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Access Pricing: A Comparison Between Full Deregulation and Two Alternative Instruments of Access Price Regulation, Cost-Based and Retail-Minus[1]

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Abstract

In this paper two instruments of access price regulation, cost-based and retail-minus, are compared with the full deregulation hypothesis. For this purpose it is developed a model that considers an upstream monopolist firm that sells a vital input to an independent firm and to a subsidiary firm in the downstream market. The main conclusion of the paper is that retail-minus regulation avoids foreclosure and leads to better results than cost-based regulation in terms of investment level and consumer surplus. Moreover, retail-minus regulation allows a higher consumer surplus than deregulation of access price as long as the regulator carefully defines the retail minus instrument.

JEL Classification: L12, L51, L96

Keywords: access regulation, vertical integration, retail-minus.

1 Introduction

The deregulation of network industries, such as telecommunications, electricity, gas or transportation, raises several questions about the conditions of access to the incumbent firm's network. In particular, when the incumbent firm is monopolist in the provision of an essential input (the network access) and is vertically integrated to the downstream market, the regulation of access price is a crucial question.[1] Without access price regulation the upstream monopolist might use its market power to foreclose the downstream rivals. However, a tight access price regulation might decrease the incumbent firm's incentive to undertake the necessary investments to improve the network quality, which is indispensable for the development of the market. Several other consequences from the definition of different levels of access prices may arise: if the access price is set "too low", inefficient entry might occur; if access price is set "too high", the entrants might have incentives to build inefficient facilities to bypass the incumbent's network (Laffont and Tirole, 2000); if the level of entry costs in downstream market is high in comparison to the potential benefits of entry, the regulator may define a high access price (Valletti, 2003).

The purpose of this paper is to compare two different instruments of access price regulation with regard to the trade-off between two objectives of the regulatory authority: the objective of enhancing competition in the downstream market and the objective of promoting the investment in network quality.[2] The first instrument under discussion is cost-based regulation, under which the regulator defines the access price equal to the marginal cost of providing the access plus a fraction of the cost of the investment undertaken by the incumbent firm. The second instrument is retail-minus regulation, under which the regulator defines the minimum value of the difference between the retail price and the access price.

From the comparison of the two instruments described above, emerges the conclusion that retail-minus regulation avoids foreclosure (as cost-based regulation does),

[1] For an extensive discussion and review of the literature on access regulation see Armstrong *et al.* (1996), Laffont and Tirole (2000) and Armstrong (2002).

[2] For simplicity, the other consequences of the access price definition mentioned above are not included in the discussion, although in several contexts they might assume an important role in the definition of the access price.

but leads to better results in terms of the level of network quality investment and consumer surplus than the cost-based regulation. Furthermore, although retail-minus regulation does not allow the investment level achieved under deregulation of access price, it leads to a higher consumer surplus as long as the difference between retail price and access price is carefully defined by the regulator.

The idea behind the instruments of access price regulation mentioned (cost-based and retail-minus) is that the emergence of competition in the retail segment might be a precursor to competition in the wholesale segment, the ultimate goal of complete deregulation. Therefore, at an initial stage of the deregulation process, some assistance to entrant firms might be necessary to allow the emergence of competition at the retail level.

Retail-minus regulation is a practical rule used by regulators aiming to protect the independent firms that compete with a vertically integrated firm. For example, the British regulator for the telecommunications sector, Ofcom - Office of Telecommunications, decided to impose retail-minus regulation on the difference between IPStream and Datastream, which are wholesale services offered by BT in the broadband Internet access market.[3]

The question studied in this paper was inspired by the market for broadband Internet connectivity with ADSL technology, although it might be applied to other vertically integrated markets where the network access by an independent competitor in the retail market is a regulatory issue. There are several examples of this structure. One of those is found in the long distance telephone market in the United States. Each Bell Operating Company (BOC) is a near-monopoly supplier of the input (exchange access), whose price is regulated. Simultaneously, each BOC can compete (through a subsidiary firm) with other firms (AT&T, Sprint, MCI and others) in the downstream long distance service (Mandy, 2000). In railway and electricity industries similar situations can be found (Weisman, 2002).

For broadband Internet connectivity there are two major networks: the telephone network and the cable network. There are alternative technologies to broadband access, such as wireless, powerline, satellite and UMTS. Hhowever these technologies are still at a developmental stage, although in the future they might compete with

[3]For more details see the Ofcom documents: Ofcom (2003) and Ofcom (2004a, 2004b).

cable and DSL. Table A1 (Appendix A) presents information about the penetration rates of broadband Internet access through DSL, cable modem and other platforms for OECD countries. From this information it is possible to conclude that DSL is the dominant technology in most of the OECD countries considered.

The broadband Internet connectivity with DSL technology implies that the firm that owns the telephone network, typically the historical incumbent firm, has to supply local access as an input to telecommunication operators in the retail market. In several European markets, the retail segment is an oligopoly where the independent firms compete with a firm that not only belongs to the same economic group as the upstream monopoly but also has a large market share. Table A2 (Appendix A) shows the historical operator's market shares in the retail market for broadband Internet with ADSL technology in several European countries.[4] This reality supports the paper's consideration of Stackelberg competition in the downstream segment, with the leadership of the subsidiary firm. [5]

Another crucial feature of the paper is the investment in network quality undertaken by the upstream firm. It is assumed that the increase in the speed of communications is seen by consumers as an important improvement in the quality of the service, not only because they might have access to new services that require high speed (such as interactive audio and video), but also because the conventional Internet services (web-browsing and e-mail) acquire greater value (Hausman et al., 2001; Foros, 2004). It is assumed that this improvement leads to more consumption by the actual consumers and to the attraction of new consumers for the market, which is represented by an increase in the retail market demand function. Also,

[4] The technology used in telephone networks is the DSL (Digital Subscriber Lines). The most popular form of DSL is ADSL (Asymmetric DSL) in which the download transmission rates are higher than the upload rates (for details see, for example, Spulber and Yoo, 2003).

[5] Weisman (1995) also assumes Stackelberg competition in the downstream market and considers that the subsidiary firm is the Stackelberg leader. This assumption considered by Weisman was strongly criticized by Beard et al. (2001) with the argument that it is unlikely that the BOC (Bell Operating Company) subsidiary firm assumes a dominant position in the long distance market where it might compete with firms such AT&T, MCI or Sprint. However, as the values of Table A2 show, the industry structure of Internet broadband access market in European countries is quite different from the long distance telecommunications market structure in the United States.

it is assumed in the paper that the investment in the network is indispensable to increasing the speed of communications and this requires investment in the network undertaken by the upstream firm. In this paper, the role of the investment undertaken by the incumbent firm is emphasized. It is assumed that the investment improves the quality of the incumbent firm's network and increases the demand size. However, in several network industries, the investments undertaken by the independent firms are also very significant to market development and thus the regulator's role in the promotion of these investments can not be ignored. In the broadband Internet market some of the new operators in most of the European countries are building their own networks. The success of these investments will be decisive for the establishment of competition at the upstream segment of the market. However, the construction of infrastructure is a long-term process during which the new operators also use the incumbent firm's network to expand their business more rapidly. This argument justifies the emphasis on the effects of the incumbent firm's investments on market demand.

The closest literature to the question under discussion in this paper is that of Armstrong and Vickers (1998), Weisman (2002) and Foros (2004). Armstrong and Vickers (1998) compare the regulation of the access price with the regulation of the margin, concluding that the social welfare and the entrant profit are higher with optimal access price regulation than with optimal marginal regulation. Armstrong and Vickers's model differs in quite important features from the model described in this paper. First, Armstrong and Vickers assume different downstream costs for the two firms while here, equal costs in the retail activity are assumed. Second, Armstrong and Vickers consider that margin regulation is equivalent to the application of the Efficient Component Pricing Rule (ECPR) with the retail price set at the monopoly level, while here it is assumed that the retail price is defined by the strategic interaction between firms. Finally, the model presented in this paper studies the incumbent firm's investment in network quality, which is not considered by Armstrong and Vickers.

In a quite different framework, Weisman (2002) compares two general access pricing rules: the marginal cost access pricing and the ECPR, assuming that, in both cases, the retail price is defined by Cournot competition. Weisman also considers that the vertically integrated firm and the independent firms might have different marginal costs in the retail activity. Weisman concludes that if the vertically integrated firm is relatively efficient, it prefers ECPR. Like Armstrong and Vickers (1998), Weisman does not analyze the incumbent firm's investment in network. On the other hand, Foros (2004) considers the incumbent firm's network investment and its effects on retail demand.[6] However, the purpose of Foros' model is to study the effects of the different ability to use network quality improvements by the downstream firms and not to compare different instruments of access regulation.

The paper is organized as follows: section 2 describes the model, section 3 compares the results obtained for the three alternative ways of defining the access price and, finally, section 4 presents the conclusions of the paper.

2 The Model

2.1 Introduction

In this paper, a very simple analytical framework is used to highlight the properties of the different instruments of access price regulation. It is considered an upstream monopoly, that could be the historical incumbent firm, which sells network access to downstream firms.[7] The retail market is characterized as an unregulated duopoly market with an independent firm and a subsidiary firm of the upstream monopolist. Figure 1 illustrates the market structure.

< Insert Figure 1 here >

In the downstream market there is quantity competition and the subsidiary firm acts as a Stackelberg leader. It is worth mentioning that the main results of the paper can be obtained under different assumptions about the nature of the strategic interaction between firms. In particular, this happens either if Cournot competition is considered instead of Stackelberg competition, or if it is assumed that firms offer

[6] Gans (2001) also studies the incentives to undertake infrastructure investments by an upstream monopolist subject to access price regulation.

[7] The model abstracts from bypass considerations by assuming that the incumbent is the only supplier of access and that access is a vital input for downstream production.

a differentiate product and compete on prices. Indeed, the authors reformulate the model considering Hotelling's interaction as it was applied by Sappington (2005) and conclude that the main results of the paper do not change.[8] The upstream monopolist might undertake investments to improve the network quality. High network quality is costly to provide but increases the value of the final product to consumers, which is represented by an increase in the retail demand function. For simplicity, a fixed coefficients technology is assumed, then the production of one unit of the final service requires one unit of the input. Also, it is assumed that the quality of the input sold by the monopolist is the same whether it is sold to the independent firm or to the subsidiary firm. Thus, the paper does not study the related question of sabotage.[9]

Demand

The inverse demand function for the market of the final homogenous output is represented by $p = 1 + \beta I - (q_1 + q_2)$, where p is the retail market price, q_1 and q_2 are the quantities offered by firm 1 (the vertically integrated firm) and firm 2 (the independent firm), respectively, and I represents the level of investment undertaken by firm 1. The term βI $(\beta > 0)$ does not change the slope of the demand function, but a modification of I changes the intersection point of the demand curve with the vertical axis, representing a modification in demand size. Therefore, it is assumed that an increase in the level of investment leads to an outward parallel shift in demand, which benefits both downstream firms.

Costs

It is assumed that the marginal cost of providing the access per user is constant and represented by c (with $c < 1$) and that the investment level does not have any impact on c. Also, it is considered that the investment cost function is quadratic,

[8] Indeed, the authors reformulate the model considering Hotelling's interaction as it was applied by Sappington (2005) and conclude that the main results of the paper do not change. The authors thank an anonymous referee for pointing out this last feature.

[9] Sabotage exists when the upstream firm intentionally reduces the quality of the input when it is sold to independent firms. This strategy raises the downstream rivals' costs and benefits the subsidiary firm. For a study of sabotage see Weisman (1995, 1998), Economides (1998, 2000), Sibley and Weisman (1998), Reiffen (1998), Bergman (2000), Mandy (2000), Weisman and Kang (2001) and Beard *et al.* (2001).

with respect to investment in network quality and is given by $C(I) = \frac{\varphi I^2}{2}$, with $\varphi > 0$. The access price that the independent firm pays to the upstream firm for the input is represented by w, assuming $w \geq c$. For simplicity, it is assumed that the cost of buying other inputs is equal for both downstream firms and normalized to zero.[10] The profit functions of firms 1 and 2 are given, respectively, by:

$\pi_1 = (p - c)q_1 + (w - c)q_2 - \frac{\varphi I^2}{2}$ $\qquad\qquad$ $\pi_2 = (p - w)q_2$

Time of the game

The time of the game is the following:

- At stage 1 the upstream monopolist decides the investment level I.

- At stage 2 the upstream firm, or the regulator, chooses the access price w.

- At stage 3 the retail price and quantities are defined by Stackelberg competition between downstream firms. Uniform pricing is assumed.

The three alternative scenarios for the definition of the access price (w) at stage 2 are characterized in the following way:

Scenario A - Deregulation: the access price is defined by the vertically integrated firm without the regulator's intervention.

Scenario B - Cost-based regulation: the access price is defined by the regulator as the marginal cost of providing the access (c) plus a fraction (α) of the total cost of the investment, that is, $w = c + \alpha C(I)$, with $\alpha < 1$. With this regulatory policy the vertically integrated firm shares the cost of the investment with the independent firm.

Scenario C - Retail-minus regulation: the regulator imposes that the difference between the retail price p and the access price w can not be below $x\%$ of the retail price p, that is, $w \leq p(1 - x)$ with $x \in (0, 1)$.

A game with perfect information is assumed, thus each player anticipates what will happen in subsequent stages of the game. Hence, the game will be solved through backward induction.

[10] This assumption is made in order to direct the attention to the effects of the different ways of defining the access price. However, if different downstream costs are assumed, an interesting, although expected, result emerges: the investment incentive is higher the more efficient firm 1 is and the less efficient firm 2 is. The authors thank an anonymous referee for pointing out this feature.

2.2 Stage 3: Stackelberg Competition

The best reply function of firm 2 is $q_2 = \frac{1+\beta I-w-q_1}{2}$.[11] Considering Stackelberg competition, the results for stage 3 are the following:

$$q_1 = \frac{1+\beta I-c}{2} \qquad q_2 = \frac{1+\beta I-2w+c}{4} \qquad p = \frac{1+\beta I+2w+c}{4}$$

2.3 Stages 2 and 1: Scenario A - Deregulation

2.3.1 Stage 2: Definition of the Access Price

Under scenario A the vertically integrated firm chooses the access price w that maximizes its profit. Then, $w = \frac{1+\beta I+c}{2}$ and from the results of stage 3, the following is obtained:

$$q_1 = \frac{1+\beta I-c}{2} \qquad q_2 = 0 \qquad p = \frac{1+\beta I+c}{2}$$

Therefore, without access price regulation, the vertically integrated firm sets an access price that forecloses the independent firm from the downstream market.[12] This is a well known result in the literature on vertical integration. In an unregulated environment, an integrated firm which controls an essential input has the incentive to foreclose the downstream rivals and extend its market power to the downstream segment of the market.

2.3.2 Stage 1: Definition of the Investment Level

If the vertically integrated firm can choose the access price without restrictions then firm 2 will not produce. Hence, firm 1 will be a monopolist also in the downstream market. The investment level that maximizes firm 1's profit is $I^A = \frac{\beta(1-c)}{2\varphi-\beta^2}$. To guarantee the verification of the second order condition, and also that $I^A > 0$, it must be assumed that $2\varphi - \beta^2 > 0$.

Assumption 1: Let $2\varphi - \beta^2 > 0$.

[11] The second order condition of firm 2's maximization problem is fulfilled. In the rest of the paper, and for simplification, the second order condition will only be mentioned when it is necessary to impose some constraints on its verification.

[12] In order to keep the model as simple as possible, fixed costs are not considered. Otherwise, if the independent firm had to recover a fixed cost to survive, the result previously obtained would be even stronger.

Assumption 1 guarantee that φ is relatively high, which means that the cost function of the investment is significantly convex. This assumption about parameter φ ensures that firm 1 will not choose an infinite investment level.

Considering the value of I^A, the final results for scenario A are:

$$q_1^A = \frac{\varphi(1-c)}{2\varphi-\beta^2} \qquad q_2^A = 0 \qquad p^A = \frac{\varphi(1+c)-\beta^2 c}{2\varphi-\beta^2}$$

$$\pi_1^A = \frac{\varphi(1-c)^2}{2(2\varphi-\beta^2)} \qquad CS^A = \frac{\varphi^2(1-c)^2}{2(2\varphi-\beta^2)^2}$$

where CS represents the consumer surplus.

2.4 Stages 2 and 1: Scenario B - Cost-Based Regulation

2.4.1 Stage 2: Definition of the Access Price

Under scenario B the regulatory authority defines $w = c + \alpha C(I)$. To simplify the calculus it is assumed that $\alpha = \frac{1}{I}$, then $w = c + \frac{\varphi I}{2}$. This definition means that the regulator sets an access price equal to the cost of providing the access plus the average cost of the investment.

2.4.2 Stage 1: Definition of the Investment Level

Considering $w = c + \frac{\varphi I}{2}$ and the results obtained at stage 3, the investment level that maximizes the profit of firm 1 is $I^B = \frac{(1-c)(\beta+\varphi)}{4\varphi-\beta^2+\varphi^2-2\beta\varphi}$. Assumption 2 is considered to ensure that $I^B > 0$:

Assumption 2: Let $4\varphi - \beta^2 + \varphi^2 - 2\beta\varphi > 0$.

Considering the value of I^B previously found, the final results for scenario B are the following:

$$w^B = c + \frac{\varphi(1-c)(\beta+\varphi)}{2(4\varphi-\beta^2+\varphi^2-2\beta\varphi)} \qquad p^B = \frac{1+3c}{4} + \frac{(1-c)(\beta+\varphi)^2}{4(4\varphi-\beta^2+\varphi^2-2\beta\varphi)}$$

$$q_1^B = \frac{\varphi(1-c)(4+\varphi-\beta)}{2(4\varphi-\beta^2+\varphi^2-2\beta\varphi)} \qquad q_2^B = \frac{\varphi(1-c)(2-\beta)}{2(4\varphi-\beta^2+\varphi^2-2\beta\varphi)}$$

$$\pi_2^B = \left(\frac{\varphi(1-c)(2-\beta)}{2(4\varphi-\beta^2+\varphi^2-2\beta\varphi)}\right)^2 \qquad CS^B = \frac{1}{32}\left[3 - 3c + (3\beta-\varphi)\frac{(1-c)(\beta+\varphi)}{4\varphi-\beta^2+\varphi^2-2\beta\varphi}\right]^2$$

2.5 Stages 2 and 1: Scenario C - Retail-Minus Regulation

2.5.1 Stage 2: Definition of the Access Price

Under retail-minus regulation, firm 1 defines the access price under the condition $w \leq p(1-x)$ and $w \geq c$. From the Lagrangian analysis results that $w = p(1-x)$. Considering $p = \frac{1+\beta I+2w+c}{4}$ (from stage 3) the access price is $w = \frac{(1-x)(1+\beta I+c)}{2(1+x)}$.

The solution of firm 1's maximization problem requires that $c \leq w$, then $c \leq \frac{(1-x)(1+\beta I+c)}{2(1+x)}$ which is equivalent to $x \leq \frac{1+\beta I-c}{1+\beta I+3c}$.

2.5.2 Stage 1: Definition of the Investment Level

The investment level that maximizes the profit function is given by $I^C = \beta\frac{(1+2x-x^2)-c(1+2x+3x^2)}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)}$[13] and the final results for scenario C are:

$$w^C = \frac{(1-x^2)(\varphi+c\varphi-c\beta^2)}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)} \qquad p^C = \frac{(x+1)(\varphi+c\varphi-c\beta^2)}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)}$$

$$q_1^C = \frac{\varphi(1-c)(1+x)^2-2c\beta^2x^2}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)} \qquad q_2^C = \frac{(x+1)(\varphi+c\varphi-c\beta^2)x}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)}$$

$$CS^C = \frac{\left(\varphi+3\varphi x+2\varphi x^2-c\beta^2x-3c\beta^2x^2-c\varphi x-c\varphi\right)^2}{2\left[2\varphi(1+x)^2-\beta^2(1+2x-x^2)\right]^2}$$

These results are valid under the constraint $x \leq \bar{x}$, with $\bar{x} = \frac{1+\beta I-c}{1+\beta I+3c}$. This restriction on x derives from the assumption that, under retail-minus regulation, the access price can not be lower than the marginal cost of providing the access. This is a reasonable assumption considering the practical regulator policy. Even when regulators use cost orientation principles, there is usually the intention to set an access price above the marginal cost so that the independent firms also bear some of the other costs of providing the access.

An interesting result concerning the retail-minus regulation is obtained if it is assumed that the regulator strategically chooses the value of x. In the previous description of the retail-minus policy x is exogenous. However, if the regulator sets the value of x to maximize the social welfare (defined as the unweighted sum of consumer surplus and firms' profits), the following results are obtained: i) the optimal retail price is equal to the marginal cost of providing the access; ii) the access price is lower than the marginal cost and iii) the optimal investment level

[13] The verification of the second order condition requires that $2\varphi(1+x)^2 - \beta^2(1+2x-x^2) > 0$. Under Assumption 1 this condition is verified.

is zero.[14] The intuitive explanation for these results is straightforward. The retail price that maximizes social welfare is the one that allows the higher retail quantity, then $p = c$. Under this retail price, the independent firm obtains a positive profit that is, however, offset by the negative profit of firm 1. It is also interesting to mention that these same results are obtained if the access price is defined directly (that is, without retail-minus regulation) by the regulator under the social welfare objective.[15]

However, considering the regulatory practice, it is assumed in the paper that the access price must be equal to or higher than the marginal cost of providing the access. Therefore, under the assumption that w$\geq c$, the access price that maximizes social welfare is $w = c$, which leads to a retail price above c and to positive values for the optimal investment level and firms' profits.

3 Comparison of the Results

Considering that the regulator's main objectives concerning the access price policy are to enhance competition in the downstream market, to promote the investment in network quality and to improve consumer welfare, scenarios A, B and C are compared analyzing three points: the existence of foreclosure, the investment level and the value of consumer surplus.

Table 1 summarizes the results obtained in the previous section:

$<$ Insert Table 1 here $>$

Foreclosure

If firm 1 chooses the access price without any restriction, firm 2 will be out of the market. On the other hand, cost-based regulation and retail-minus regulation protect the independent firm allowing it a positive profit. Note that the equilibrium quantity of firm 2 in scenario C, $q_2^C = \frac{(x+1)(\varphi+c\varphi-c\beta^2)x}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)}$, is positive for all admissible values of x.[16] These results reinforce the arguments in favor of access price

[14] See Appendix B1 for a detailed explantion of these results.
[15] See Appendix B1 for a detailed explantion of these results.
[16] See proof in Appendix B2.

regulation, at least during a transitional period to full deregulation and until the consolidation of the competition in retail markets.

Investment Level

The comparison of the optimal investment levels of scenarios A and B leads to the conclusion that the optimal investment is higher under deregulation as long as $2\varphi - \beta^2 < \beta(2 + \varphi - 2\beta)$. This condition is described by Assumption 3.

Assumption 3: Let $2\varphi - \beta^2 < \beta(2 + \varphi - 2\beta)$.

The interpretation of assumption 3 is straightforward: although the investment cost function is increasing and convex, it is necessary to assume that this function is not excessively increasing in relation to its impact on demand. If the investment cost function is "too" increasing in relation to the investment's impact on demand, then the optimal investment level is higher when the vertically integrated firm shares the cost of the investment with the entrant firm.

The comparison of scenarios C and B shows that retail-minus regulation leads to higher investment level than cost-based regulation if x is lower than a critical value x_2. The value of x_2 depends on the model's parameters, as described in Appendix B3.

The comparison of scenarios A and C leads to the conclusion that the optimal investment level is higher with deregulation than with retail-minus regulation for every admissible values of x.[17]

Therefore, in what concerns the investment level, retail-minus regulation can produce intermediate results between deregulation and cost-based regulation if the regulator carefully defines the value of x, that is, if x is not "too high".

Usually the practice of regulators in the definition of cost-based policy is to require that the entrants contribute to cover the fixed cost of providing the access. Then, regulators define a mark-up to cover the fixed cost, or part of it. The concept of cost-based regulation adopted by many telecommunication regulators (for example, in the United States, the United Kingdom and advocated by the European Commission since 1994) is the Long Run Incremental Cost (LRIC).[18] The implemen-

[17] See proof in Appendix B4.

[18] For a detailed description of the concept of Long Run Incremental Cost see, for example, Valletti and Estache (1999), Laffont and Tirole (2000) and Cave and Vogelsang (2003).

tation of LRIC involves the quantification of the incremental cost of providing the access in a forward-looking perspective, that is, considering the replacement cost of the assets. This perspective is in contrast to the historic cost accounting. However, the precise quantification of the Long Run Incremental Cost raises many questions, namely concerning the allocation of common costs and the informational requirements to compute the appropriate replacement costs (Mason and Valletti, 2001). Hence, there is some discretion in the practical implementation of LRIC (Laffont and Tirole, 2000).

Moreover, even if the Long Run Incremental Cost is correctly quantified, several other problems can be indicated. Hausman (1997, 2000) argues that the Federal Communications Commission's definition of LRIC does not cover all the the investment costs when there is rapid technological progress, as happens in the telecommunications sector. This occurs because, in Hausman's perspective, the concept of cost used by the FCC considers neither the irreversible nature of many of the telecommunication investments, nor the costs with unsuccessful services.

In the same line of argument as Hausman, also Cave and Prosperetti (2001) conclude that the regulatory approach to access price based on the Long Run Incremental Cost adopted by some European countries discourages investment in the fixed networks by the incumbent firms because they anticipate that they will be required to offer access at cost-based prices. Additionally, Farrell (1997) emphasizes the poor performance in terms of dynamic efficiency of cost-based regulation because firms do not have the incentive to innovate if they know that they will be required to offer the access to their rivals at cost-based prices.

The above mentioned concerns about cost-based regulation are also present in the argumentation of Ofcom defending the retail-minus regulation for the broadband Internet access market: *"Ofcom believes that, since these are still immature markets, setting cost-based charges would be a risky exercise which may lead to charges that do not provide the correct signal to entrants. In immature markets there is a high degree of uncertainty with regards to costs, and issues such as the timing of cost recovery and the appropriate rate of return on the capital employed are more complicated than in established markets. The downsides of setting incorrect charges, particularly if they are set too low, are significant. It would deter investment in broadband access* *technologies by the existing operators, i.e., BT and cable companies who are still rolling out their networks (...) This, would, in the long term, affect the development of competition. Accordingly, Ofcom considers that regulating charges on a cost-plus (i.e. LRIC plus) basis would be premature and potentially harmful to investment decisions and that, given the specific nature of the markets, retail-minus appears to be the most appropriate pricing rule."* (Ofcom, 2004b).

The conclusions from the model described in the above sections reinforce Ofcom's arguments. Also, it is important to emphasize that retail-minus regulation does not require that the regulator has precise information about firm's costs and, attending to the difficulty of the regulator's process of gathering information, this is an important feature of any regulatory instrument.

Consumer Surplus

The comparison of consumer surplus of scenarios A and B shows that deregulation leads to higher consumer surplus than cost-based regulation if $2\varphi - \beta^2 < \frac{2(4\varphi - \beta^2 + \varphi^2 - 2\beta\varphi)}{6+\varphi-2\beta}$. This condition is described by Assumption 4:

Assumption 4: Let $2\varphi - \beta^2 < \frac{2(4\varphi - \beta^2 + \varphi^2 - 2\beta\varphi)}{6+\varphi-2\beta}$.

Assumption 4 means that consumers prefer the deregulation hypothesis when the investment cost function is increasing and convex but not excessively convex in relation to the impact of the investment on demand. This result is explained by the high level of investment of scenario A that leads to a significant increase in demand. If, on the contrary, $2\varphi - \beta^2 > \frac{2(4\varphi - \beta^2 + \varphi^2 - 2\beta\varphi)}{6+\varphi-2\beta}$, consumers would prefer cost-based regulation. This means that, even without regulation, the investment level would not be high because of the strong increasing investment costs and, therefore, from the consumers' point of view, it would be better to have a duopoly rather than a monopoly in the downstream market.

The comparison of scenarios A and C shows that retail-minus regulation leads to higher consumer surplus than deregulation if $x < x_3$. The value of x_3 depends on the model's parameters in the way described in Appendix B5.

Therefore, from the consumers' perspective, retail-minus regulation allows better results than the other alternatives in place, provided that the regulator sets a value for x that is not higher than a critical value.

The above conclusions are summarized in Propositions 1, 2 and 3:

Proposition 1: Retail-minus regulation allows the presence of the independent firm in the retail market. The same conclusion is obtained with cost-based regulation and the opposite conclusion results from deregulation.

Proposition 2: Under Assumptions 1, 2 and 3, the optimal investment level with retail minus regulation is higher than the one obtained with cost-based regulation and lower than the one obtained with deregulation (that is $I^B < I^C < I^A$) if the regulatory authority carefully defines the value of x, that is, if $x < min\{\bar{x}, x_2\}$.

Proposition 3: Under Assumption 1, 2 and 4, retail-minus regulation leads to a higher consumer surplus than deregulation or cost-based regulation if the regulator carefully defines x, that is, if $x < min\{\bar{x}, x_3\}$.

Table 2 summarizes the conclusions described above assuming that $x < min\{\bar{x}, x_2\}$ and $x < min\{\bar{x}, x_3\}$:

< Insert Table 2 here >

Therefore, retail-minus regulation can be a good choice for the regulatory authority: it protects the independent firm position in downstream market and does not damage consumer surplus. The main drawback is the impact on the incentives to invest in the network, although the performance of retail-minus regulation is better than the cost-based regulation. Also, retail-minus regulation has the advantage of not requiring that the regulator has information about the firm's costs.

4 Conclusions

When the regulatory authority has multiple objectives regarding the access price regulation (Laffont and Tirole, 2000) and only one instrument to apply, there is a trade-off between the possible outcomes of the regulatory policy. The model described in previous sections leads to the conclusion that if the regulator carefully defines the margin between retail and access prices, with retail-minus regulation it is possible to achieve a better result than either with deregulation or cost-based regulation, in terms of protection of downstream competition and consumer surplus.

Retail-minus regulation allows greater flexibility in access price definition than cost-based regulation. Under the former, the access price definition is influenced not only by the costs but also by demand characteristics and oligopoly interaction that occurs in the retail market. Additionally, the incumbent firm has a higher incentive to invest in network improvements, which has positive consequences on market development.

Also, retail-minus regulation does not require that the regulator has precise information about firms' costs. This is a very important feature for a regulatory instrument considering the deep difficulties that regulators face in gathering information about internal characteristics of the firms, in particular in new markets where there is high uncertainty about costs.

Retail-minus allows the development of competition in downstream market and, if the regulator carefully defines this instrument, the damage on the incentives of the incumbent firm to invest might be limited. Therefore, retail-minus has good performance as a transitory instrument to full deregulation of the market.

Appendix A

Table A1

Broadband access in OECD countries per 100 inhabitants, June 2005

	DSL		Cable Modem		Other Platforms		Total
		%		%		%	
Australia	8.5	77.3	2.4	21.8	0.1	0.9	11.0
Austria	7.0	56.0	5.4	43.2	0.1	0.8	12.5
Belgium	11.0	60.1	7.3	39.9	0.0	0.0	18.3
Canada	9.4	49.0	9.7	50.5	0.1	0.5	19.2
Czech Republic	1.8	64.3	1.0	35.7	0.0	0.0	2.8
Denmark	13.2	60.8	6.1	28.1	2.4	11.1	21.7
Finland	16.3	87.2	2.2	11.8	0.2	1.1	18.7
France	11.9	93.7	0.8	6.3	0.0	0.0	12.7
Germany	9.9	96.1	0.3	2.9	0.1	1.0	10.3
Hungary	2.9	63.0	1.6	34.8	0.1	2.2	4.6
Iceland	21.0	96.8	0.3	1.4	0.4	1.8	21.7
Ireland	3.5	79.5	0.4	9.1	0.5	11.4	4.4
Italy	9.4	94.0	0.0	0.0	0.6	6.0	10.0
Japan	11.0	67.1	2.4	14.6	3.0	18.3	16.4
Korea	13.9	54.5	8.9	34.9	2.7	10.6	25.5
Luxembourg	10.4	88.9	1.3	11.1	0.0	0.0	11.7
Mexico	0.8	80.0	0.2	20.0	0.0	0.0	1.0
Netherlands	13.6	60.4	8.9	39.6	0.0	0.0	22.5
New Zealand	6.4	91.4	0.3	4.3	0.3	4.3	7.0
Norway	14.8	81.3	2.5	13.7	0.9	4.9	18.2
Poland	2.5	75.8	0.7	21.2	0.1	3.0	3.3
Portugal	5.1	52.0	4.7	48.0	0.0	0.0	9.8
Slovak Republic	1.2	75.0	0.3	18.8	0.1	6.3	1.6
Spain	7.0	75.3	2.2	23.7	0.1	1.1	9.3
Sweden	11.3	68.5	2.7	16.4	2.5	15.2	16.5
Switzerland	12.7	62.6	7.2	35.5	0.4	2.0	20.3
Turkey	1.1	100.0	0.0	0.0	0.0	0.0	1.1
United Kingdom	9.7	71.9	3.8	28.1	0.0	0.0	13.5
United States	5.5	37.7	8.0	54.8	1.1	7.5	14.6

Source: OECD (Organisation for Economic Co-operation and Development)

Table A2

ADSL share of the incumbent firms in December 2003

Country	Incumbent firm	ADSL share (in %) of the incumbent firm
Austria	Austria Telekom	80
Belgium	Belgacom	86
Denmark	Teledanmark	92
Finland	Tele Sonera	93
France	France Telecom	57
Germany	Deutshe Telekom	100
Greece	OTE	47
Ireland	Eircom	81
Italy	Telecom Italia	85
Netherlands	KPN Telecom	100
Portugal	Portugal Telecom	85
Spain	Telefonica	79
Sweden	Telia Sonera	75
United Kingdom	British Telecom	50

Source:ECTA (European Competitive Telecommunications Association)

Appendix B

B1. Social welfare is represented as $W = CS+\pi_1+\pi_2 = \frac{1}{2}Q(1+\beta I+p-2c)-\frac{\varphi I^2}{2}$. Considering that, under retail-minus regulation, the access price is $w = p(1-x)$ and considering the results obtained in the third stage of the game, W is represented as $W = \frac{1}{2}(\frac{1+\beta I-c}{2} + \frac{1+\beta I+c}{2}\frac{x}{1+x})(1+\beta I + \frac{1+\beta I+c}{2(1+x)} - 2c) - \frac{\varphi I^2}{2}$. The value of x that maximizes W is $x = \frac{1+\beta I-c}{2c}$. Considering this value of x, the retail price and the access price are $p = c$ and $w = \frac{3c-1-\beta I}{2}$. From these results, and under the assumption that $I \geq 0$, the investment level that maximizes firm 1's profit is $I = 0$. Then, firm 1 has a negative profit which is offset by the positive profit of firm 2, and globally the highest quantity $1+\beta I - c$ is produced. These same results are obtained if the regulator directly defines the value of w that maximizes W defined as $W = \frac{1}{32}(3+3\beta I - c - 2w)^2 + (\frac{1+\beta I+2w+c}{4} - c)\frac{1+\beta I-c}{2} + (w-c)\frac{1+\beta I-2w+c}{4} - \frac{\varphi I^2}{2} + (\frac{1+\beta I+2w+c}{4} - w)\frac{1+\beta I-2w+c}{4}$.

B2. Under Assumption 1, the condition $2\varphi(1+x)^2 - \beta^2(1+2x-x^2) > 0$ is true for all $x \in (0,1)$. Then, $q_2^C > 0$ if $\varphi + c\varphi - c\beta^2 > 0$ or, equivalent, if $\varphi > \frac{2c}{1+c}\frac{\beta^2}{2}$. As $\frac{2c}{1+c} < 1$ for $c \in (0,1)$ and, by Assumption 1, $\varphi > \frac{\beta^2}{2}$, then $\varphi > \frac{2c}{1+c}\frac{\beta^2}{2}$ is true.

B3. The condition $I^C > I^B$ is equivalent to $\beta\frac{(1+2x-x^2)-c(1+2x+3x^2)}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)} > \frac{(1-c)(\beta+\varphi)}{4\varphi-\beta^2+\varphi^2-2\beta\varphi}$. As both the denominators are positive, it is necessary to guarantee that

$[\beta(1+2x-x^2) - c\beta(1+2x+3x^2)]\, h - (1-c)(\beta+\varphi)\left[2\varphi(1+x)^2 - \beta^2(1+2x-x^2)\right] > 0$, with $h = 4\varphi - \beta^2 + \varphi^2 - 2\beta\varphi$. This condition is equivalent to $ax^2+bx+d > 0$, with $a = -h\beta - 3\beta ch - (1-c)(\beta+\varphi)(2\varphi+\beta^2)$, $b = 2h\beta - 2\beta ch - (1-c)(\beta+\varphi)(4\varphi - 2\beta^2)$ and $d = h\beta - \beta ch - (1-c)(\beta+\varphi)(2\varphi-\beta^2)$. Considering Assumption 1, it is possible to conclude that $a < 0$ and $d > 0$ if $\beta < 2$.

Then ax^2+bx+d is a concave second degree equation in x whose roots are: $x_1 = \frac{-b-\sqrt{b^2-4ad}}{2a}$ and $x_2 = \frac{-b+\sqrt{b^2-4ad}}{2a}$. As $b^2 - 4ad > 0$, then x_1 and x_2 are real roots.

As $x_1 < 0$ and $x_2 > 0$, then $I^C > I^B$ if $x < x_2$.

B4. $I^C > I^A$ is equivalent to $\frac{\left[(1+2x-x^2)-c(1+2x+3x^2)\right](2\varphi-\beta^2)-(1-c)\left[2\varphi(1+x)^2-\beta^2(1+2x-x^2)\right]}{\left[(2\varphi(1+x)^2-\beta^2(1+2x-x^2)\right](2\varphi-\beta^2)} > 0$.

As the denominator is positive then $I^C > I^A$ if the numerator is also positive.

The numerator can be written as $4x^2(-\varphi - c\varphi + c\beta^2)$. However, $-\varphi - c\varphi + c\beta^2 < 0$, because $\frac{c}{1+c} < \frac{1}{2}$ and $\varphi > \frac{\beta^2}{2}$. Then, $I^C < I^A$ for all admissible x.

B5. As the demand function is linear, if $Q^C > Q^A$ then $CS^C > CS^A$. Then $Q^C > Q^A$ can be written as

$$\frac{(2\varphi x^2+3\varphi x+\varphi-\varphi xc-c\varphi-3c\beta^2x^2-c\beta^2x)(2\varphi-\beta^2)-\varphi(1-c)\left[(2\varphi(1+x)^2-\beta^2(1+2x-x^2)\right]}{\left[2\varphi(1+x)^2-\beta^2(1+2x-x^2)\right](2\varphi-\beta^2)} > 0.$$

Under Assumption 1 the denominator is positive. Then, to have $Q^C > Q^A$, the numerator must also be positive. Solving for x it is obtained:

$x < \frac{2\varphi^2-3\varphi c\beta^2-\varphi\beta^2+2\varphi^2c+c\beta^4}{-(2\varphi^2-5c\beta^2\varphi-3\varphi\beta^2+3c\beta^4+2c\varphi^2)}$. Let $x_3 = \frac{2\varphi^2-3\varphi c\beta^2-\varphi\beta^2+2\varphi^2c+c\beta^4}{-(2\varphi^2-5c\beta^2\varphi-3\varphi\beta^2+3c\beta^4+2c\varphi^2)}$.

It is necessary to guarantee that x_3 is positive. Let $N = 2\varphi^2 - 3\varphi c\beta^2 - \varphi\beta^2 + 2\varphi^2 c + c\beta^4$ and $D = 2\varphi^2 - 5c\beta^2\varphi - 3\varphi\beta^2 + 3c\beta^4 + 2c\varphi^2$. Then, $x_3 = \frac{N}{-D}$. x_3 is positive either if $N > 0$ and $D < 0$ or if $N < 0$ and $D > 0$. Analyzing the expressions of N and D it can be concluded that $N > 0$ and $D < 0$ if $z < c\beta^4 < y$ with $z = -\varphi(\varphi(2+2c) - \beta^2(1+3c))$ and $y = \frac{\varphi}{3}(\beta^2(3+5c) - \varphi(2+2c))$.

Notice that N can be written as

$N = \varphi\left[(\varphi(2+2c) - \beta^2(1+3c)\right] + c\beta^4$. Hence, $N > 0$ if $c\beta^4 > -\varphi\left[(\varphi(2+2c) - \beta^2(1+3c)\right]$; and D can be written as

$D = \varphi(\varphi(2+2c) - \beta^2(3+5c)) + 3c\beta^4$. Then, $D < 0$ if $c\beta^4 < -\frac{\varphi}{3}(\varphi(2+2c) - \beta^2(3+5c))$, because $\varphi < \beta^2$ and $\frac{3+5c}{2+2c} > 1$.

It is also important to note that, as $\varphi > \frac{\beta^2}{2}$ and $\frac{c}{1+c} < \frac{1}{2}$, the condition

$-\varphi\left[\varphi(2+2c) - \beta^2(1+3c)\right] < -\frac{\varphi}{3}\left[\varphi(2+2c) - \beta^2(3+5c)\right]$ is true; and that, as $\frac{2+4c}{4c} > 1$, the condition $-\frac{\varphi}{3}\left[\varphi(6c+2) - \beta^2(5+9c)\right] > -\frac{\varphi}{3}\left[\varphi(2+2c) - \beta^2(3+5c)\right]$ is true.

Finally, by Assumption 1, and knowing that $\frac{c}{1+c} < \frac{1}{2}$, it is not possible to have $N < 0$ and $D > 0$.

Now it can be demonstrated that, when $z < c\beta^4 < y$, $A < 0$ and $B > 0$, with $A = \varphi(\varphi(6c+2) - \beta^2(5+9c)) + 3c\beta^4$ and $B = 8\varphi^2 c + 3\varphi\beta^2 - 9\varphi c\beta^2 + c\beta^4$.

$A < 0$ is equivalent to $c\beta^4 < -\frac{\varphi}{3}(\varphi(6c+2) - \beta^2(5+9c))$, and this condition is verified because $-\frac{\varphi}{3}(\varphi(6c+2) - \beta^2(5+9c)) > -\frac{\varphi}{3}(\varphi(2+2c) - \beta^2(3+5c))$ is true.

Also, $B > 0$ is equivalent to $c\beta^4 > -8\varphi^2 c - 3\varphi\beta^2 + 9\varphi c\beta^2$ and this condition is verified because $z > -8\varphi^2 c - 3\varphi\beta^2 + 9\varphi c\beta^2$ is true.

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Figure 1 - Market Structure

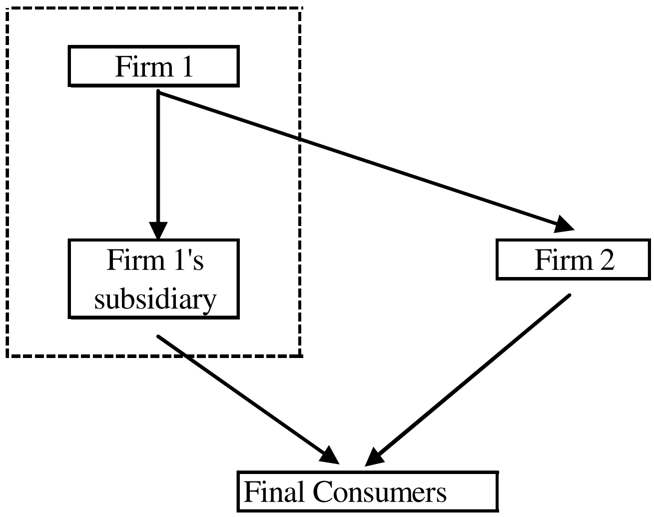

Table 1 - Results of scenarios A, B and C

Scenario	π_2	**I**	**CS**
A	0	$\frac{\beta(1-c)}{2\varphi-\beta^2}$	$\frac{\varphi^2(1-c)^2}{2(2\varphi-\beta^2)^2}$
B	>0	$\frac{(1-c)(\beta+\varphi)}{4\varphi-\beta^2+\varphi^2-2\beta\varphi}$	$\frac{1}{32}\left[3-3c+(3\beta-\varphi)\frac{(1-c)(\beta+\varphi)}{4\varphi-\beta^2+\varphi^2-2\beta\varphi}\right]^2$
C	>0	$\beta\frac{(1+2x-x^2)-c(1+2x+3x^2)}{2\varphi(1+x)^2-\beta^2(1+2x-x^2)}$	$\frac{\left(\varphi+3\varphi x+2\varphi x^2-c\beta^2x-3c\beta^2x^2-c\varphi x-c\varphi\right)^2}{2\left[2\varphi(1+x)^2-\beta^2(1+2x-x^2)\right]^2}$

Table 2 - Comparison of the Results

Scenario	**Foreclose**	**I**	**CS**
A	Yes	+++	++
B	No	+	+
C	No	++	+++

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