

Service-based vs. Facility-based Competition in Local Access Networks*

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Abstract

In this paper we argue that service-based competition may deter (or delay) facility-based competition. Hence, to the extent that service-based and facility-based entry are perceived as substitute strategies by the entrants, regulatory policies that are aimed at each one of them may exhibit conflicts. We develop our arguments on the basis of our formal studies, Bourreau and Dogan (2002a and 2002b), where an incumbent and an entrant compete for providing high-bandwidth services. We claim that an incumbent who faces an effective threat of facility-based competition can strategically delay facility-based entry by providing attractive terms of access to its facilities. The delay that is introduced by attractive terms of access is by virtue of a replacement effect, which may also affect the choice of technology to be eventually built by the entrant.

1 Introduction

The nature of competition in local access networks is shaped by the “build or buy” decisions of the entrants. *Build* refers to the entrant’s building its own facility, whereas *buy* refers to some type of arrangement that allows the entrant to use the Incumbent Local Exchange Carrier’s (ILEC) local network to compete for services. Profitability, and hence the conditions, of buying is one of the main determinants of attractiveness of building.

Regulatory policies in the telecommunications industry aim at promoting both service-based and facility-based competition. However, by and large, facility-based competition is favored over service-based competition, since it is expected to remove heavy regulation requirements in the industry. Furthermore,

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consumers have varying needs that are best satisfied with different competing technologies; the British Regulatory Authority, OFTEL, writes

“competition at the infrastructure level should in turn feed through to competition in the provision of services, providing consumers with a choice of packages, pricing structures and customer service options”¹.

For the full functioning of competition, it is necessary that each operator control its supply chain to the largest possible extent. Facility-based competition is perceived as a necessary condition for long-term efficiency. This is because the benefits from flexibility and innovation obtainable under this state of affairs exceed by far those achievable under facility-sharing settlements. Under facility-sharing agreements, the entrants rely on the ILECs’ network for providing services, and hence, are restricted by the ILECs’ choices of price, service and technologies. Woroch (2002) points this out as a limitation of service-based competition, and argues that service-based competition *at best*, over the long run, is a stepping stone to facility-based competition.

In this paper, we argue that service-based competition *at worst* deters (or delays) facility-based competition. Hence, to the extent that service-based and facility-based entry are substitute strategies for the entrants, policies that are designed to support each one of them may exhibit conflicts. We develop our arguments on the basis of our formal dynamic model in Bourreau and Dogan (2002a and 2002b), where an incumbent and an entrant compete to provide high-bandwidth services. In Bourreau and Dogan (2002a and 2002b) we show that an incumbent who faces an effective threat of facility-based competition can strategically delay facility-based entry by providing attractive terms of access to its facilities. The delay that is introduced by attractive terms of access is by virtue of a replacement effect, which may also affect the choice of technology to be eventually built by the entrant.

The organization of the paper is as follows. We begin by discussing service-based and facility-based competition in the local access market, and different means to attain them. We also provide some discussion of current practices. Then, following Bourreau and Dogan (2002a and 2002b), we show how service-based competition through unbundled access to the local loop can affect the entrants’ incentives to build their own facilities. Prior to our conclusions, we discuss the regulatory tools that may be useful in achieving socially desirable outcomes.

2 Service-based vs. facility-based competition

When the entrant uses the facilities of the incumbent, competition is called service-based and can be realized either through resale or through unbundling schemes. When the entrant builds its own facility, competition is facility-based.

¹OFTEL (2001 a), Chapter 3, §3.

	Downstream	Upstream	Max. length of line
ADSL	1.5 to 9 Mbps	16 to 640 kbps	2.5-5 km
HDSL	1.544 or 2.048 Mbps	1.544 or 2.048 Mbps	3-4 km
SDSL	1.544 or 2.048 Mbps	1.544 or 2.048 Mbps	2-6 km
VDSL	13 to 52 Mbps	1.5 to 2.3 Mbps	1.5 km

Table 1: DSL Technologies
Source: DSL forum, <http://www.dslforum.org/>.

In a simplified account, the entrants' incentives to build their own facilities depend on the difference between the expected profit flows from facility-based competition and service-based competition. On the one hand, the profit flows of the entrant from facility-based competition depend on how efficient the entrant's facility is, as opposed to the incumbent's (for example, some technologies may provide a superior quality of service compared to the copper local loop, and some may be cost-efficient). On the other hand, the entrant's profit flows from service-based competition depend on the terms of its access to the incumbent's facilities. For this reason, the incumbent operators can strategically manipulate the potential entrants' build-or-buy decisions if the terms of access that form service-based competition are not regulated.

In the following, we discuss both service-based and facility-based competition in practice.

2.1 Service-based competition

As mentioned earlier, service-based competition takes place when the entrant relies on the facilities or the services of the incumbent to provide Digital Subscriber Lines (DSL) services. DSL is the method by which copper loops are upgraded to support high-speed data access. Various DSL technologies are available today. Each has its own performance and constraints which are summarized in Table 1.²

While ADSL or Very High Data Rate DSL (VDSL) technologies target residential customers (with applications such as high-speed Internet access for ADSL or high definition television for VDSL), High Data Rate DSL (HDSL) and Symmetric DSL (SDSL) target professional customers (with applications such as Private Branch Exchange network connections or remote Local Area Network access).

²One of the restrictions to DSL technologies is the maximum length line. Since signal attenuation increases with line length, DSL technologies provide bandwidths to copper lines whose length is below the maximum length. The maximum length of a DSL line is a constraint in terms of broadband coverage. In particular, in rural areas, where access lines are longer, Asymmetric DSL (ADSL) services may not be feasible. We distinguish between downstream bandwidth (from the network to the subscriber) and upstream bandwidth (from the subscriber to the network) because some technologies (e.g., ADSL) provide different bandwidth downstream and upstream.

When the entrants rely on the incumbents' facilities, their degree of freedom to choose among the DSL technologies may be restricted, and depends on the type of service-based entry. Mainly, the entrants can compete with the incumbent on the basis of services, either with resale arrangements, or by having unbundled access to the local loop.

Resale Resale occurs when the incumbent provides its retail services on a wholesale basis to new entrants. An entrant can buy the service with a discount on the incumbent's retail tariff³ and then replace its brand name on the services and commercialize the rebranded services to end customers. Competition takes place in the marketing and distribution of services. Differentiation is very limited, as entrants do not control the network and are obliged to use the same technology as the incumbent. In the US, ILECs are obliged to offer for resale any retail service they provide, whereas in Europe, ILECs have no such obligation. In practice, resale of ADSL offers exist only in a few European countries, e.g., Belgium, France, and the UK.

Unbundled Access to the Local Loop Unbundling of the local loop refers to a series of regulatory offers.⁴ The most fundamental one is raw copper unbundling. With *raw copper unbundling*, the incumbent provides access to its copper lines. The entrant then co-locates in the incumbent's facilities and installs its own equipment (either for telephony or DSL). With *line sharing* or *shared access* to the local loop, the same local loop is used both by the incumbent and the entrant. The incumbent rents the high frequency band to the entrant for DSL services, while it keeps the low-frequency band for analog telephony services. Finally, with *bitstream access*, the incumbent leases access to its high bandwidth architecture. The incumbent chooses the technology and decides on its investment plan.⁵

³For instance, in France, France Télécom's ADSL resale offerings propose a discount of 15% versus the public price of France Télécom's retail ADSL services.

⁴The European Commission requires operators with significant market power to provide access to their copper lines through raw copper unbundling and line sharing offers (EU Regulation on unbundled access to the local loop, December 2000), whereas bitstream access is not mentioned in its regulatory order that was adopted in December 2000. However, even though line-sharing schemes are mandatory, they are not fully implemented in every European country. On the contrary, in some countries (e.g., Norway and Sweden), the ILECs decided to unbundle their local loops without the direct intervention of the regulatory authorities. In the US, copper loop unbundling has been mandatory since the 1996 Telecom Act. In 1999, the Federal Communications Commission (FCC) adopted rules that required ILECs to provide line-sharing (see FCC, 1999 a), but in May 2002 the US Court of Appeals for the District of Columbia overturned this decision. As for bit stream access, the FCC declined to require ILECs to unbundle DSL access multiplexers in September 1999 (see FCC, 1999 a; FCC, 1999c).

⁵Another type of unbundling scheme is *sub-loop unbundling*. Sub-loop unbundling allows new entrants to connect at a point between the end user and the incumbent's site (e.g., to provide VDSL services, which require much shorter access lines). This form of unbundling is available in only a few European countries, e.g., Austria, Belgium, Greece, Luxembourg, Spain, Sweden, and the United Kingdom.

Resale arrangements and different unbundling schemes provide operators with different degrees of differentiation. Whereas differentiation is limited with resale or bistream access, raw copper unbundling and line sharing provide the best possibilities for service differentiation, as the entrant can choose among a number of DSL technologies.

Figure 1 here

Source: ECTA, May 2003, <http://www.ectaportal.com/>.

✖ By March 2003.

Figure 1 provides an overview of service-based competition for broadband access in the EU. It shows that service-based competition has not yet proved effective to challenge the ILECs' dominant position in local markets. Even in the countries that have been leading in unbundling practices, e.g., Germany, unbundling has failed to foster local access competition. Figure 1 also shows that bit stream access of resale offerings –when available– have been more successful than raw copper unbundling schemes.

2.2 Facility-based competition

Facility-based competition takes place when the entrant builds its own facility. Currently, new entrants have access to a range of alternative local loop technologies.⁶

Cable networks Cable networks were built to deliver television programs. Today, the new generation of cable systems, namely hybrid fibre coax cable networks, can also provide high bandwidth Internet services to end users (old generation cable systems can deliver broadband access only if they are upgraded). Bandwidth available on cable networks is of the same magnitude as that for ADSL networks (1-3 Mbps downstream and 256 kbps-2.5 Mbps upstream). Cable networks might have a cost advantage over DSL networks due to economies of scope between cable television and Internet access.

Broadband wireless local loop Broadband wireless local loop (WLL) provides high bandwidth access up to 10 Mbps. In the European Union, licences were awarded in 2001. However, the deployment of broadband WLL has proved slower than expected. For instance, in France, in September 2002, there was only one national WLL service left out of two, and 14 regional WLL networks left out of 22. It has often been stated that WLL has a cost advantage over wirelines technologies in low density areas.

⁶See NRC Broadband Report 2002 for an extensive discussion of technological options for providing high-bandwidth services. We exclude powerline technologies, which use existing electricity networks to provide bandwidth, but whose prospects are still vague.

3G mobile networks UMTS (Universal Mobile Telecommunications System) aims at providing technology 2 Mb/s per base station. Larger bandwidth – doubled or tripled compared to the bandwidth available today on UMTS networks – will not be provided by UMTS, but by fourth or fifth mobile generation networks. It is likely that mobile technologies will remain as a more costly option to provide large bandwidth, compared to wireline technologies, such as DSL, but UMTS provides consumers with mobility, which may constitute a quality advantage.

Fibre-optic networks Fibre optic local loops provide customers – including residential customers – with very high bandwidth connections. For example, a single wavelength on a single fibre can provide 40 Gbps. However, as this technology is very expensive, the supply of fibre loops will depend on the customers' willingness to pay for bandwidth. Currently, fibre-optic networks are installed mainly in business areas.

Satellite networks Even though satellite constellations like Iridium have been economic fiascos,⁷ satellite technology appears to be the most cost-efficient technology under certain conditions. In particular, low-orbit satellite technologies can provide global coverage for very large regions. They might be useful and viable technologies when wireline infrastructures are not available. Hence, satellite may be differentiated from DSL services by providing larger coverage.

This description shows that access infrastructures may provide new entrants with either a cost advantage (WLL, cable) or a quality advantage (fiber, UMTS, satellite).

Figure 2 here

Source: ECTA, <http://www.ectaportal.com/>. Market shares on broadband connections. Infrastructure-based competition: cable or others. Service-based competitors: fully unbundled lines used for broadband, shared access, and bit-stream access.

* By March 2003.

Figure 2 shows that service-based competition and infrastructure-based competition are two different means of developing competition in the local loop. The figure also suggests that there is a relationship between these two different forms of competition. We would like to address this point in the next section.

⁷Iridium filed for bankruptcy under Chapter 11 of the U.S. Bankruptcy Code on Friday 13, August 1999. Globalstar, another satellite network operator, also filed a voluntary petition under the same chapter.

3 A framework for high-bandwidth competition

In this section, following Bourreau and Dogan (2002a and 2002b), we provide a simple framework in which an incumbent and an entrant compete for the provision of high-bandwidth services. For detailed analysis and formal proofs, the reader should refer to Bourreau and Dogan (2002a and 2002b). In this framework, while the incumbent uses its copper local loop, the entrant can either lease loops (if available) or build its own facility to provide services. The entrant can also lease loops prior to building its own facility.⁸ When the entrant leases the loops, it incurs a fixed cost f , which is due to co-location and order handling. The incumbent who is not subject to regulation decides whether or not to unbundle its loops, and sets the rental price, r , if it decides to unbundle.

Consumers are uniformly distributed on a unit square, where their vertical and horizontal locations define their tastes towards quality and variety, respectively. A consumer of type (x, θ) derives utility $U = v + \theta q_i - (x - y_i)^2 - p_i$ from purchasing an access line from firm i , where v is the fixed utility from high bandwidth services, θ and x represent consumer's taste for quality and variety, respectively, y_i and p_i represent the horizontal location and price of firm i . Along with the following assumptions, we assume market coverage for high bandwidth services.

- *When firms compete on the basis of services, they provide the same quality of service, i.e., the same bandwidth.* Let q_I and q_E denote the quality of service (i.e., the bandwidth) that the incumbent and the entrant provide, respectively. When the entrant leases loops, i.e., when there is service-based competition, firms provide horizontally differentiated products. However, as they use the same infrastructure, we assume that they cannot differentiate in quality. Therefore, in this case we assume that $q_I = q_E = q$. This is more likely to happen with bitstream access.
- *The new technology is more efficient than the traditional copper loop.* We assume that the new technology brings a superior quality of service compared to the copper local loop ($q_E > q_I$), and let this quality difference be denoted by q_F ⁹, where the subscript stands for facility-based competition. That is to say, the maximum bandwidth that can be achieved through upgrading the loops is inferior to what can be achieved with the new technologies. Indeed, 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. Although we model the new technology as a quality-improving technology, one could also consider a cost-reducing new technology. As innovations

⁸Our analysis could also be applied to service-based competition with resale agreements (instead of an unbundled access), although resale agreements provide less room for variety differentiation.

⁹We impose an upper limit, \bar{q} , on this quality difference to ensure that a price equilibrium exists in this three dimensional setting (quality, variety and price). The approach we adopt is that of Neven and Thisse (1989).

in the telecommunications sector are mainly realized by equipment manufacturers and are then adopted by carriers, we do not consider a new technology that is less efficient than the existing one as a viable new technology. When firms compete with different technologies, as they do in service-based competition, they position their services on the horizontal line.

- *Cost of adopting the new technology is declining over time.* This is the classical assumption in the innovation literature. We adopt a quadratic cost with the following form $A = (a/2)\Delta^2$,¹⁰ where $\Delta \in [0, 1)$ is the discount factor determined by the adoption date, and a is a positive constant. A higher Δ corresponds to an earlier adoption date, and since $A'(\Delta) \geq 0$ and $A(0) = 0$, the adoption cost decreases over time and converges to zero as time goes to infinity. We further assume that, whenever there are multiple new technologies available for adoption that bring different levels of quality of service, at any time it is more costly to adopt the technology with a higher quality (therefore, a is greater for a higher quality technology than a lower quality one). However, better technologies bring higher profit flows to the entrant.
- *The incumbent cannot by-pass its own infrastructure with the new technology.* We assume that the incumbent cannot adopt the new technology. This can be justified by some regulatory bans on cross-ownerships. For example, the European Commission established rules in 1999 that require incumbent operators to legally separate their cable operations from their traditional phone services. Furthermore, some technologies require specific licenses; this is the case for cable networks or wireless local loops. For instance, ILECs in Austria and Portugal were excluded from the tendering process for wireless local loop licenses. Also, incumbent operators usually find it more profitable to upgrade their existing local loops than to build new access networks, as the upgrade cost is small relative to the cost of a new infrastructure.

We limit the bounds of both f and a in order to exclude "uninteresting" cases for our analysis. That is, we assume away the following cases i) the entrant does not lease the loop, even if the r is set at the marginal cost which is normalized to zero, (upper bound on f), ii) the incumbent never unbundles its loops¹¹ (upper bound on a), iii) quasi-monopolistic equilibrium in the phase of service-based competition, that is, the equilibrium in which the entrant leases the loops although r is too high (lower bound on f), and iv) immediate technology adoption, i.e., $\Delta = 1$.

Let $\pi_i^F(q_F)$ and $\pi_i^S(r)$ denote profit flows of firm i , where $i = E, I$. We find that, when the quality advantage of the entrant is sufficiently high firms

¹⁰We use the same notation and interpretation as Riordan (1992).

¹¹It is important to note that we are not artificially imposing the incumbent to unbundle its loops. We merely exclude the cases in which it *never* unbundles. This could be the case when a is very large, so that there is no effective threat of entry with the new technology.

obtain minimum horizontal differentiation. On the contrary, when the quality advantage is small, firms obtain maximum horizontal differentiation. One can show that the entrant's service-based profits flows decrease with the rental price of the loop ($\partial\pi_E^S(r)/\partial r < 0$). We also show that $\pi_E^F(q_F) > \pi_E^S(r)$ for all r , and q_F . This means that the entrant obtains higher profit flows when it competes on the basis of facilities than it does when it competes on the basis of services. Conversely, the incumbent is better off with service-based competition, as, in this case, it has no quality disadvantage, and it receives rental revenues from the lease of its loop. Naturally, the incumbent is better off when it is the monopolist provider of high-bandwidth services. Therefore, $\pi_I^F(q_F) < \pi_E^S(r) < \pi^M$, where π^M denotes the incumbent's flows when the incumbent is alone in the market. This order suggests that if there is no threat of facility-based entry, the incumbent would deny unbundled access to its local loop.

When do entrants build their own facilities? The entrant obtains higher profit flows with facility-based competition. Furthermore, as the cost of adopting the new technology decreases over time and converges to zero, the entrant eventually builds its own facility. More precisely, the entrant waits to build its own facility until the time that it is optimal to adopt the new technology. The optimal timing of adoption depends on the opportunity cost of technology adoption, which is, in turn, determined by the terms of the entrant's access to the local loop. Clearly, when there is no unbundling¹², the entrant has no opportunity cost of building its own facility, and, hence, the entrant adopts the technology at a relatively earlier date, Δ^* . In this case, the optimal adoption date is defined by $\arg \max \Pi_E^F(\Delta)$, where $\Pi_E^F(\Delta)$ is the discounted profits of the entrant when there is no unbundling. Since there is no service-based competition prior to technology adoption, for all $\Delta \in (\Delta^*, 1]$ the incumbent is the monopolist provider of high bandwidth services. From the technology adoption date on, i.e., for all $\Delta \in (0, \Delta^*]$, there is facility-based competition. Therefore, its discounted profit is defined as

$$\Delta\pi_E^F(q_F) - A(\Delta),$$

which, in turn, implies an adoption date of $\pi_E^F(q_F)/a$.

If an unbundled access to the local loop is possible, and if the rental price is sufficiently low, there is service-based competition prior to technology adoption. The optimal timing of the technology is defined by $\arg \max \Pi_E^{S+F}(\Delta_S(r), q_F, r)$, where $\Delta_S(r)$ is the technology adoption date and $\Pi_E^{S+F}(\Delta_S(r), q_F, r)$ is the discounted profits of the entrant when it competes on the basis of services prior to its technology adoption, which is defined as

$$\Delta_S(r)\pi_E^F(q_F) - A(\Delta_S(r)) + (1 - \Delta_S(r))\pi_E^S(r) - f.$$

Hence, the optimal timing of adoption, $\Delta_S^*(r)$, is defined as $(\pi_E^F(q_F) - \pi_E^S(r)) / a$, and naturally depends on the profit flows obtained from service-based competition, and, hence, on the rental price of the loop. This is due to the so called

¹²This also corresponds to the case in which the incumbent sets too high a price for the loop, and the entrant does not lease the loop prior to technology adoption.

replacement effect. It takes more time for the entrant to build its own facility if it is already operating in the market and is making positive profits. The higher profits the entrant obtains during the phase of service-based competition, the later the entrant builds its own facility. The delay due to the replacement effect is $\Delta^* - \Delta_S^*(r) = \pi_E^S(r)/a$. Since the entrant's service-based profit flow decreases with r , this suggests that the adoption delay that is caused by unbundling decreases with r . The higher the rental price (unattractive terms of lease), the earlier the entrant adopts the new technology. Note that, when r is sufficiently high, the entrant does not lease loops prior to building its own facility, which implies that effectively, there is no unbundling, and, hence, no delay in technology adoption.

In this setting, the replacement effect may have another implication when there are multiple types of new technologies available for adoption. For simplicity, normalize q_I to zero, and consider two new technologies, technology H (igh) and technology L (ow), with H providing a higher bandwidth than L . Let $q_L \in (0, \underline{q})$ and $q_H \in [\underline{q}, \bar{q}]$. We assume that adopting technology H is more expensive than adopting L at any time, i.e., $a_H > a_L$, but that it yields a higher profit flow for the entrant. Now, assume that the entrant adopts technology L without unbundling. As both technologies become cheaper to adopt over time (i.e., the cost of adopting both technologies converges to zero), and as unbundling introduces a replacement effect, the entrant may adopt technology H if the adoption is sufficiently retarded. Therefore, unbundling may not only distort the timing of the technology adoption, but also the type of technology to be adopted. However, to conclude how a distortion of this type affects social welfare is not a straightforward process and depends on the quality difference between different technologies and on consumers' valuation for quality.

ILECs' incentives to unbundle the local loop As already mentioned, the incumbent obtains the highest profit flows when it operates as a monopolist. This implies that if there were no threat of facility-based entry, the incumbent would deny the entrant the access to the unbundled loops and maintain its monopoly profits. However, as new technologies become cheaper to adopt over time, there is an effective threat of facility-based entry. Furthermore, the incumbent obtains higher profit flows by service-based competition than facility-based competition, i.e., $\pi_I^F(q_F) < \pi_E^S(r)$. This is true even if the new technology does not bring a superior quality to the local loop, since the incumbent obtains rental revenues when it leases its loops to the entrant, but these are non-existent during the phase of facility-based competition. As a consequence, the incumbent has strong incentives to determine attractive terms of lease for its loops. In the following, we characterize the rental price –both fixed and time-dependent– likely to be set by an unregulated incumbent.

Fixed rental price First, consider the case in which the incumbent sets and commits to a fixed rental price for the local loop. When determining the rental price, r , the incumbent faces the following trade-off. Setting a very high

rental price (which is equivalent to denying unbundled access to its loops) protects its monopoly profits in the short run, but triggers facility-based entry. The incumbent is better off when the entrant leases its loops, as in this case, the incumbent has no quality disadvantage and obtains additional revenues from the lease. Therefore, the incumbent sets a relatively low rental price (but still, well above the marginal cost), in particular when adoption cost for the new technologies (parameters a_H and a_L) is sufficiently low. Indeed, the rental price is sub-optimally low –as the incumbent does not encounter the consumers’ valuation for better quality technologies– and, hence, the new technology adoption occurs too late from a social welfare point of view. However, if the adoption cost is sufficiently high so that there is no effective threat of facility-based competition in the near future, the incumbent is better off by not unbundling its loops.

Time-dependent rental path Although commitment to a fixed rental price can be justified by the fulfillment of long-term leasing contracts, clearly, a time dependent path provides the incumbent with a greater flexibility. When the incumbent determines a time dependent rental path, $r(\Delta)$, there is no longer a trade-off regarding the pricing of the loops. In this case, at date Δ , if the entrant leases loops, given that it has not yet adopted the new technology (and that it will adopt it at some future date $\hat{\Delta}$), the technology adoption problem is

$$\max_{\hat{\Delta} \leq \Delta} \Pi_E^{S+F} = \max_{\hat{\Delta} \leq \Delta} \left\{ \int_{\hat{\Delta}}^{\Delta} \pi_E^S(r(x)) dx + \hat{\Delta} \pi_E^F - A(\hat{\Delta}) \right\}.$$

The rental price changes the service-based profit flows of the entrant, and, hence, its discounted profits when it leases loops prior to technology adoption. We, therefore, need to make the following distinction for the following phases. The solution of the maximization problem is $\hat{\Delta} = \hat{\Delta}_1^*$ for $r(\Delta) \in [0, v - 5/4]$, $\hat{\Delta} \in [\hat{\Delta}_1^*, \hat{\Delta}_2^*)$ for $r(\Delta) \in [v - 5/4, v - 3/4)$, and $\hat{\Delta} \in [\hat{\Delta}_2^*, \Delta^*)$ for $r(\Delta) \in [v - 3/4, v)$ with $\hat{\Delta}_1^* < \hat{\Delta}_2^* < \Delta^*$, since $\partial \pi_E^S / \partial r \leq 0$. Again, this implies a replacement effect. The optimal adoption strategy for each phase is defined as follows. For $\Delta \in (\Delta^*, 1]$, the entrant leases loops if $r(\Delta) \in [0, v]$, and does not enter otherwise. For $\Delta \in (\hat{\Delta}_1^*, \Delta^*]$, the entrant leases loops if $\Pi_E^{S+F}(\Delta) \geq \Pi_E^F(\Delta)$, and adopts the new technology if $\Pi_E^{S+F}(\Delta) < \Pi_E^F(\Delta)$. For $\Delta \in [0, \hat{\Delta}_1^*]$, the entrant adopts the new technology, given any $r(\Delta)$. Hence, from $\hat{\Delta}_1^*$ on, competition is facility-based.

Given the above optimal adoption strategy of the entrant, the incumbent sets a different rental price for each phase. With an incentive to protect its monopoly profits, the incumbent can charge an unattractive rental price (or refuse to unbundle) during the time when there is no effective threat of entry because of the high adoption cost. That is, for $\Delta \in (\Delta^*, 1]$, the rental rate is set at v or at any price above v . However, at Δ^* , which is the optimal adoption date given that there is no unbundling, the incumbent optimally changes its pricing

strategy. One can show that the optimal rental path has the following property: $\partial r^*(\Delta)/\partial \Delta \geq 0$, for all $\Delta \in (\widehat{\Delta}_1^*, \Delta^*]$. This is because the incumbent charges a rental path, such that at each time the entrant prefers (or continues preferring) leasing loops to adopting the new technology. Therefore, the rental price set by the incumbent tends to decrease over time, as the new technology becomes cheaper to adopt. The rental price would continue to decrease until the time when the entrant finds it optimal to adopt the new technology, no matter how low the rental price is. That is, the rental price becomes irrelevant for all $\Delta \in [0, \widehat{\Delta}_1^*]$, since the entrant adopts the new technology at (latest) $\widehat{\Delta}_1^*$ for any rental price. By following such a strategy, the incumbent can delay technology adoption and, at the same time, can extract as much rent as possible from the entrant. Hence, similar to our argument with a fixed rental price, unbundling with a time-dependent unregulated rental path may sub-optimally delay technology adoption.

4 Regulatory Tools

4.1 Regulating rental price

In practice, incumbents do not choose to unbundle their local loops, but rather, they are mandated by the regulatory and competition authorities to do so. Some policy papers point out the resistance of the incumbent operators to unbundling.¹³ Our model implies that this confrontation would end as soon as the incumbents anticipate an effective threat of a facility-based entry.

Our analysis calls for a regulatory intervention for determining the rental price, which is necessary for achieving a socially optimum adoption date. We suggest that when the cost of adopting the new technology has sufficiently declined, regulating the rental price should comprise a price floor. Furthermore, the subject floor is beyond the one required for the ‘cost recovery’ of the incumbent.

The *Unbundling Regulation* issued by the European Commission does not specify the pricing methodology for fixing the rental rate of the unbundled loops. Therefore, European national regulatory authorities (NRAs) choose different pricing methodologies, which we present in Table 2. In some countries, the NRA chose the LRIC *plus* (Long Run Incremental Cost + markup to cover common costs) scheme (e.g., in France, Germany and in the UK). Other NRAs chose historical costs (e.g., in Ireland and Italy). The Belgium NRA, IBPT, chose a retail minus scheme.

The nature of regulatory intervention also differs across Europe. In some countries, the regulator intervenes *ex ante* to fix unbundling prices (e.g., France and the UK). In other countries (e.g., Denmark or Finland), unbundling prices

¹³For example, see CWU Response to DG Information Society Working Document on Unbundled Access to the Local Loop.

are left to commercial negotiations and are subject to ex-post regulatory intervention.

Regulation of bit stream access prices is even more heterogeneous. Bit stream access prices are regulated -to some extent- in only a few countries, and pricing methods differ substantially. In the UK, OFTEL chose a “retail minus” scheme to foster investment.¹⁴ In France, bit stream access prices are subject to French NRA ART’s approval; ART assesses whether these prices allow competitors to have a viable business.

The optimal rental price is not necessarily the same for all geographies. Geographical limitations to facility-based entry plays an important role in determining the nature of the regulatory intervention. In low demand areas where facility-based entry is not feasible, service-based entry may be the only way to achieve competition. De-averaging may therefore provide more efficient outcomes in the unbundling process. There are at least two reasons why the rental price of the loops should be de-averaged. The first argument is based on the fact that the costs of the loops may vary in different geographies. Second, the cost of facility-based entry may also depend on geographical settings. In areas where facility-based entry is prohibitively expensive, regulators should set rental prices that aim at promoting service-based entry, without the fear of delaying facility-based competition.

4.2 Regulating quality of access

Numerous complaints regarding quality have been assessed by NRAs and competition authorities. These complaints indicate the ability –and, apparently, the will– of ILECs to degrade the quality of service of their rivals by various means.

First of all, incumbent operators can delay full unbundling-based entry. Indeed, before leasing loops to the incumbent operator, new entrants must install or *co-locate* broadband equipments (i.e., DSLAM) in the incumbent’s premises. Different forms of co-location exist. With physical co-location, new entrants’ equipment is often located in a specific area reserved for unbundling. Hence, delivering a new co-location site can take a long time when incumbent operators have to build a new area. For example, it takes more than 6 months to deliver a new co-location site in Germany or Belgium. Co-location delivery terms have given rise to complaints in Belgium, France, Greece, the Netherlands, Portugal, and in the UK. In France, with its recent decision, ART requires the incumbent operator (France Télécom) to install new entrants’ equipment in areas where France Télécom operates its own equipment whenever no specific collocation site is available.¹⁵ This form of co-location (called co-mingling or cageless co-location) is also available in Belgium, Denmark, Spain and in the UK.

Second, incumbent operators can also favor their DSL subsidiary by delaying the provision of unbundled lines to new entrants. Indeed, some new entrants complain (e.g., in Belgium or Portugal) about the delays in the delivery of

¹⁴OFTEL (2001 b).

¹⁵Decision n° 02-323, ART, 16 April 2002 .

Country	The Method	
	for full ULL	for bit stream access
Austria	LRIC plus markup	Not regulated
Belgium	Retail minus	Cost orientation
Denmark	Commercial negotiation	Not regulated
Finland	Commercial negotiation	(no bit stream access)
France	LRIC plus markup	Viability of competitors
Germany	LRIC plus markup	(no bit stream access)
Greece	n/a	(no bit stream access)
Ireland	LRIC plus markup	Cost orientation
Italy	Historical costs	Retail minus
Luxembourg	n/a	(no bit stream access)
the Netherlands	Historical costs ¹	n/a
Portugal	Historical costs	(non discrimination)
Spain	Historical costs and competitiveness of local markets	Regulated
Sweden	n/a	n/a
United Kingdom	LRIC plus markup	Retail minus (ADSL)
United States	LRIC plus markup	Not regulated

Table 2: Pricing of the Local Loop

Sources: Squire Sanders (2001).

²The Netherland is in the process of transition from historical costs to LRIC method.

unbundled lines. For instance, the provision of a new unbundled line in the Netherlands may take 40 days, while it takes only between 1 and 2 weeks in Finland.¹⁶ In the UK, OFTEL decided that British Telecom will be obliged to offer compensation when it fails to meet its contractual obligations, in particular in terms of delivery of lines. Compensation is based on an estimation of the new entrant's loss. For instance, BT will pay £10 per undelivered loop per working day when it is not delivered when due.¹⁷

Third, the quality of service provided by the incumbent to new entrants may be lower than that provided to its own subsidiary. Some new entrants have claimed that incumbent operators provided unbundled lines of poor quality or even not functioning (e.g., in Germany and Denmark).¹⁸ The incumbent operator may also provide a computerized ordering system (to accelerate the testing and ordering of DSL lines) only to its own subsidiary. For example, in France, an entrant operator, T-Online France filed a complaint in November 2001 and claimed that France Télécom had installed a system in its commercial agencies, which was used to commercialize the ADSL offers of its own subsidiary, while it was not made available to competitors.¹⁹ Finally, new entrants also complain about the absence or the scarcity of information, which can adversely affect the quality of their operations.

Quality degradation strategies are often cited as an alternative to preemptive pricing strategies, and ILECs are more likely to engage in them when they have no control on the rental price. Hence, it is essential to supplement price regulations with ex-ante or ex-post quality measures. However, regulation of quality is a difficult task because of informational constraints.

4.3 Regulating final prices

There is a certain degree of substitutability between regulating access prices and final prices, and hence, with the enhancement of service-based competition, regulation requirement displays a shift from final prices to access terms. In practice, final prices –prices for high bandwidth services– are not subject to heavy regulation. When high bandwidth services are provided by the historical operator itself, generally, the price has to be approved because of the incumbent's dominant position. In particular, the regulatory authority assesses the offer in terms of predatory practices. However, the regulator cannot fix final prices. Furthermore, some of the incumbent's high bandwidth services are provided by its Internet access provider, which is usually not subject to sector-specific regulation. For instance, in France, France Télécom has two ADSL offers. First, it

¹⁶ According to "Legal Study on Part II of the Local Loop Sectoral Inquiry", February 2002.

¹⁷ See: "Local loop unbundling: service level commitments and compensation", Statement and Direction issued by the Director General of Telecommunications, 15 November 2001.

¹⁸ See: "Annexes to the Legal Study on Part II of the Local Loop Sectoral Inquiry", February 2002.

¹⁹ The Competition Authority decided that France Télécom would not be allowed to offer Wanadoo's ADSL offers in its agencies until a computerized ordering system is available to competitors. See Conseil de la Concurrence, France (2002).

offers an ADSL line, whose price has to be approved by the Ministry of Telecommunications (which takes the advice of the regulatory authority, ART). But to have complete ADSL access, consumers must also subscribe to an ADSL Internet access service. Second, France Télécom's Internet access provider, Wanadoo, offers ADSL access (i.e., an ADSL line together with an ADSL Internet access service). Since Wanadoo is not regulated, the price of the latter does not require any approval.

Although direct regulation of final prices in the high-bandwidth market is not observed in practice, in theory, a regulator which attributes different weights to consumer surplus and industry profits may choose to regulate both the terms of access and final prices.

4.4 Sunset Clauses

Another important supply condition is the timing of the introduction of local loops for leasing. *Sunset clauses* specify ex ante a period of time after which the incumbent's facilities are no longer regulated. The motivation behind these sunset clauses is to provide the entrants with incentives to build their own facilities. In this respect, deregulating the rental rate is assumed to render leasing loops an unattractive option to the entrant. In the setting we have described, sunset clauses do not improve social welfare. This is because the unregulated rental price determined by the incumbent is too low, so commitment to remove regulation after the clause does not give the entrant an additional incentive to build its own facility. In this regard, if a regulator can commit to *banning* unbundled access to the local loop after a certain period, it may achieve a good balance of service-based and facility-based competition, since the ban will require the entrant operators to build their own facilities.

Sunset clauses have been specified in the unbundling regulations in Canada and the Netherlands. 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."²⁰ However, Opta announced in April 2001 that at the end of the five-year period, it would review competition in the local loop to decide whether to continue or to stop regulating the rental rate.²¹ Similarly, the Canadian Radio-Television and Telecommunications Commission issued a decision (CRTC-97-8), which stated that following a five-year mandatory unbundling, the incumbent's services and 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. In March 2001, CRTC extended this sunset period without specifying a termination date.²² As the Canadian and the Dutch experiences suggest, there are commitment problems in determining sunset clauses. The credibility of the sunset clauses affect the ex-ante incentives of the entrants to build their facilities.

²⁰OPTA (1999).

²¹See OPTA (2001).

²²See Order CRTC 2001-184.

5 Concluding Remarks

Profits from service-based competition constitute an opportunity cost to an entrant to build its own facilities. Hence, regulating the terms of access to the ILEC's local access network plays an essential role in determining the shape of the competition in the telecommunications industry. We argue that, at least in geographies where by-passing the copper loop network is feasible, regulating the rental price should comprise a price floor instead of a price ceiling. This is because the ILECs would be better off by setting attractive conditions for the lease to delay facility-based entry, and this is true in particular when facility-based entry occurs with a technology that brings a superior quality of service to the conventional copper loops. The ILECs' incentives to delay (or deter) facility-based entry depends on several other factors as well. In the following, we briefly discuss how such factors might affect our conclusions.

Switching Costs High-bandwidth services do entail some costs for switching providers, which are similar to those associated with low-bandwidth Internet access. Therefore, ILECs may have additional incentives to deny access to the unbundled loop so that they can lock in some customers before any entry can occur. The locked-in customers would then be reluctant to switch to new providers, even if they provide better services in terms of quality and/or price. In some countries, where unbundling was introduced at an earlier date than the development of the ADSL services (e.g., Germany and the Netherlands), lock-in effects were the main concern, whereas in other countries, they have been considered by the regulatory authorities. For example, in France, the Competition Authority banned France Telecom from providing ADSL services until it provided either raw copper unbundling or bit stream access, so that other providers could enter the market. Recently, the ADSL services offer of the ILEC in Ireland (Eircom) was approved simultaneously with the introduction of an ADSL wholesale offer.²³

Upgrade Investments ILECs do upgrade their loops. An important question regarding our analysis is whether the ILECs can achieve a quality of service that is superior to new technologies by upgrading their loops. Throughout our analysis, we assumed that this is not the case. However, the incentives of the ILECs to upgrade their loops depend on unbundling requirements. This is because the upgrade improves the quality of service that can be provided with the copper loop, and, hence, the incumbent can charge a higher rental price. This implies an increase in the incumbent's profit flows during service-based competition. Furthermore, it delays technology adoption, since the entrant has a smaller (or no) quality advantage over the service provided by the incumbent

²³Eircom will be able to launch its ADSL retail service 21 days after approval of its wholesale offer (see ODTR (2001)). The Portuguese regulator (Anacem) stated also that "bitstream access should be offered in principle from the moment that the NO [network operator] begins to provide DSL services, in accordance with the principle of non-discrimination" (see Anacem (2000)).

when it builds its own facility, and, hence, expects a lower profit flow in the phase of facility-based competition. Finally, note that the type of unbundling scheme may result in different incentives for upgrade investments.

Learning Effects Learning effects are also claimed to support unbundling practices. The entrants may prefer to have some experience in the industry before building their own infrastructures. Learning would be particularly important when the entrant is asymmetrically uninformed about the demand and/or when experience improves efficiency. The latter is prominent when adopting a new technology is very expensive without a prior experience. We have argued that when the adoption cost is sufficiently high, the incumbent may not unbundle its loops; a learning effect of this type would give even stronger incentives to the incumbent to refuse unbundling its local loops.

Number of Potential Entrants We have based our discussions on the assumption of a single potential entrant. However, number of entrants may play an important role in particular when firms decide when to build their own facilities. This is because the profitability of building infrastructure depends on the number of other new operators that are intending to build their own infrastructure. In such a case, some operators may build their infrastructure preemptively, whereas some others may not find it profitable to build their own infrastructure (and may instead rely on the ILEC's infrastructure for competition).

These factors do not change the essence of our policy conclusion, that an effective threat of facility-based competition would give the ILECs an incentive to offer too attractive terms of unbundled access to their loops. The observation that most ILECs are currently unwilling to unbundle their loops (or charge too high price for it) does not imply that there are no prospects for facility-based competition. Since the ILECs do not determine their unbundling strategies at once and for all times, it appears that the ILECs do not expect an immediate facility-based entry.

We have argued that the rental price of the unbundled loop affects the entrants' incentives to build their own facilities, and, hence, its regulation is necessary. However, regulators may also employ direct policies that promote facility-based entry (e.g., lower licence fees for WLL). This would, in turn, influence the unbundling strategy of the ILECs. For example, an ILEC that is reluctant to unbundle its loops may voluntarily open the access if policies to promote facility-based entry prove to be efficient. In this regard, the ILECs' attempt to justify their refusal to unbundle with the argument that they face a significant amount of facility-based competition is inconsistent.

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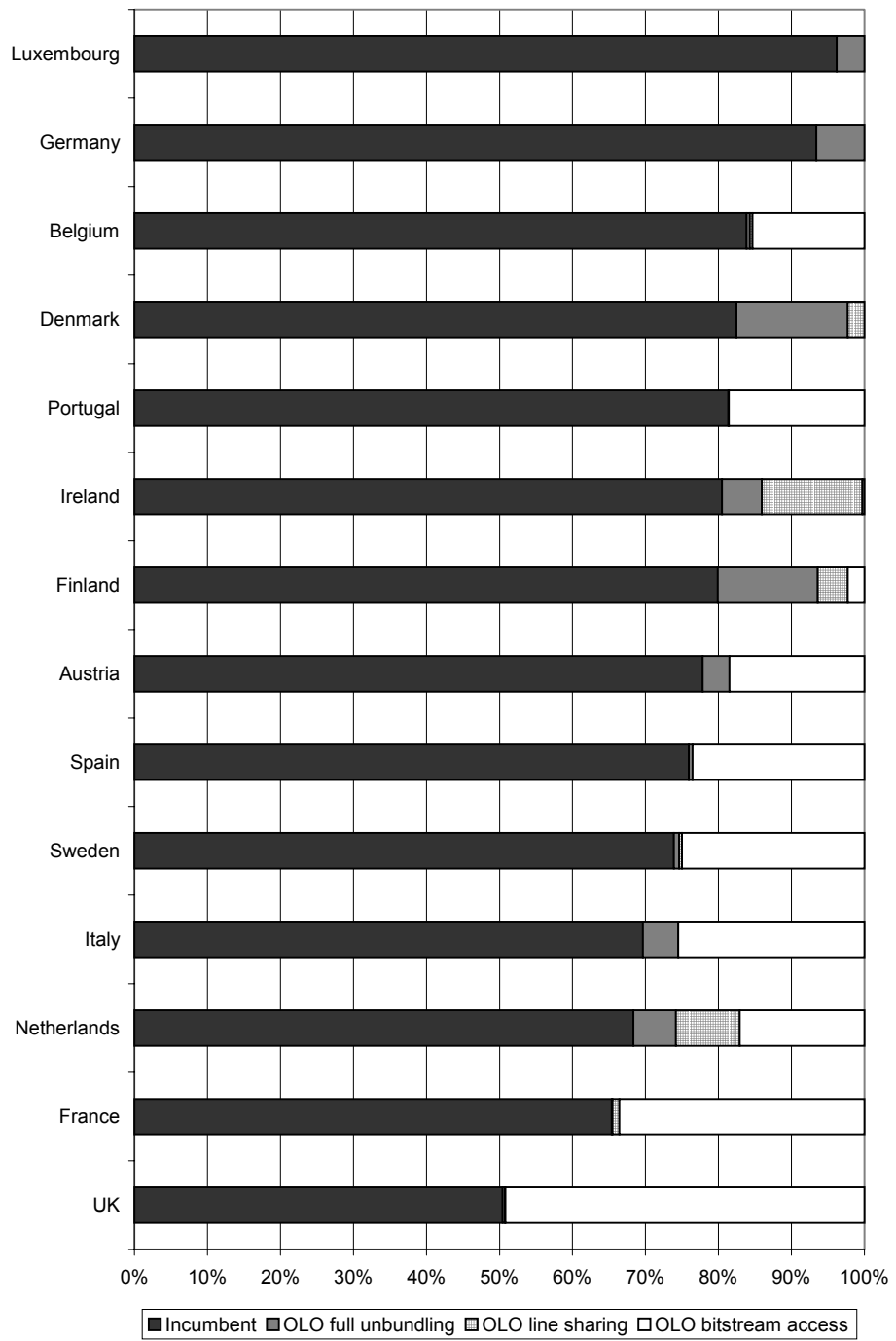


Figure 1: Service-based Competition in Europe

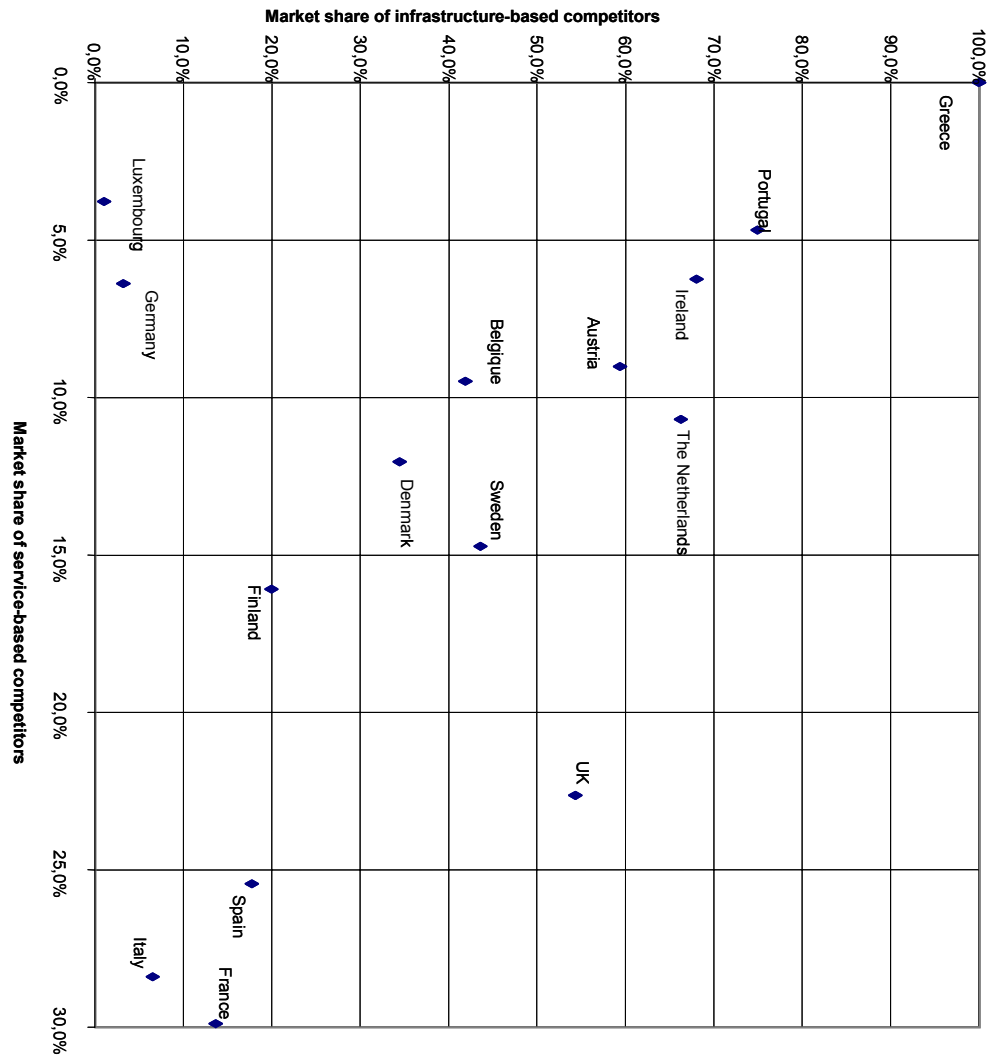


Figure 2: Service-based vs. infrastructure-based competition in Europe