An Economist's Guide to Local Loop Unbundling

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Abstract: This guide provides a critical review of the economics literature on the desirability and the effects of unbundling the local loop. Firstly, we discuss recent contributions, which aim to quantify the effect of unbundling regulations on the development of broadband services. Secondly, we review the literature on the potential impact of unbundling on investment and innovation incentives. Finally, we conclude this paper by offering some suggestions for further research.
Key words: Unbundling, broadband diffusion, investment and innovation

Unbundling of the local loop refers to a series of regulatory measures, aimed at providing access to the incumbent's local network. The most fundamental measure is raw copper or full unbundling. With full 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 broadband DSL [1] services). 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 and keeps the low frequency band for analogue telephony services. With bitstream access, the incumbent leases access to its high bandwidth architecture. Finally, with resale, the incumbent provides its broadband or telephony retail services to new entrants on a wholesale basis [2].

(*) We would like to thank Alain de FONTENAY for useful remarks.

1 DSL stands for Digital Subscriber Line. It refers to the technology used to provide broadband access on copper lines.

2 Note that all types of unbundling schemes are not available in all countries (see BAUER and de BIJL & PEITZ, in this issue, for more details).

Unbundling of the local loop aims to stimulate competition in the local loop. This has been its main goal, both in the U.S. (see, in this issue, the review of U.S. unbundling regulation by BAUER and in the European Union by de BIJL & PEITZ). Whereas the roll out of alternative local networks requires huge investments and takes time, unbundling allows new entrants to enter local markets and win market share more quickly. In some countries, unbundling was also viewed as a critical regulatory measure to ensure that new entrants could compete with incumbents in broadband services on a level playing field.

However, in policy debates, it has often been claimed that unbundling could undermine the investment and innovation incentives of both entrants and incumbents. Eventually, unbundling could be detrimental to competition, by retarding the roll out of competing infrastructures inefficiently.

A relatively broad body of theoretical and empirical literature has emerged on the desirability and the effects of unbundling the local loop, and in particular, its impact on the development of broadband services. In order to shed light on current policy debates, we believe it is useful to provide a review of this literature.

The rest of the paper is organized as follows. We begin by discussing the papers that analyze the effect of unbundling regulatory measures on the development of broadband services. We subsequently present some more theory-focused papers, which study the impact of unbundling on investment and innovation incentives. We conclude this paper by offering some suggestions for further research.

■ Broadband diffusion and unbundling

Broadband diffusion has given rise to a fairly extensive body of literature in recent years. Some of these papers focus on the characteristics of demand, while others seek to analyse the impact of regulation policies and supply conditions on broadband penetration. Recent papers tend to focus more specifically on the interactions between intra-platform and inter-platform competition.

Socio-cultural and demand factors

Demand factors are traditionally characterised by demographic data such as, for example, age, education levels, revenues and the percentage of urban residents. The first empirical studies centered on the adoption behaviour of residential users by focusing more specifically on demand for internet access. As a result, MADDEN, SAVAGE & SIMPSON (1996) [3], provide an econometric study that offers a precise analysis of the influence of these demographic factors on adoption decisions by broadband households in Australia. Their results notably establish the positive relationship existing between education levels and interest in broadband.

More recently, and in line with this research, RAPPOPORT, KRIDEL & TAYLOR (2002) completed the results provided by previous models by distinguishing between broadband and narrowband users. By using the model of discrete choices, they show that the revenues and size of households are demographical factors that better explain a choice in favour of broadband. To a lesser degree, demand for broadband is positively correlated to age. The results of this research are confirmed by a statistical study conducted by the U.S. Department of Commerce (2002).

A later study by KIM, BAUER & WILDMAN (2003) confirms the importance of the role played by education in broadband adoption behaviour and underlines the determining influence of the preparedness of populations to use advanced technologies, especially ICTs.

HOWELL (2002) goes even further with regard to the need to account for drivers of demand. He very clearly explains the close link that exists between application development and broadband growth. It follows that pursuing an active policy in terms of applications requiring broadband accelerates penetration rates. In other words, it is the demand generated by the emergence of new applications in markets that induces substitution behaviour by consumers and therefore strongly contributes to the spread of the new technology.

From this point of view, South Korea is an important example. Along the same lines, AIZU (2002) shows that social and cultural factors can sometimes have a much greater impact on the development of broadband than demand

[3] These were the first papers on this topic. Other papers followed such as, for example, EISNER & WALDON (1999), MADDEN, SAVAGE & COBLE-NEAL (1999) and MADDEN & SIMPSON (1997).

and traditional economic factors (like economic and population growth rates) by comparing South Korea, Hong Kong, Singapore and Japan. It is precisely these socio-cultural factors that make it possible to explain the amazing growth of broadband in South Korea versus Singapore and Japan. These factors had all the more impact due to the country's favourable political climate and the dynamism of its Ministry for Information and Communications (MIC).

Supply conditions and traditional regulation

Research by GABEL & KWAN (2000) completes these analyses of demand and socio-cultural factors by integrating the impact of supply conditions, and notably of cost factors. They support the standard results obtained in the context of models for demand and use and specify the key factors in supply that significantly influence broadband penetration. The most important supply-related factors that explain broadband penetration consequently include teledensity, which has a positive impact, and the cost of routing traffic towards backbones, which adversely effects penetration. In the case of competition in services, the prices of unbundled network elements (UNEs) represent costs for the competitors of incumbent local exchange carriers (ILECs). As these costs are very heavily influenced by regulation, their impact on broadband penetration depends on regulatory conditions.

PRIEGER (2003) identifies three main channels whereby public policies can influence broadband penetration. The first concerns the use of traditional direct tools for promoting growth in broadband infrastructures such as tax breaks and lending programs. The second channel involves direct regulation of broadband access prices [4]. Lastly, the regulator can influence broadband deployment via the regulation of basic services. PRIEGER (2003) is particularly interested in this third channel. He examines two forms of regulation: regulation by rate of return and regulation by price cap, and looks at how these regulatory conditions affect incentives to deploy DSL. The arbitrage is relatively simple. In fact, in the case of regulation by rate of return, the Aversh-Johnson effect applies to broadband infrastructure. In the case of price cap type regulation, the relatively low price of unbundling induced lowers the profitability of DSL. The effect of these regulations on DSL lowers incentives for operators of alternative technologies to offer

[4] See the year (2002) for an analysis of the effectiveness of public aid for the development of broadband in South Korea.

broadband access. The results of the model indicate that, in the case of price cap type regulation, the aggregate effects on broadband penetration are favourable on the whole. This type of regulation also reinforces the effect of unbundling on penetration [5].

CRANDALL, HAHN & TARDIFF (2002) also comment on the effects of regulation on broadband penetration. They notably insist on the negative effects produced by regulation on incentives for firms to invest in value-creating services for consumers.

In order to test the influence of public policies on broadband penetration, KIM, BAUER & WILDMAN (2003) constitute three groups of homogenous countries. These groups are composed according to their similarities in terms of unbundling and ownership policies and the separation of telephony and cable operators and of public policies promoting broadband. Their results show that the contribution made by demand and supply related factors to broadband penetration is very sensitive to the shape of public policies in individual countries.

Intra-platform and inter-platform competition

The unbundling of the local loop is a regulatory tool that was favoured in Europe and more widely in OECD countries. It consists of obliging the incumbent operator to provide access to its network infrastructures to competitors at prices and under conditions stipulated by the regulator. The growth of unbundling should therefore promote competition between services on the same platform.

HOWELL (2002) highlights empirical evidence based on a study of OECD countries. He shows that the strong orientation of these countries in favour of growth in unbundling has had relatively negligible effects on growth in DSL services compared to countries that have not chosen to implement such a policy.

ARON & BURNSTEIN (2003) look to estimate the impact of competition on broadband penetration in cases where a single platform is available, and then in cases where several platforms are available to consumers. Their results show that the presence of intra-platform competition has a negligible

[5] This latter result confirms the arguments of LEHMAN & WEISMAN (2000).

effect on penetration, regardless of the technology in question (DSL or cable). The presence of inter-platform competition, on the other hand, significantly influences broadband penetration [6]. These results place a particular onus on the effectiveness of a public policy that encourages competition through infrastructures and highlights the ineffectiveness of competition between infrastructures, thus underlining the inefficiency of discriminatory policies in terms of investment growth.

As far as intra-platform competition is concerned, HÖFFLER (2005) shows that the gain in market share by the incumbent's competitors, even if this is sometimes major, does not necessarily have the impact expected on penetration levels. In other words, if we adopt the market share of competing local exchange carriers (CLECs) as an indicator of intensity of competition, intra-platform competition in terms of unbundling does not systematically lead to very high broadband penetration rates. On the other hand, HÖFFLER (2005) shows that inter-platform competition, notably between DSL and cable, has a significant effect on broadband penetration rates. Lastly, a major contribution made by Höffler's research relates to the analysis of causality between broadband diffusion and inter-modal competition. In fact, should we assume that a high market share of cable implies a high broadband penetration level or, on the contrary, admit that high levels of penetration encourage cable operators to enter the broadband access market? The results of the model would seem to favour the first outcome. In terms of well-being, the gains from a higher penetration due to inter-platform competition do not compensate for the losses due to the duplication of infrastructure costs resulting from the upgrading of cable networks.

DISTASO, LUPI & MANENTI (2004) go futher in tracing the links between broadband penetration and competition between platforms. They construct a theoretical model that establishes a positive link between the stimulating effect of a reduction in the price of unbundled elements and the intensity of competition between platforms on penetration levels. This theoretical result of complementarity between intra-platform and inter-platform competition is confirmed by an econometric analysis, provided that the types of access offered by the two platforms are sufficiently differentiated and/or that the degree of relative concentration on the two platforms is not too high.

[6] Remark that two competing infrastructures might share some facilities. For instance, in some countries (e.g., France or the US), cable and telephone networks share some conduits or poles.

■ The effects of unbundling on entry and investment and innovation incentives

How unbundling affects entry decisions

Unbundling of the local loop affects entry decisions in two different ways. Firstly, the terms and conditions of unbundling contracts influence entry decisions, i.e., whether or not to enter, and, hence, the number of new entrants. Secondly, unbundling affects entry strategies, and in particular, whether entrants enter the market by building alternative access networks (infrastructure-based entry) or by leasing loops (service-based entry).

Unbundling affects the number of entrants

Firstly, by giving access to the incumbent's local loop, unbundling allows potential entrants to provide high bandwidth services. Moreover, the *terms* of unbundling contracts affect the post-entry profits of entrants. The more favourable the terms of entry, the higher the expected profits and, hence, the higher the entry rate. In terms of social welfare, there is a trade off between the benefits of an additional entrant (increased competition and/or variety) and the costs (duplication of fixed entry costs).

Box 1 - Unbundling may stimulate entry

Let us assume that there is a large number of potential entrants. Entry is only possible by leasing lines from the incumbent, and the unbundling tariff is composed of a price *r* per leased line and a fixed fee *f* for co-location, command handling, etc. New entrants are symmetric. If *n* entrants enter, each entrant makes a profit of $\pi(n,r)$; a potential entrant makes zero profit if it stays outside of the market. We assume that profit decreases with the number of entrants ($\partial\pi/\partial n<0$) and with the rental price ($\partial\pi/\partial r<0$). We also assume that, in addition to the fixed cost *f* associated with unbundling, there is a fixed cost *F* of entry.

In this setting, assuming unrestricted entry, there is entry as long as an entrant expects positive profit from entry. Therefore, the number of entrants at the equilibrium, *n**, is the maximum *n* such that

$$\pi(n,r)\geq f+F.$$

Given our assumptions regarding π, it is straightforward that: *the more favourable the terms of unbundling, i.e. the lower the rental rate r and/or the fixed cost of unbundling f, the greater the number of entrants at the equilibrium, n** (note that this simple rule does not give the socially optimal number of entrants).

Unbundling affects entry strategies

When the entrant uses the incumbent's facilities, competition is *service-based* and can be realized either through resale or through unbundling schemes. When the entrant builds its own access network, competition is *facility-based*.

Facility-based competition is perceived as a necessary condition for long-term efficiency (see BOURREAU & DOĞAN, 2001). This is because the benefits of flexibility and innovation obtainable under facility-based competition far exceed those achievable under service-based competition. Under service-based competition, the entrants rely on the incumbents' network for providing services, and hence, are restricted by the incumbents' choices of price, service and technologies. WOROCH (2002) points to this as a limitation of service-based competition and argues that service-based competition is, at best, a stepping stone to facility-based competition in the long run.

Service - and infrastructure - based entry can be viewed as *complimentary* means of entry (CHRISTODOULOU & VLAHOS, 2001). In particular, this is true when there is some uncertainty over demand, technologies or competition and/or when experience improves efficiency. De BIJL & PEITZ (2004) propose a model of network competition with two way access, *à la* Armstrong-Laffont-Rey-Tirole. An entrant and an incumbent compete during T periods with 2-part tariffs. Network operators are supposed to be myopic, that is, they maximize flow profits at each period. The dynamics of the model come from the fact that the entrant's quality increases over time, up to the point at which it reaches the incumbent's level (the incumbent's quality is fixed). Using numerical methods, the authors show that a cost-based lease price is best for consumer surplus, but that it may reduce the entrant's incentives to build an alternative infrastructure. However, since a low (i.e., cost-based) price for leased lines allows the entrant to build market share and reputation gradually, incentives to invest in its own infrastructure may increase over time.

Other authors argue that service- and infrastructure-based entry are *substitute* means of entry. For instance, CRANDALL, INGRAHAM & SINGER (2002) claim that mandatory unbundling encourages entrants to delay facilities-based investment. Using a statistical analysis, they show that a one per cent increase in the price of unbundled network elements relative to the price of building a line from scratch will lead to a 1.23 per cent increase in the ratio of leased to build lines.

BOURREAU & DOĞAN (2003, 2004) also provide some empirical evidence of the substitutability between service-based and infrastructure-entry in the broadband and long distance telephony markets.

Box 2 - Service- versus infrastructure-based entry

Let us assume that there is an incumbent and a potential entrant. The entrant is outside the market at the beginning of the game, but can enter the market, either by building its own infrastructure, or by leasing lines from the incumbent. The entrant gets a gross profit of π^F and incurs a fixed cost *F* if it builds its own network (infrastructure-based competition). If it leases lines from the incumbent (service-based competition), it pays a fixed fee *f* and makes a gross profit of $\pi^S(r)$, where *r* denotes the rental price of a line. We assume that $\pi^S(r)$ is decreasing in *r*. In this setting, the entrant prefers infrastructure-based entry to service-based entry if:

$$\pi^F - F \geq \pi^S(r) - f.$$

Given our assumption regarding π^S, it is straightforward that: *the more favourable the terms of unbundling, i.e. the lower r and/or f, the lower the incentives of the entrant to build its own infrastructure, rather than leasing the incumbent's facilities.*

Therefore, the terms of unbundling affect the choice of the entrant between infrastructure and service-based entry.

How unbundling affects investment and innovation decisions

The terms and conditions of unbundling of the local loop shape market competition and, hence, alter industry profits. This is because when the incumbent's facilities are subject to local loop unbundling, a higher rental price inflates the entrant's perceived costs, and reduces the intensity of competition (see BOURREAU & DOĞAN, 2005; de BJIL & PEITZ, 2004). Since unbundling affects industry profits, it also alters the investment and innovation incentives of both entrants and incumbents.

Unbundling affects the investment and adoption decisions of the entrants

Many policy studies discuss the possible effects of unbundling on building alternative technologies [7]. For instance, JORDE, SIDAK & TEECE (2000) argue that mandatory unbundling distorts the investment incentives of

[7] See SIDAK & SPULBER (1998), KAHN *et. al* (1999), and DUMONT (1999).

new entrants. In particular, they claim that unbundling delays facilities-based entry, because there are benefits to waiting, such as the reduced costs of technologies, new information regarding demand, technologies or competition, etc.

BOURREAU & DOĞAN (2002, 2005) provide a formal framework to study unbundling of the local loop, which can delay infrastructure-based competition. They show that, insofar as service-based and facility-based entry are substitute strategies for entrants, policies designed to support each one of them may prove conflictual. In a dynamic setting, an incumbent and an entrant compete to provide high-bandwidth services. While the incumbent uses its existing 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. The authors assume that the cost of adopting the new technology declines over time. They show that an incumbent facing the effective threat of facility-based competition can strategically delay facility-based entry by providing attractive terms of access to its facilities. The delay introduced is by virtue of a replacement effect, which may also affect the choice of technology to be eventually built by the entrant.

BOURREAU & DOĞAN (2005) show that when the rental price remains constant over time, the rental price determined by the incumbent in an unregulated environment, is sub-optimally low 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 not unbundling its loops.

BOURREAU & DOĞAN (2002) show that when the rental price can vary over time, the rental price set by the incumbent decreases over time, as the new technology becomes cheaper to adopt. The rental price should continue to decrease until the time when the entrant finds it optimal to adopt the new technology, regardless of how low the rental price is. Similar to the setting with a fixed rental price, unbundling with a time-dependent unregulated rental path may sub-optimally delay technology adoption.

Apart from delaying infrastructure-based entry, unbundling of the local loop can also distort technological choices. JORDE, SIDAK & TEECE (2000) claim that with unbundling, the incentives to develop telephony services by innovative means (for instance, telephony over DSL) are reduced.

BOURREAU & DOĞAN (2005) show that the type (quality) of technology to be adopted may also suffer distortion.

Finally, decisions to invest in a particular geographic area can be affected by the availability and conditions of unbundling schemes. In particular, when the unbundling rates are averaged, the incentives for an entrant to build its own infrastructure are higher in urban (low cost) areas than in rural (high cost) areas (see JORDE, SIDAK &TEECE, 2000, for a discussion).

Box 3 - Unbundling may delay infrastructure-based entry

Let us consider the same setting as in box 2, but in a dynamic framework. The entrant can either lease lines from the incumbent at the beginning of time or build its own infrastructure at a date *t*; the entrant can also lease lines until date *t*, and then build its own infrastructure. The fixed cost of an access network is $F(t)$ and we denote δ is the discount rate. We assume that $F(t)$ decreases over time *t* and that $-F'(t)/e^{-\delta t}$ decreases in *t* (this setting corresponds to that used in Bourreau and Doğan, 2005).

Assuming that unbundling is a viable option for the entrant, if it leases lines until date *T*, and then installs its own infrastructure at date *T*, its discounted profit is:

$$\Pi(T) = \int_0^T e^{-\delta t}\pi^S(r)dt + \int_T^\infty e^{-\delta t}\pi^F dt - F(T) - f\,.$$

The entrant chooses *T* so as to maximize its discounted profit, $\Pi(T)$. Writing the first-order condition for profit maximization with respect to *T* gives the following condition:

$$\frac{-F'(T)}{e^{-\delta T}} = \pi^F - \pi^S(r)\,.$$

Given our assumptions, the lower the rental rate, *r*, the higher the date at which the entrant installs its own infrastructure. That is, *the incumbent can retard infrastructure-based competition by providing attractive terms for access to its lines*.

Starting from this point, Bourreau and Doğan (2005) show that insofar as the incumbent prefers service-based competition to infrastructure-based competition, it faces the following trade off: a low rental rate retards infrastructure-based competition, whereas a high rental rate increases profits under service-based competition.

Unbundling affects the investment and innovation decisions of the incumbent

Unbundling can affect the incentives of the incumbent to maintain and/or upgrade its facilities or to invest in new access technologies.

Maintenance of existing facilities

JORDE, SIDAK & TEECE (2000) argue that mandatory unbundling decreases the incumbent's incentives to upgrade and maintain its existing network. Indeed, unbundling reduces the ex ante expected profits of the incumbent, because the incumbent cannot appropriate the excess return due to increased efficiency and, cannot gain any cost advantage over entrants, as entrants have access to the efficiency gains of the incumbent.

However, BOURREAU & DOĞAN (2005) show that the incentives of the incumbents to upgrade their loops depend on unbundling requirements. This is because the upgrade improves the quality of service that can be provided via 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 when it builds its own facility, and, hence, expects a lower profit flow in the phase of facility-based competition.

Innovation

JORDE, SIDAK & TEECE (2000) argue that mandatory unbundling reduces the incentives to invest in new and risky technologies. If innovation is successful, the entrant is given access at a cost-oriented price through unbundling regulations. If innovation fails, the incumbent bears the cost, not the entrant. Hence, ex ante, the incumbent's investment incentives are reduced compared to a situation without mandatory unbundling, to the extent that regulation does not internalize the costs of failed innovative efforts. One implication of this argument is that unbundling distorts the investment decisions of the incumbent regarding technologies that are less susceptible to mandatory unbundling.

■ Concluding remarks

This article provides an overview of the empirical and theoretical literature on unbundling. It focuses on the impact of unbundling on broadband penetration, as well as on the entry, investment and innovation decisions taken by the incumbent and new entrants.

As far as the impact of unbundling on broadband penetration is concerned, the literature, which is mainly empirical, indicates how unbundling, as well as the price of unbundled network elements, affects broadband penetration. However, it would seem that supply and demand factors also have a considerable effect on penetration levels. The most recent studies qualify the effectiveness of policies promoting inter-platform competition over the effectiveness of intra-platform competition from a penetration point of view.

The literature that centres on the impact of unbundling on entry and investment decisions is of a more theoretical nature. It notably tries to assess the efficiency of competition between infrastructures and services respectively. This literature points to how the various arbitrages made by firms, incumbents and entrants are affected by the form of competition in the local loop. In general terms, the results obtained are relatively close to those of traditional literature in terms of innovation and R&D. They notably emphasise the importance of substitution effects on the technological choices made by companies.

Despite the fact that this literature is relatively extensive, several questions still remain: how will unbundling affect competition in the end market? How should strategies of bundled service offerings be analysed in this perspective? What should we make of the role of public initiatives in terms of broadband? What is/are the role(s) to be played by regulation in unbundling when different levels of access are offered? De BIJL & PEITZ (2005) offer a certain number of answers to the first two questions. As far as the role of public initiatives and the regulation of various levels of unbundling are concerned, we shall proceed by raising a few points that merit further consideration and by suggesting areas of research that seem particularly interesting.

Public initiatives and broadband

Experiences and empirical analyses (GILLETT, LEHR ET OSORIO, 2003) show that the involvement of local government in the development policies of broadband has seen major growth in recent years. The desire of local authorities to become major players in the development of broadband access can largely be attributed to the expected effects on local economic development and the improvement in users' quality of life.

Moreover, public initiatives on a local level undoubtedly play a major role in the evolution of access infrastructures insofar as they influence key growth factors in various ways. Local policies influencing broadband penetration can be divided into four categories. Firstly, local government can accelerate the growth of broadband by acting as a major consumer on the demand side. It also wields the political power to change the local legislative framework and can act as a financial backer by awarding aid and subsidies. Lastly, local government can act on the supply side by investing directly in infrastructures. Such public intervention is nevertheless not neutral from the point of view of the conditions of competition in end markets, insofar as the conciliation of public objectives and private initiatives often result in complex arbitrages.

This raises a certain number of questions regarding the effects of public intervention on private initiatives and on the growth of broadband. An important question is related to the effect of a public investment on the power of the local market. On the other hand, it is interesting to measure the impact of public investments on private incentives to provide broadband access infrastructures. In particular, are collective efforts to provide broadband substitutable for, or complementary to, private initiatives? How do decisions by authorities regarding the choice of offering end services or focusing their efforts on the wholesale service offering affect private incentives?

Once the problem of the effect of public investment on private behaviour is raised, this merits closer examination of how such an investment is financed. From this point of view, it is worth highlighting at least two aspects of the question. The first concerns the way in which the type of financing has a lasting effect on competition in the end market. The second aspect involves the strategic interactions arising from the choice of a mode of financing in the framework of competition between local authorities. This analysis should lead to regulatory political orientations, which should make it possible to better co-ordinate local intervention policies in these markets. More generally, it is a question of analysing the impact of public intervention on a competitive market. As far as this is concerned, the literature on mixed oligopolies (CREMER, MARCHAND & THISSE, 1989; De FRAJA & DELBONO, 1990; SAPPINGTON & SIDAK, 2003) offers an insight into the main consequences of such intervention on market mechanisms [8].

[8] We would initially expect public firms to adopt less anti-competitive behaviour than a private firm insofar as its objective should not be to maximise profit. However, some theoretical

Regulation of different levels of unbundling

The modelling proposed by BOURREAU & DOĞAN (2002, 2005) or by BIJL & PEITZ (2005) of the arbitrage between competition between services and competition between infrastructures is based on an "all or nothing" type of choice for the entrant: either it invests heavily and it is completely independent from the incumbent, or it invests little (or not at all) and then has to rely completely on the existing infrastructure.

In reality, this "build or buy" type of choice offers a far wider range of possibilities. For broadband networks, the full unbundling, bitstream access and resale options imply decreasing levels of investment and differentiation possibilities for entrants. A new entrant can choose between these options almost at the level of each local area.

The transition from a discrete choice (to build or to lease) to a choice from a menu of access offerings at various levels of the incumbent's network has major implications. Firstly, the players' strategies are more complex when there is a range of access offerings, instead of just a single access offering. Secondly, major questions in terms of competition and regulation are raised: how many levels of access are necessary? As the various levels of access are interdependent, how can they be optimally regulated to avoid squeeze effects? What is the impact of an intermediary market (whereby some entrants having chosen, say, full unbundling access, lease their broadband network to other operators that have chosen bitstream or resale types of access) on competition?

To our knowledge, there is no model that accounts for this type of situation. A special case is the partial licensing model of BOURREAU & DOĞAN (2004). The authors study the conditions whereby an incumbent company with a product innovation provides a partial licence to an entrant competitor in the end market. The product is supposedly "modular", namely it is composed of a fixed set of interoperable modules. The incumbent can thus choose the proportion of modules that it wishes to licence to the entrant. Competition is characterised by the degree of differentiation between products, which depends on the proportion of modules that the incumbent and the entrant have in common. As a result, by selecting the level of access to its product, namely the "size" of the licence, the innovator determines the intensity of competition in the market. The authors show that

research explains why, in some cases, public firms can be more aggressive than their private sector counterparts.

the size of the licence increases when i) the development cost of the entrant to finish its product increases and when ii) the marginal effect of the size of the licence on differentiation decreases.

This framework makes it possible to analyse a situation whereby a large degree of flexibility exists in the choice of access level. On the other hand, the authors do not include the possibility of several levels of access, the regulation of various types of access or the resale possibilities between access levels in their model.

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