.

4 The Social Optimum and Regulatory Tools

In this section, we introduce a social welfare maximizing regulator in order to compare the unregulated outcome with the socially efficient outcome.

The regulator maximizes social welfare which is defined by the sum of consumer surplus and industry profits, and uses the rental path to achieve that end. We assume that the regulation of the rental path is the only regulatory tool, and that the regulator does not control final prices. We also investigate the effect of sunset clauses as a regulatory tool to achieve socially desirable outcomes.

We begin by describing the socially optimal date of facility-based entry. Let w_M, w_S and w_F denote welfare flows under monopoly, service-based competition and facility-based competition, respectively. Given the date Δ of facility-based entry, and the rental path $r(\Delta)$, social welfare is defined by

$$W = \int_{\Delta}^{1} w\left(r\left(x\right)\right) dx + \Delta w_F - A(\Delta),$$

where

$$w\left(r\right) = \begin{cases} w_S\left(r\right) & \text{if} \quad r \leq \overline{r} \\ w_M & \text{if} \quad r > \overline{r} \end{cases} .$$

The regulator can induce facility-based entry at any date after Δ_{nu}^*,[14] by setting a prohibitevely high rental price for the loops from that date on. Therefore, at any date during phase of service-based competition the regulator compares the gains from switching from service-based competition to facility-based competition to the cost of building an infrastructure.

Let

$$r^w = \arg\max_r w\left(r\right),$$

[14] The regulator cannot induce facility-based entry before the date Δ_{nu}^*, since it is not optimal for the entrant.

that is, r^w yields the highest welfare flows from service-based competition. Then, the socially optimal date of facility-based entry, Δ_w^*, is defined by

$$\Delta_w^* = \arg \max_{\Delta \in [0,1]} \left\{ (1-\Delta)\, w\,(r^w) + \Delta w^F - A\,(\Delta) \right\}.$$

Since the second order condition is satisfied, the optimal date of facility-based entry is given by the first order condition, and is

$$\Delta_w^* = (A')^{-1} \left(w^F - w\,(r^w) \right).$$

In the unregulated setting, facility-based entry takes place at date

$$\underline{\Delta} = (A')^{-1} \left(\pi_E^F - \pi_E^S\,(0) \right).$$

Since $(A')^{-1}$ is an increasing function, we can conclude that the date of facility-based entry in the unregulated environment is *socially optimal*[15] if

$$w^F - w\,(r^w) = \pi_E^F - \pi_E^S\,(0)$$

is *suboptimally late* if, and

$$w^F - w\,(r^w) > \pi_E^F - \pi_E^S\,(0)$$

and is *suboptimally early* otherwise.

In what follows, we argue that depending on the demand specifications, either of these can be true. We first decompose $w^F - w\,(r^w)$ as

$$\left(w^F - w\,(0) \right) + \left(w\,(0) - w\,(r^w) \right). \tag{9}$$

Let $s_S(r)$ and s_F denote consumer surplus flows under service-based competition and facility-based competition, respectively. Equation (9) can be now rewritten as

$$\left(\pi_E^F - \pi_E^S\,(0) \right) + \left(\pi_I^F - \pi_I^S\,(0) \right) + \left(s_F - s_S\,(0) \right) + \left(w\,(0) - w\,(r^w) \right).$$

Therefore, if the sign of

$$\left(\pi_I^F - \pi_I^S\,(0) \right) + \left(s_F - s_S\,(0) \right) + \left(w\,(0) - w\,(r^w) \right)$$

is positive (negative) the unregulated date of facility-based entry is suboptimally late (early). The first term of this expression is negative, since we have assumed that $\pi_I^F < \pi_I^S\,(0)$.[16] The last term is non-positive, since r^w yields maximum welfare flows. The sign of the second term depends on how consumers value facility-based competition compared to service-based competition with a low (marginal cost) rental price. We can now conclude that the date of facility-based entry in the unregulated environment is

[15] Note that this does not imply that the social welfare under the unregulated environment is maximized. The unregulated path may yield the socially optimal adoption date, however, the welfare flows during and before the phase of service-based competition would be inferior to those achieved with r^w.

[16] Note that this term would disappear if we consider $c > 0$, and if for some values of $r < c$ we have $\pi_I^F \leq \pi_I^S\,(r)$; in such a case the incumbent would engage in below cost pricing for the loops.

1. *suboptimally early* if
$$s_F - s_S(0) \leq 0,$$
or if
$$s_F - s_S(0) > 0,$$
and $s_F - s_S(0)$ sufficiently small,

2. *suboptimally late* if
$$s_F - s_S(0) > 0,$$
and $s_F - s_S(0)$ sufficiently large.

In either of the cases the optimal regulation of the rental price entails setting r^w until the date at which facility-based entry is socially optimal, and then banning access to the loops (or setting too high a price for it) from that date on.

In Appendix we provide two examples. The first example draws on the demand specifications in Bourreau and Doğan (2005), which assumes full market coverage (perfectly inelastic demand), and the second example uses the demand specifications in Katz and Shapiro (1985b). In both examples, we assume that the new infrastructure provides a higher quality of service than that of the incumbent's infrastructure, and show that the date of facility-based entry in the unregulated environment is suboptimally late.

Price cap for leased loops A price cap of r^w might not yield the socially desirable outcome if the date of facility-based entry in the unregulated environment is suboptimally late. In such a case, the cap would be effective only during the phase in which there is no effective entry threat, and during the dates at which the entrant would prefer leasing loops at r^w rather than building its infrastructure. A price cap during that phase would indeed, improve welfare flows from service-based competition. However, from the date Δ on, at which the following equality (the entrant's participation constraint) is satisfied,

$$\left(\Delta - \widehat{\Delta}^*\right) \pi_E^S(r^w) + \widehat{\Delta}^* \pi_E^F - A(\widehat{\Delta}^*) = \Delta \pi_E^F - A(\Delta)$$

the price cap will no longer be effective. This is the date at which the unregulated incumbent's rental path and r^w intersect; the incumbent is then better off by setting a lower rental price for each date so as to satisfy the entrant's participation constraint, which would in turn delay facility-based entry from a social welfare point of view.

Sunset Clauses When unbundling is deemed to suboptimally delay facility-based entry, the introduction of sunset clauses is argued to be a remedy. *Sunset clauses* specify ex ante a period of time after which the incumbent's facilities are no longer regulated. Sunset clauses have been specified in the unbundling regulations in Canada and in the Netherlands. For example, Opta, the Dutch regulatory authority, has specified a five-year period after which the incumbent operator, KPN Telecom, would be "in principle, free to set a tariff on a commercial basis".[17] Similarly, Canadian Radio-Television and Telecommunications Commission issued a decision (CRTC 1997-8), which stated that following a five-year mandatory unbundling period, the incumbent's services and

[17] See Guidelines on access to the unbundled loop, OPTA, March 1999.

components that are deemed to be essential facilities (including local loops in certain areas) would not be subject to mandatory unbundling and the rental rate would not be regulated any longer.[18]

Sunset clause regulation implicitly assumes that the ILECs would charge the CLECs too high a price when the mandatory unbundling requirements are removed. Studying the unregulated incumbent's strategy helps us to predict the potential implications of sunset clauses. We claim that the regulatory "threat" to remove regulation, so as to induce CLECs to invest in their own infrastructures, is not effective. To see this, consider a regulator who commits to the following rental path: $r(\Delta) = r^w$ until $\Delta > \widetilde{\Delta}$ (where $\widetilde{\Delta} \geq \Delta_w^*$), and then no regulation on rental price from date $\widetilde{\Delta}$ on (therefore the sunset clause is determined by $\widetilde{\Delta}$). With the following we argue that sunset clauses are redundant, regardless of whether the date of facility-based entry is too late or too late from the social welfare point of view.

First, suppose that the date of facility-based entry in the unregulated environment is suboptimally early. Then, the unregulated path does not yield the socially optimum date of facility-based entry (entry occurs earlier than Δ_w^*). Therefore, the sunset clause has no effect.

Second, suppose that the date of facility-based entry in the unregulated environment is suboptimally late. In this case, the path does not yield the socially optimum date of facility-based entry, which is Δ_w^*. Indeed, as it is optimal for the incumbent to do so, it will charge its optimal rental scheme, which delays facility-based entry up to the date $\underline{\Delta}$.

To induce the optimal date of facility-based entry, regulators could adopt one of the two following strategies: either ban unbundled access to the the loops at Δ_w^*, or regulate the rental path until the facility-based entry occurs. Note that in the latter case the optimal regulation would involve charging higher prices for the loops as the viability of facility-based entry increases.

5 Conclusion

In this paper, we have demonstrated how unbundling of the local loop may delay facility-based competition in an unregulated environment. We have shown that the incumbent operator has a tendency to resist unbundling in the earlier periods during which building an alternative infrastructure is too expensive for the entrant. During that phase the unregulated ILEC protects its monopoly profits by setting too high a price for the unbundled elements. However, as soon as there is an effective threat of facility-based entry, the ILEC begins to offer relatively attractive terms for the lease of its loops. The ILEC then sets a rental price which is decreasing over time, which follows the reduction in the cost of building infrastructures.

The delay that is brought by the incumbents pricing strategy may be suboptimal, in particular when consumers value facility-based competition over service-based competition. Studying the unregulated incumbent's strategy helps us predict the potential implications of regulatory tools such as sunset clauses. Sunset clause regulation implicitly assumes that the incumbent operators would charge the entrants too high a price when the regulatory unbundling requirements are removed. This is misleading, since the incumbent operators are expected to respond to exogenous changes that would shape the industry structure (i.e., cost of building alternative infrastructures). Essential facilities do not remain essential over time. Therefore, the ILECs that initially oppose providing unbundled access to their facilities, would change their strategies as their facilities become *less*

[18] In practice, some regulators exhibit lack of credibility regarding such commitments. The Dutch and the Canadian regulators have ex-post decided to extend the period for the sunset clauses. For the Canadian case see CRTC 2001-184 Order.

essential over time.

Certainly, our model does not reflect all the economic factors of the unbundling problem. There are at least two other issues worth studying. First, entry via unbundling may provide the entrant with information about the demand in the industry. Such a learning effect would operate in the opposite direction of the replacement effect, and hence may hasten facility-based entry. Second, the number of potential entrants also plays an important role for determining optimal unbundling schemes, and would change the nature of our analysis. A larger number of entrants would imply lower profit flows both for service-based and facility-based competition. Depending on the assumed sequence of the entry decisions, as well as the asymmetries among the CLECs, some CLECs may build their infrastructure preemptively, whereas some others may instead rely on the ILEC's infrastructure for competition.

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A Appendix

Example 1. We use the competitive setting in Bourreau and Doğan (2005). Consumers are uniformly distributed on the unit square $[0,1] \times [0,1]$. A consumer of type (x, θ) has a taste x for variety and a valuation θ for quality, with $x, \theta \in [0,1]$. The indirect utility function of the consumer type (x, θ) is

$$U = v + \theta q_i - (x - y_i)^2 - p_i.$$

where p_i, y_i, q_i denote price, horizontal location, and quality of firm i, respectively, with $i = I, E$. See Bourreau and Doğan (2005) for assumptions on the modelling parameters, and for the computation of equilibrium prices and profit flows for service-based and facility-based competition.

Service-based competition When the firms compete on the basis of services, for $r \in [0, v - 5/4)$, we have

$$s_S(r) = v - 13/12 - r,$$

$$\pi_I^S(r) = 1/2 + r,$$

and

$$\pi_E^S(r) = 1/2.$$

The social welfare flow, $w_S(r)$, is maximized by any $r \in [0, v - 5/4]$.

Facility-based competition Let q denote $q_E - q_S$ under facility-based competition, with $q \in [2,3]$. When the firms compete on the basis of facilities, we have $\pi_I^F = q/9$, and $\pi_E^F = 4q/9$ and

$$s_F = v - 1/12 - q/9.$$

One can verify that

$$\pi_I^F - \pi_I^S(0) < 0,$$

and that

$$s_F - s_S(0) > 0.$$

The question is then, whether if $s_F - s_S(0)$ is sufficiently large to offset

$$\left(\pi_I^F - \pi_I^S(0)\right) + \left(w(0) - w(r^w)\right)$$

which is negative. Since $w_S(r)$, is maximized by any $r \in [0, v - 5/4]$, let's set $r^w = 0$. Then, the above equation reduces to $\pi_I^F - \pi_I^S(0)$. We have

$$-\left(\pi_I^F - \pi_I^S(0)\right) = -q/9 + 1/2 < s_F - s_S(0) = 1 - q/9,$$

which implies that the date of facility-based entry in the unregulated environment is *suboptimally late*.

Example 2. We use the competitive setting in Katz and Shapiro (1985b). The indirect utility function of the consumer of type τ is

$$U = \tau + q_i - p_i,$$

where q_i and p_i denote quality and price of firm i, with $i = I, E$. Consumers' types are uniformly distributed over $[0, 1]$.

Service-based competition When the firms compete on the basis of services, we assume that the firms provide the same quality of service, s_I. Profit flows and consumer surplus flows during this phase are as follows.

$$\pi_I^S(r) = \frac{(1+q_I)^2}{9} + \frac{5(1-r+q_I)}{9}r,$$

$$\pi_E^S(r) = \frac{(1+q_I-2r)^2}{9},$$

and

$$s_S(r) = \frac{(2+2q_I-r)^2}{18}.$$

The social welfare flow is defined by

$$w^S(r) = \frac{(4+4q_I+r)(2+2q_I-r)}{18},$$

and is decreasing in r, therefore, it is maximized at $r^w = 0$.

Facility-based competition When the firms compete on the basis of facilities, we assume that $q_I < q_E$. Profit flows and consumer surplus flows during this phase are as follows.

$$\pi_I^F = \frac{(1+2q_I-q_E)^2}{9},$$

$$\pi_E^F = \frac{(1+2q_E-q_I)^2}{9},$$

and

$$s_F = \frac{(2+q_I+q_E)^2}{18}.$$

Note that for $q_I = q_E$ we have $\pi_I^F < \pi_I^S(r)$ for any $r > 0$. The social welfare flow is defined by

$$w^F = \frac{4(1+q_I+q_E)}{9} + \frac{11q_E^2 + 11q_I^2 - 14q_Iq_E}{18}.$$

One can verify that

$$s_F - s_S(0) > 0$$

for $q_E > q_I$. Again the question is whether if $s_F - s_S(0)$ is sufficiently large. We have

$$\pi_I^F - \pi_I^S(0) + s_F - s_S(0) = \frac{(q_E-q_I)^2}{6} > 0,$$

which implies that the adoption date in the unregulated environment is *suboptimally late*.