Chapter 4

Broadband Internet access in developing countries: Universal service provision and pricing schemes

Carlos Gutiérrez Hita[1], Juana Aznar Márquez
Economic and Financial Studies Dept., Universitas Miguel Hernández, Spain
Universitat Oberta de Catalunya, Spain
cgutierrez@umh.es cgutierezhi@uoc.edu
juana.aznar@umh.es juana.aznar@uoc.edu

Abstract

Income inequality and the existence of rural areas where access is difficult may mean that the entire population does not have access to a network facility. The reasons are the existence of large sunk costs and low service affordability. The former strongly depends on geography and historical circumstances. The latter is also positively correlated with GDP per capita. We present a model in which consumers' capacity to access broadband Internet facilities is negatively correlated with the price charged by the network owner per consumption capacity unit. We motivate the model by analyzing the South America telecommunication market. In the reference scenario, a natural monopoly operates in both the network and the service provision market. In the liberalized scenario, we assume duopolistic competition in the service provision market between the network owner and a potential entrant firm. We find that network capacity may be maximal depending on the regulation scheme. Accordingly, there is a trade-off between network capacity and retail prices. Moreover, the liberalized structure does not necessarily enhance consumer surplus. Furthermore, competition in the service provision market may reduce social welfare, either due to excessive differentiation or due to a low network capacity.

Keywords: telecommunications markets, universal provision, pricing schemes, developing countries

Introduction

In developing countries, the stylized fact is the existence of high income inequality jointly with a low GDP per capita. Moreover, it is well know that in rural areas it is difficult to access a network facility. It yields low service affordability which, combined with large sunk investment costs (necessary to provide broadband Internet access on the part of the service provider), leads to lack of broadband Internet access for the entire population as has been pointed out by international institutions such as the United Nations (2009) and ECLAC (2009).[2] Firms try to pass on these investment costs to consumers in order to recover part of them. The main reason for which telecommunications are often regulated by the state relates to the special characteristics of the supply and demand structures and overall market organization. Historically, service provision has been undertaken by a natural monopolist who is also the network operator. In this case, the role of regulation has been to ensure that the monopolist behaves in accordance with the public interest, avoiding possible abuses of monopoly power. The main economic argument for this kind of market structure is that a single operator would be able to provide services at lower rates and with a wider coverage than a market served by a number of smaller scale competitive operators. In fact, a single operator is in a better position to dimension and plan the construction of a network (technical efficiency) and to avoid unnecessary investments and excess capacity. Thereby, economies of scale can better ensure compatibility of all parts of the network, and technical and administrative costs related to network integration and interconnection can be minimized.

However, this institutional setup has proved to be rather inefficient in accommodating sharp demand increases. Moreover, the requirements for broadband Internet access and the desirability of universal service provision of this facility jointly with the traditional voice telephone service have collapsed the old telecommunications structures in

---

[2] The telecommunications sector is capital-intensive, characterized by large sunk investments necessary to set up a network.

almost all developing countries. Free and open competition benefits individual consumers by ensuring lower prices, and offering new and better products and services in comparison with monopoly conditions. In order to achieve the benefits of competition described above, governments and regulators must establish an appropriate regulatory framework for the telecommunications sector. In this sector, achieving perfect competition is difficult if not impossible because in most areas there is typically only one network supplier. Therefore, it may be very difficult for new suppliers to enter into the market due to larger investment (sunk) costs and institutional or technical barriers to entry. The latter may include economies of scale and economies of scope. Furthermore, economies of vertical integration beyond the network are usually large in telecommunication markets. Then, in many cases new operators provide final services accessing the local loop of the incumbent's network. This is the case addressed in the literature on one-way access.[3]

Internet has been adopted all over the world at an amazing speed. Using the International Communication Union´s data for Latin America and the Caribbean,[4] we can see that internet users were close to zero in 1990 but in 2007 they represented 25,7 percent of the total population. In fact, this quite recent innovation is now a part of daily life, at least in urban areas in developed countries. Latin America has joined the Internet revolution later than most developed areas. However, we can find a positive aspect in the delayed introduction to the Internet revolution: Latin America can take advantage of already existing innovations and with lower costs.

Latin America's innovation and productive structures are not dynamic and its human capital is insufficient.[5] Information and communication technologies (ICT, hereafter) represent the way to foster productivity and create opportunities for sustainable economic growth and employment. ICT reduce transaction costs, speed information

---

[3] For a detailed review of one- and two-way access and the pricing rules used in telecommunications markets see Vogelsang (2003).
[4] More information is available at http://www.itu.int/ITU-D/ict/mdg (19/12/2009).
[5] See, for example, Jorgenson (2007).

flows and they allow for higher technology diffusion and human capital development. ICT can also improve public services and promote more responsible and efficient governments. The ICT4D concept (ICT for development) supported by the United Nations and other international development partners appear as a useful platform for development, but for doing that the role of investment is essential. In fact, the greater the willingness to invest the larger will be the response to new technology and the greater will be the adoption of the Internet.[6]

Moreover, public institutions play an important role in innovation by means of design and the implementation of policies at national or regional level, in particular in rural and remote areas. To achieve the goal of access for all, telecommunication infrastructure must be expanded and public support is required for telecommunication companies to promote investment in rural and remote areas. Thanks to joint actions, ITC can reach those groups that otherwise would remain marginalized or excluded from the information and knowledge society.

In the telecommunications industry, a consumer's connection to the network depends on the network owner's decision to provide the service in a given region (location). Moreover, the capacity of the available network determines the customer's capacity to access telecommunication services. Usually, incumbent operator (network owner) can provide Internet access by narrow band (by dial-up telephone connection) or by broadband band through a DSL (Digital Subscriber Line) technology. In the latter, the network owner may decide the capacity available at each price. Depending on the cost of different connection alternatives, users may subscribe to a superior Internet connection enhancing Internet access speed. This means they can access the Internet services (perform searches, download pages, upload files, etc.) they desire within the time they have available to spend online. The physical wire connection between a

---

[6] The willingness to invest is affected by many factors, among others, income level, infrastructure levels, access to credit, educational level and economic openness.

customer and the company is known as a local loop, and it is owned by the incumbent local exchange firm. Accessing the local loop requires a regulatory process known as local loop unbundling. It allows multiple telecommunications operators to use connections from a telephone exchange's central office to serve customers.[7]

In this paper we set up a model with a unique network owned by an incumbent operator. The network capacity is determined by an access price fixed by the network owner which determines the consumer's consumption capacity (the network capacity) along the service characteristics space. A central feature of our analysis is the fact that the network provision market is less competitive than the service provision one due to the institutional history and the size of sunk costs necessary to set up the network infrastructure. Once network capacity is determined, the incumbent and an entrant firm engage in the provision of the final service. Consumer heterogeneity captures consumers' differing degrees of affordability to join the service. Finally, we allow for the entrant's connection fee to be determined by either the regulator or the network owner. In this environment, we study, i) the relation between service competition, network access pricing, and the level of connection fee when endogenous network capacity is assumed, ii) the efficiency of the resulting market depending on the overall capacities and market split among the providers of the final service, and iii) the degree of differentiation between service providers in comparison to the socially optimal one.

The literature on markets served by a network has paid special attention to suppliers' ability to apply nonlinear pricing schemes. Trillas and Calzada (2005) revise regulatory pricing schemes by country in the case of both one-way and two-way interconnection. They found that many countries experience legal and institutional barriers to apply regulatory recommendations made by theorists, in particular the cost-based approach and its efficiency. Concerning the literature on one-way access, De Bijl and Peitz

---

[7] The general Agreements on Trade in Services (GATS) within the framework of WTO telecommunications law require unbundling of the local loop to give access to new entrants (section 5ª of the GATS Annex on Telecommunications). See http://www.wto.org/english/tratop_e/serv_e/telecom_e/telecom_e.htm for more information (28/09/2009).

(2006) have explored the nature of local loop unbundling when there is full consumer participation; that is, when total demand is perfectly inelastic with respect to retail price changes. In the same paper, they also analyze partial consumer participation. They found that, with full participation, unbundling requirements are neutral to competition: they do not affect the entrant's profit and market share. Indeed, this is a generalization of early results reported in De Bijl and Peitz (2002) studying a number of issues related to one-way and two-way interconnection problems in-depth, in the context of an asymmetric oligopoly and with a number of regulatory mechanisms and competition rules. In their paper they also found that access regulation is typically appropriate in the early stages of competition, when entrants have not yet installed alternative infrastructures. We use here the main elements of their basic one-way model to study the capacity interconnection regime and the non-linear tariff schemes that arise. Previous studies on one-way access have focused on the optimal second-best pricing (Ramsey pricing) in a context of homogeneous and differentiated services with a competitive fringe. The literature has also considered access price rules for given retail prices, paying special attention to the efficient component pricing rule (ECPR). Both strands are thoroughly analyzed in Armstrong (2002), discussing the interaction between competition and regulation in telecommunications markets. He shows that because of the incumbent's monopoly position in the access market, monopolists often set access charges too high.[8] Finally, Laffont and Tirole (1994) have analyzed Ramsey prices and other pricing formulas to find optimal regulation.

The remaining part of this paper is structured as follows. Next section provides the motivation for this study by providing a useful descriptive analysis of the situation in South America. After it, the natural monopoly model is developed and solved whereas in the subsequent section the model is extended by solving different scenarios concerning industry configuration. It follows a discussion of the main results and

---

[8] For a broad discussion see also Laffont and Tirole (2000) and Vogelsang (2003).

welfare implications of the cases studied. Last section presents conclusions and gives policy implications.

Motivation and descriptive analysis

In this section we highlight the current situation in the South America telecoms market and we provide some statistical evidence to motivate the theoretical model.[9] In general, the telecoms market has experimented huge growth in the last decade in South America region. However, there are some important differences between countries due to different stages of development. In particular, GDP per capita, the existence of isolated rural areas and the grade of liberalization and regulation yield different environments depending on the country considered as we show in the following paragraphs.

Chile is often portrayed as a role model by the international business community for its adoption of progressive social policies together with a competitive free market approach. In fact, Chile has a liberalised fixed-line market with several operators providing fixed telephony in competition with the incumbent *Telefónica Chile*. In the broadband sector, Chile's Internet and broadband penetration rates are the highest in South America. As in Chile, Argentina's telecom market is one of the most advanced in Latin America. Two regional incumbents, *Telefónica de Argentina* and *Telecom Argentina*, dominate the local fixed line market. Concerning the broadband market, it is divided fairly equally between three players: *Telefónica de Argentina*, *Telecom Argentina*, and *Grupo Clarín.* Competition has driven prices down so that broadband is cheaper in Argentina than in other Latin American countries.

Brazil is one of the key emerging markets, with a telecom sector that has been fully liberalised. The incumbents in the fixed-line market are still the infrastructure leaders but they are losing market share at a slow rate in benefit of the smaller operators.

---

[9] This market includes the countries of Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela.

Meanwhile, broadband uptake has been stifled by high prices and weak competition. In this wave of emerging markets, Venezuela is a country with high telecom growth potential. State-owned CANTV has been undertaking social programs for disadvantaged groups in the population. As in Brazil case, Venezuela's broadband penetration is lower than the Latin American average. CANTV dominates the market with its ADSL service and lack of competition has made ADSL quite expensive compared with neighbouring countries, and the speed is slow.

Uruguay's local fixed line market has achieved the second highest teledensity in Latin America after Costa Rica. Moreover, mobile telephony and broadband internet access have been the fastest growing telecom sectors. Uruguay is one of the few countries in the world where broadband access via cable modem is forbidden. In the case of Peru, the government promotes digital possibilities through FITEL, a fund that finances rural operators under the rule of less-bid subsidy. The local telephony market is still dominated by the incumbent *Telefónica del Perú*. Internet user penetration is remarkably high compared with Peru's other economic indicators. The success of the Internet in Peru is primarily due to the mushrooming of cheap public Internet facilities known as *cabinas públicas*. In fact, Peru is a world leader in terms of users who access the Internet in public places.

Colombia has around 30 local telephone providers, partly private and partly owned by the municipalities where they operate. The incumbent, *Colombia Telecom*, has been taken over by *Telefónica* and renamed *Telefónica Telecom*. The basic telephony market is stagnant, and broadband penetration is only slightly below average for Latin America and it has been growing at an impressive rate. In the same way, Ecuador's fixed-line penetration is considerably behind other Latin American countries, but the new incumbent CNT, created from the merger of state-owned *Andinatel* and *Pacifictel*, has ambitious plans to raise it from 14 percent in 2008 to 19 percent in 2010. CNT also plans to boost the country's low broadband penetration by increasing coverage and

reducing prices. The main broadband technology is cable modem, but ADSL is on the rise.

Paraguay has experimented problems with the development of telecoms markets. In fact, Paraguay is one of the poorest and least developed Latin American nations. This scenario derives in a poorly developed telecom system. Despite repeated attempts at privatisation and liberalisation, the fixed-line sector remains a state-owned monopoly until 2009. In March 2009, the wholesale Internet market was liberalised, and *Copaco* lost its monopoly over the international backbone for Internet connectivity. Finally, Bolivia's fixed-line market is open to competition, with several cooperatives and private companies offering local and long-distance telephony services. ADSL technology is available in Bolivia although the broadband market is still embryonic.

Descriptive analysis

We show here some variables to motivate the theoretical model. First, we use some dummies in order to approximate the retail and access prices that a customer must pay to access Internet facilities. In our model, we suppose that a given customer may access Internet facilities by either a fixed telephone dial-up (narrow band) or broadband line. In the first case, he pays the retail price r whereas $r + p$ is paid in the case of broadband access. Broadband access is offered by a local loop which is traditionally owned by the network fixed line operator. Then, in the case of liberalization of the service provision it is unbundled in order to give access to entrant firms. We use 2006 data of monthly telephone subscriptions as a dummy for r and telephone connection fees as a dummy for p,

$$r \approx f(monthly\_telephone\_subscription)$$
$$p \approx f(telephone\_connection\_fee)$$

Moreover, we use the ratio of rural population over urban population as dummy of the cost t that a customer experiments to access telephone fixed lines and broadband lines.[10] Then,

$$t \approx f(\frac{rural\_pop}{urban\_pop})$$

Finally, as the maximum global price R that a customer is willing to pay for the service we use the *GDP per capita* (2006). We also explicitly emphasise that individual preferences play an important role, unless they are unobservable,

$$R \approx f(GDP_{percapita}, preferences)$$

Table 4.1. Descriptive statistic analysis.

Country	GDP per cápita (R)*	rural/urban (t)	r*	p*
ARG-Argentina	5475,7	0,10	4,33	49,11
BOL-Bolivia	1224,2	0,54	18,72	37,44
BRA-Brazil	5665,7	0,17	12,34	24,14
CHL-Chile	8893,4	0,15	18,74	35,88
COL-Colombia	2931,5	0,33	3,12	31,31
ECU-Ecuador	3085,3	0,58	6	60
PRY-Paraguay	1472,0	0,70	3,90	146,39
PER-Peru	3286,1	0,34	17,10	120,44
URY-Uruguay	5537,9	0,06	9,19	45,69
VEN-Venezuela	6779,3	0,14	8,98	30,92

Data 2006. Source: UN, ITU and own construction. * Magnitudes in US$.

Table 4.1 above shows the GDP per capita of the ten South American countries as well as *R, r* and *p*.

Table 4.2 below shows the current situation in these countries concerning the telecom market. In the case that an historic firm (former natural monopoly) has significant market power it is an *incumbent*. The fringe is the number of firms that act as followers. In the case that a fringe is formed by a reduced number of firms we use *few*. When there is fair competition we use *large*.

---

[10] Notice that broadband access is usually offered to subscribers of fixed telephone lines as an extra service. This is the reason an extra access fee of *p* is paid.

Table 4.2. Service providers and liberalization, 2009.

Country	# service providers Fixed (dual-up)	# service providers DSL	Liberalized (yes/no)
ARG-Argentina	2	3	YES
BOL-Bolivia	large	large	YES
BRA-Brazil	Incumbent + fringe		YES
CHL-Chile	Incumbent+fringe	large	YES
COL-Colombia	Incumbent + fringe		YES
ECU-Ecuador	Monopoly		NO
PRY-Paraguay	Incumbent+few	Incumbent+fringe	YES (since 2009)
PER-Peru	Incumbent + fringe		YES
URY-Uruguay	Incumbent + few		YES (since 2001)
VEN-Venezuela	Incumbent + fringe		YES

Source: own construction.

Finally, we estimate the number of Internet users by mean of two regressions. First, we use the following macro variables: *GDP per capita* and the inverse of the ratio rural over urban population,

$$Internet\_users^i = \alpha + \beta_{GDP_{pc}} GDP^i{}_{pcapita} + \beta_{urb\_pop} urban\_pop^i + \varepsilon^i$$

We estimate the equation by OLS yielding,

Internet_users = - 103739 + 0,000015 GDP + 0,166 Urban_pop
                              (0.022)   (0.002)

with an adjusted R-Square of 99,5 percent. Second, we calculate the number of Internet users by means of the following micro variables: number of Internet subscribers who use dial-up connections (*ISUBS_dial_up*), and the number of Internet subscribers who use DSL connections (*ISUBS_DSL*),

$$Internet\_users^i = \alpha + \beta_{ISUBS\_dup} ISUBS^i{}_{dial-up} + \beta_{ISUBS\_DSL} ISUBS^i{}_{DSL} + \varepsilon^i$$

We estimate the equation by OLS yielding,

Internet_users = 425929 + 2,50 ISUBS_dial-up + 8,96 ISUBS_DSL
                              (0.012)   (0.003)

with adjusted R-Square of 99,1 percent.[11] In both regressions parameters are significant so Internet users are well approximated, at macro and micro levels.

In the next section we develop a model in which Internet is accessed by DSL. Moreover, we assume that dial-up service is offered to all customers, so in our model we are interested in the intensity (i.e, the network capacity) of the broadband connection.

The benchmark model: A natural monopoly

We consider a telecommunications market where a firm labelled *M* is the owner of the network infrastructure to provide telecommunications services (dial-up fixed telephony and broadband Internet access) to a fixed population of users. Consumers' affordability difference to join the services is represented by the spatial model of Hotelling (1929) where consumers are uniformly distributed along the unit interval with a constant density, D. Let D represent the broadband network capacity resulting from a consumer's installed capacity decision. We assume that D inversely depends on an access price *p* charged by the network owner, as implied by $D = 1 - p$. The resulting capacity available to customers is offered at a constant unit cost $k \in [0,1)$.

As a benchmark case, we consider that *M* is also the monopolist in the provision of the service to consumers, incurring a constant marginal cost c_M, so this firm is a vertically integrated network. We assume throughout the paper that service suppliers are obliged to provide universal service, although the network capacity is determined by consumer's affordability. The timing is as follows: after having charged a connection fee *p* for the capacity installed, *M* chooses the location (type of service, hereafter) at the second stage; then, at the third stage *M* sets a retail price r_M per unit of service consumed. When the model is extended to allow competition in the service provision

---

[11] In parenthesis p-values. Both regressions fitted at 95 percent confidence.

customers may connect to firm *E*, which pays an access fee to *M* in order to get access to the network. Figure 4.1 below describes these market structures.

Figure 4.1. Market structures: monopoly and liberalized service provision.
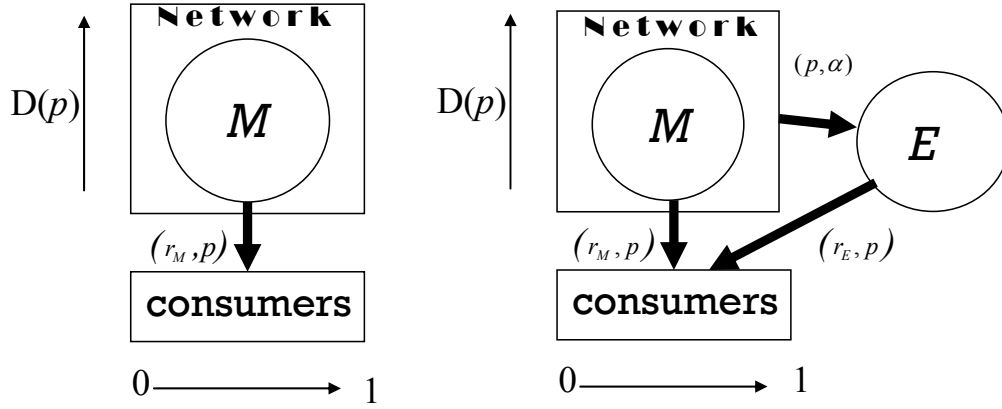
The intuition behind these types of structures is that a monopolist offer a basic telecom service as occurs in early stages of telecoms markets. In contrast to this, when the service is liberalized, an increase in consumer affordability is revealed with different consumer profiles.

The tariff structure is $T(p, r_M) = p + r_M$ where the first part determines the network capacity and the second extracts surplus from a fixed population of consumers. Given *p* and the resulting network capacity *D*, each consumer is assumed to have a unit demand for the service which yields her a utility of $U = \{R - p - r_M - t(l_M - x)^2\}$, where *R* is a reservation price for the service, l_M is the monopolist's type of service, *x* is the user's ideal service (given her affordability for it) on the interval [0,1] and $(l_M - x)^2$ is a term capturing the quadratic utility loss experienced by the user due to the distance between his ideal service and that actually provided to her by *M*.[12] Using the universal service provision assumption, the monopolist's profit is given by:

$$\pi_M = D \cdot [(p - k) + (r_M - c_M)] \tag{1}$$

---

[12] This is a special case of quasi-linear preferences with full customer participation. For a more general model see Bijl and Peitz (2005).

where the first part specifies the network mark-up and the second part the service mark-up. Then, the following holds:

Proposition 1 (Monopoly outcome): [13] *A network monopolist M operating under the restriction of universal service provision locates in the middle of the segment* $l_M^* = 1/2$ *charging an access price of* $p^* = 0$ *yielding maximal density* $D^* = 1$ *and a retail price for the provision of the service equal to* $r_M^* = R - t/4$.

Proposition 1 implies that unlike having induced maximal network density (setting the capacity access price equal to zero) a monopolist extracts the maximum possible surplus. Moreover, minimizing distance from the consumers located on the extremes of the [0,1] interval (which have the minimum service affordability). Substituting the equilibrium magnitudes presented in Proposition 1 into the monopolist's profit function (1) we get:

$$\pi_M^* = R - c_M - k - t/4.$$

Therefore, as expected, the monopolist's equilibrium profits positively depend on the consumer's maximal willingness to pay for the service, and negatively on the marginal costs as well as on service and transportation costs as measured by the coefficient *t*. Notice that cost parameters c_M and *k* have a greater impact on the monopolist's maximal profit than does the heterogeneity of consumers measured by *t*, because all demand is automatically captured by *M*.

The solution coincides with the implementation of the socially optimal monopoly location and access pricing scheme, as it maximizes the network capacity. However, this should not be the best solution for the consumer, given that the transfer of r_M from the consumer to the network monopolist is not taken into account. Given that there are

---

[13] All proposition proofs are available upon request.

infinite pricing schemes involving different levels of consumer surplus, all of which would lead to the same level of aggregate welfare, it should be a task undertaken by the regulator to split this aggregate welfare in a proper way to encourage consumer surplus. In fact, there is a trade-off between the monopolist's profitability and consumer surplus. More specifically, when $r_M{}^* = c_M + k$ the monopolist's profits are minimized with $\pi_M{}^* = 0$ and consumer surplus is maximal. This, then, implies the possibility for a continuum of regulation schemes yielding maximal total social welfare, depending on the regulator's target and the subsequent decision on the implemented $r_M \in \{c_M + k, R - t/4\}$. We develop this idea in the next section.

Competition in service provision

We now extend the environment to set up a model in which a new entrant, *E*, competes in prices with *M* in the provision of the service, setting r_E and facing marginal costs c_E. The new entrant *E* owns a backbone and switches, and needs to connect to the incumbent firm's local loop to access the network. Then, apart from variable costs related to the provision of the service, the entrant has to pay the network owner a connection fee $\alpha \in [0,1]$ per unit of service it provides to its clients. In this sense, our framework is one of one-way access where the entrant needs to connect to the network in order to supply the service.

Depending on the scenario considered, this connection fee may be set by the regulator or the network owner. Therefore, apart from the usual business-stealing effect, the entrant's market share has also a positive effect on the network owner's profits, as the latter earns *α* per service unit provided by *E*. From the definition of *α*, we do not rule out the possibility of $\alpha \le k$. Thus, the cost *k* borne by *M* may not be fully covered by the entrant's connection fee or may be just equal to it. Although this would not be what one would expect in the case of monopolist's decision on α, it could correspond to the

regulator's decision to subsidize the entrant or only partially compensate *M* for the costs incurred to maintain the network infrastructure. We then consider 2 cases:

- *Case A*: Exogenous connection fee.

- *Case B*: Endogenous connection fee.

We solve the resulting games by backward induction to characterize the corresponding Subgame Perfect Nash Equilibria (SPNE). Without loss of generality, *M* is always the firm on the left and *E* is the firm on the right. We assume that the two firms provide services which correspond to the extremes of the segment *[0,1]* along which consumers' ideal type of service are distributed. When the entrant's connection fee is exogenously given by the regulator authorities, we consider α as a model parameter.

Exogenous connection fee

In this subsection we suppose that the regulator sets exogenously the entrant's connection fee α paid to *M*. The game consists of two stages. At the first stage, *M* sets *p*, which determines the density *D*; secondly, firms compete setting retail prices (r_M, r_E), simultaneously taking each other's type of service on the extreme of the [0,1] interval as given. For a given pair of retail prices (r_M, r_E) the indifferent consumer' between the two types of service offered by firms is given by:

$$x = \frac{1}{2} - \frac{r_M - r_E}{2t}$$

yielding service demands $d_M = D \cdot x$ and $d_E = D \cdot (1-x)$ for the incumbent and the entrant, respectively. Then, at the second stage firm *M* and *E* maximize,

$$\pi_M = (p-k)d_M + (p+\alpha-k)d_E + (r_M - c_M)d_M,\qquad(2)$$

and

$$\pi_E = (r_E - c_E - \alpha)d_E, \tag{3}$$

respectively. It is important to note that the access tariff p paid by customers served by E is transferred through the entrant to the network owner, so that the entrant's profits are not affected directly by it. We obtain the equilibrium in the pricing stage first, and substitute the solution into $M's$ profit function to determine the network capacity. The resulting equilibrium yields the following proposition,

Proposition 2: When the service is provided by a duopoly consisting of the network owner M and an entrant E who is asked to pay a connection fee α to the former, an access price of $\hat{p} = \dfrac{2(1+k-\alpha)-t}{4} + \dfrac{(c_M - c_E)(6t - c_M + c_E)}{36t}$ *is charged to the consumers yielding a network capacity* $\hat{D} < 1$. *Then, Nash equilibrium retail prices for the provision of the service are given by* $\hat{r}_i = \alpha + t + \dfrac{1}{3}(2c_i + c_j),$ *with* $i, j = 1,2,$ *and* $i \neq j$.

The solution described in Proposition 2 accounts for the fact that the network owner's profit is affected less than in the usual spatial competition model by its rival's sales, given that the latter pays the former a connection fee of α per unit of service provided. The equilibrium in retail prices is symmetric and the effect of the per service unit transfer α from E to M has a positive, direct impact on retail prices of both service suppliers, $\partial \hat{r}_i / \partial \alpha = 1, i = M, E.$ This result lies on the line of previous results (see for instance De Bijl and Peitz 2006). An interesting property of the model is that the connection fee has a direct impact on the network density. Explicitly, the higher the connection fee α, the larger the network density fixed by the incumbent:

$\dfrac{\partial \hat{D}}{\partial \alpha} = \dfrac{\partial \hat{D}}{\partial \hat{p}(\alpha)} \dfrac{d\hat{p}(\alpha)}{d\alpha} = \dfrac{1}{2}.$ This suggests that regulators can implement α to achieve

different targets: maximize the network capacity (but at high retail prices) or provide cheap DSL connections with a moderate network capacity. This issue is especially relevant in the case of developing countries where consumers' affordability is reduced.

Substituting retail prices and the equilibrium price into the profit functions for the incumbent and the entrant firm we obtain,

$$\hat{\pi}_M = [\frac{18t(1+\alpha-k)+9t^2+(c_E-c_M)(c_M-c_E-6t)}{36t}]^2 \text{ , and}$$

$$\hat{\pi}_E = [\frac{(c_M-c_E+3t)^2}{18t}]\sqrt{\hat{\pi}_M} \text{ ,}$$

respectively. These expressions show that in our framework not only *M*'s equilibrium profits are (positively) affected by α. In fact, for the entrant, an increase in retail prices due to α has a direct effect on the entrant's equilibrium profits because the latter positively depends on the incumbent's profits,

$$\frac{\partial \hat{\pi}_E}{\partial \hat{\pi}_M} = [\frac{(c_M-c_E+3t)^2}{18t}]\frac{1}{\sqrt{\hat{\pi}_M}} \text{ ,}$$

which is always positive for all parameter values, contrary to the property obtained by De Bijl and Peitz (2006) in a similar setting where $\frac{\partial \hat{\pi}_E}{\partial \hat{\pi}_M} = 0$. The higher the participation of *M* in *E*'s revenues, the less are the entrant's incentives to undercut prices in order to steal business from the incumbent. Moreover, if the aim of the regulator is to maximize density and give incentives to new competitors to enter into the market regardless the level of retail prices, an increase in α is a right measure. Finally, total transportation costs are equal to those of the monopoly case above. However, a source of inefficiency identified here relates to the network owner's

reduced incentives to encourage installation of maximal network capacity, because the entrant will now enjoy part of the benefits from a high network capacity.

Endogenous connection fee

In this subsection the regulator makes no further intervention on the level of the connection fee α, except for the requirement that $\alpha \leq 1$. Then, the network owner decides on *α* that the entrant is charged per service unit provided to its clients. Usually, such a decision is made at the same stage at which p is fixed because now the incumbent can use both instruments to define his market strategy. The timing of the model is the following: at the first stage the incumbent chooses the dual strategy (p,α) simultaneously in order to fix network capacity and a connection fee level; then, at the second stage retail competition takes place between the incumbent and the entrant.

Profit maximization functions at the third stage are given by (2) and (3), and the remaining notation introduced in the previous case is valid here. Solution of the game using backward induction leads us to the following result:

Proposition 3: When the service is provided by a duopoly consisting of the network owner M and an entrant E who is asked to pay a connection fee α to the former, M sets $\widetilde{p} = 0$, yielding maximal network capacity and charges E a connection fee of $\widetilde{\alpha} = 1$. Then, the Nash equilibrium retail prices for the provision of the service are given by

$$\widetilde{r}_i = 1 + t + \frac{2c_i + c_j}{3}, \;\; i,j = 1,2, i \neq j.$$

From the result reported in Proposition 3, efficiency losses due to less than maximal network capacity induced by a positive $\widetilde{p}$ vanish. Moreover, this case and the monopoly structure are equally efficient, although it should be noted that the duopoly case studied here improves consumer surplus through competition yielding lower retail prices.

Substituting the equilibrium magnitudes presented in Proposition 3 into the two firms' profit functions yields:

$$\widetilde{\pi}_M = \frac{2(1-k)+t}{2} + \frac{(c_M - c_E)(c_M - c_E)(c_M - c_E - 6t)}{18t},$$

and,

$$\widetilde{\pi}_E = \frac{(c_M - c_E + 3t)^2}{18t}.$$

We relegate a more detailed discussion of the results and welfare consideration to the next section.

Discussion: Universal access, service quality, and social welfare considerations.

Here, we report the main results that arise from each market environment in order to highlight the effects of the interaction between marker structure, competition and regulation. For simplicity of the discussion, we assume that both firms have the same marginal cost at the service provision stage, $c_M = c_E = c$. Then, we pay attention to the level of p (thus D), r_i, and α as a function of the structural parameters t, k. Table 4.3 reports equilibrium magnitudes of the variables.

We first observe the following network capacity chain $D^* = \widetilde{D} > \hat{D}$ (the inverse order holds for access prices p). Accordingly, liberalization of service provision provides maximal network capacity when the regulator gives firm M the ability to fix α. However, a further inspection of retail prices gives us information on the impact of each case on consumer surplus and social welfare. We find that $\widetilde{r}_i > \hat{r}_i$. Then, when the regulator fixes the connection fee, network capacity is reduced, but it is offered at the lowest retail prices. If the regulator gives to firm M the capacity to choose α, and the

aim of the regulator is to provide maximal network capacity, it is at the cost of high prices. In this case, it is optimal in terms of social welfare but no maximal consumer surplus is achieved, because retail prices are higher than those under *case A*. The relevant issue for policy makers is that the regulator can achieve maximal network capacity by means of an increase in retail prices, so there is a trade off between capacity and availability of the service, especially when consumers' affordability is reduced.

Table 4.3. Market results by type of environment

	Monopoly	**Duopoly, exogenous α CASE A**	**Duopoly, endogenous α CASE B**
p	*0*	$\dfrac{2(1+k-\alpha)}{4} - \dfrac{t}{4}$	*0*
D	*1*	$\dfrac{2(1-k+\alpha)}{4} + \dfrac{t}{4}$	*1*
α		$0 < \alpha \leq 1$	*1*
r_i	$R - t/4$	$\alpha + t$	$1 + t$

Social welfare considerations

In this framework, social welfare analysis becomes both relatively straightforward and insightful. Let us recall that the case of monopoly under the assumption of universal service provision (or full market coverage) achieves the maximum level of social welfare that can be reached by a single provider of the service. This is given by:

$$SW_M = R - k - c_M - 2\int_0^{1/2} tx^2 = R - k - c_M - \frac{t}{12}.$$

We use this case as a benchmark to assess the effects of liberalization on overall market efficiency. By observation of the above expression of social welfare, given a specific market structure, there are two sources of possible inefficiencies: first,

deviations from the maximal network density ($D^* = \tilde{D} = 1$) resulting from access capacity prices $p > 0$; and second, inefficient splits of the market between the two suppliers. Regarding this last source of inefficiency, consider the case of equal service provision marginal costs $c_M = c_E = c$. Then, if firms are symmetrically located with respect to the consumers' unit length segment the efficient market split is one in which consumers are equally shared between the two suppliers. As the indifferent consumer is located at ½, with $c_M \neq c_E$, the desirable condition is that the more efficient supplier serves more consumers than the inefficient one up to the point at which the extra travelling cost paid by clients served along a broader market segment, equals the efficiency gains from being supplied by the efficient provider, as the expression below shows,

$$SW_{DUOPOLY} = R - k - \frac{t}{12} + \frac{(c_M - c_E)(5c_M - 5c_E - 18t)}{36t}.$$

Comparison between duopoly cases *A* and *B* shows that the existence of a connection fee paid by the entrant to the incumbent induces asymmetric splits when there are cost asymmetries between suppliers in the service market. In this framework, this is the major justification for regulating the conditions offered to the entrant in the network connection stage.

Finally, the general conclusion drawn from our analysis is that competition may increase the consumer's surplus, but does not necessarily enhance social welfare. Monopoly is as efficient as Duopoly under *Case B*, but *Case A* lead to further efficiency losses due to the incentives for the network owner to restrict output in the capacity provision stage.

Conclusions

In this paper we have studied the impact of ICT on different economic aspects of developing societies. Broadband subscribers are likely to grow even during the global economic downturn, albeit at a much slower rate than previous years.[14] As demand for Internet services is growing both in urban and rural areas, an important decision for governments and regulators is whether to provide universal service provision at low navigation speed or to provide urban populations and consumers located near large cities a high speed connection (with possibly rising prices). Moreover, the decision to introduce competition in the service provision market may mean that the former monopoly decides to vary the network capacity and the connection fees to reach network facilities, with potential customer welfare losses. In particular, we have shown that different pricing schemes arise depending on market structure. These schemes seem to have different impacts on consumer surplus and on consumer welfare.

Our analysis has focused on the fact that a network which is used to provide a service may be accessed by consumers whose connection capacity determines the quality of their service and also the market size. In our analysis, the network owner (incumbent operator) participates in the service provision market. In our benchmark model, the network owner also provides Internet access to a population of consumers. In the liberalized model, new entrants are charged a connection fee per service unit they provide to their clients. [15] In both environments, the network monopolist and the entrant are assumed to have market power and compete in retail prices in the service provision stage.[16] Under this simple framework of one-way access, unbundling the local loop seems the right measure in order to enhance competition when new entrants offer broadband Internet access by using '*digital subscriber line*' (DSL) technology.

---

[14] See for example, http://www.internetworldstats.com/stats.htm (18/12/2009).
[15] A survey on global Internet competition can be found at http://www.itu.int/ITU-D/icteye/Reporting/ShowReportFrame.aspx?ReportName=/TREG/LevelOfCompetition2007&RP_intClassID=2&RP_intLanguageID=1 (18/12/2009).
[16] Future research will include an extended model of competition to measure the impact of global competition on broadband Internet access. Such a situation can be modelled by supposing an oligopoly market which includes a competitive fringe. Another possibility is to consider a Stackelberg sequential market where some firms are leaders and another group of firms plays the role of followers.

Moreover, as voice telephony can be alternatively implemented by using Voice Internet protocol (VoIP), local loop unbundling may also enhance competition in the voice telephone market. It is also important to understand local loop unbundling regulation within the general framework of liberalization of telecommunications markets. In the case of broadband for data, regulators should ask themselves whether consumers wish to have fast broadband connections that can increasingly be used for hi-tech services or, in the other hand, there is perhaps little need for such advanced products, and consumers care more for decent speed at a reasonably lower price. If the answer to the first question is affirmative, wholesale regulation of the local loop should encourage full unbundling and line sharing and discourage bit stream and simple resale access. However, if the answers are in the opposite directions, then regulation should respond accordingly, making bit stream access and simple resale access (i.e, wholesale connection fee) available at low wholesale prices.

References

Armstrong, M. (1998): Network Interconnections in Telecommunications. The Economic Journal, 108: 545-564.

Armstrong, M. (2002): The theory of access pricing and interconnection. In: M. Cave, S. Majumdar, and I. Vogelsang (ed.), Handbook of Telecommunications Economics. North-Holland: Amsterdam.

De Bijl, W.J., Peitz, M. (2002): Regulation and Entry into Telecommunications Markets. Cambridge University Press: Cambridge.

De Bijl, W.J., Peitz, M. (2005): Local loop unbundling in Europe: experience, prospects and policy challenges. Communications and Strategies, 57: 33-57.

De Bijl, W.J., Peitz, M. (2006): Local Loop Unbundling: One-Way Access and Imperfect Competition. In: R. Dewenter and J. Haucap (ed.), Access Pricing: Theory and Practice. Elsevier Science.

ECLAC (2009): Information and Communication for Development Report (IC4D 2009). Extending Reach and increasing impact. http://issuu.com/world.bank.-publications/docs/9780821376058.

European Parliament and Council (2002): Directive 2002/19/EC of the European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive). Official Journal of the European Communities, 108: 7-17.

European Parliament and Council (2007): Proposal for a Directive amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to, and interconnection of, electronic communications networks and services, and 2002/20/EC on the authorisation of electronic communications networks and services. Official Journal of the European Communities, {SEC(2007) 1472} {SEC(2007) 1473}. COM/2007/0697 final - COD 2007/0247.

Hotelling, H. (1929): Stability in Competition. Economic Journal, 39: 41-57.

Jorgenson, D. (2007): Latin America in the World Economy. Mimeo.

Laffont, J-J., Tirole, J. (1994): Access pricing and competition. European Economic Review, 38: 1673-1710.

Laffont, J-J., Tirole, J. (2000): Competition in telecommunications. MIT Press: Cambridge.

Trillas, X., Calzada, J. (2005): Los Precios de Interconexión en las Telecomunicaciones: de la Teoría a la Práctica. Hacienda Pública Española, 173: 85-125.

UN (2009): MGD Task Force Report 2009: Millennium Development Goal 8: Strengthening the Goal Partnership for Development in a Time of Crisis http://www.un.org/millenniumgoals/pdf/MDG_Gap_%20Task_Force_%20Report_2009.pdf.

Vogelsang, I. (2003): Price Regulation of Access to Telecommunications Networks. Journal of Economic Literature, 41: 830-862.