Access Pricing Under Stackelberg Competition: Results Interpretation and Regulatory Implications

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Abstract— This paper discusses the impact of the first-mover advantage on the optimal access price that maximizes social welfare. Thus, it compares the results derived when (a) the incumbent; and (b) the entrant, is the Stackelberg leader in the downstream market. It proves that regardless of which firm is the leader, the optimal regulatory policy is to set the access price to the marginal cost of providing the access (first best) since this policy provides zero profits for both firms. Any deviation from this policy leads either the incumbent or the entrant to make a loss and hence to exit the market.

***Index Terms*—Access pricing, Local loop, Competition, Social welfare**

I. Introduction

THE deregulation of network industries, such as telecommunications, raises several questions about the conditions of access to incumbent firm's network. Without access price regulation, when the incumbent firm is a monopolist in the provision of an essential input (network access) and also a supplier of final products, there is an obvious danger that this integrated firm will seek to exclude competing final product suppliers by setting high access prices, thereby raising rivals' costs [1], [13]. This strategy is known as price squeeze.

Suppose that a new Internet Service Provider (ISP) wants to enter a market monopolized by an incumbent. In this case, the new ISP (the new entrant) can either lease incumbent's facilities or create its own network in order to supply its services to its consumers. Figure 1 depicts graphically the framework that we are presenting.

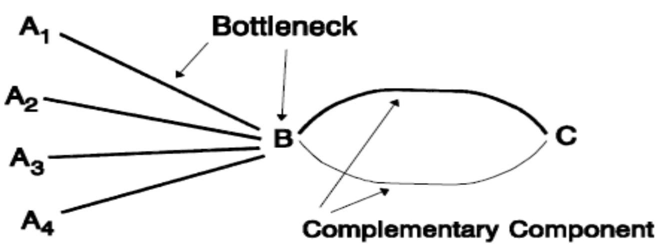

Fig. 1. The framework of access pricing

The monopolist owns all the links between points A_1, A_2, A_3, etc and B that represent the local loop. All of the local consumers A_1, A_2, A_3 , etc must use the monopolist's local loop to communicate with point C, which may be a website or another switch. The same firm that provides access to local loop also provides service from points A_1, A_2, A_3, etc., through switch B to point C.

Therefore, the new entrant can lease the incumbent's backbone facilities between BC (drawn in bold) and the links A_1B, A_2B, etc. in order to supply its consumers with the "through" service ABC (and CBA). In this case, the new entrant pays an access price for leasing the facilities. Alternatively, the new entrant can invest in its own network. However, that rival owns only facilities between BC since the local loop is still monopolized by incumbent due to its high fixed cost. As a result, the new entrant requires access to (through) the switch in order to provide the A_1, A_2, A_3, etc., customers with the "through" service ABC (and CBA). In this case, each provider pays an interconnection charge for having its traffic terminated on the rival network but the new entrant also pays an access price for having access to the local loop.

The above access issues can be categorized into the two broader categories of access pricing problem: *one-way* access and *two-way* access. One-way access (or the access model) concerns the provision of bottleneck inputs by an incumbent network provider to new entrants, while two-way access (or the interconnection model) concerns reciprocal access between two networks that have to rely upon each other to terminate traffic [16]. In each case, policy makers intervene in the market in order to ensure that access price encourages the right amount of entry, efficient network investment and network utilization, while being manageable. The optimal access price in cases of one-way access has been discussed in [4], [6], [7], whereas the optimal access price in cases of two-way access has been discussed in [8], [9], [11], [12].

Our work is related to the literature on one-way access pricing under Stackelberg competition. Stackelberg model is an oligopoly model in which firms choose quantities sequentially. In our model there are only two firms and as a result it is described by Stackelberg duopoly: a model of duopolies under which two firms choose the quantity to produce with one firm (the leader) choosing before the other (the follower) in an observable manner. Stackelberg competition is widely applied to telecommunication market since:

i. incumbent has already developed network facilities that cover the whole market whereas new entrants invest mainly in profitable areas.
ii. incumbent was the only provider in the market before entry occurs. Therefore, it is reasonable that incumbent will have the largest market share due to the existence of switching costs.

As a result, incumbent supplies its consumers and then provide the unused network facilities to new entrants in order to supply their consumers. For the above reasons, the incumbent is thought to be the Stackelberg leader.

However, Ji-Ho Joo, Hyeon-Mo Ku & Jae-Cheol Kim [6] support that in view of the recent regulatory trend that the incumbent, when requested, is obligated to provide its own bottleneck facilities to entrants, it is more reasonable to take the entrant than the incumbent as the one who plays a leader role. In other words, the incumbent's decision is dependent on the entrant's access request, which is taken into account by the entrant in making its decision on facility lease.

Previous works examine a certain instrument of setting the access price under a certain type of competition. In our paper, we examine the effect of each type of Stackelberg competition (when the incumbent is leader and when the new entrant is leader) on the social welfare. Then, we compare the results in order to draw regulatory implications. As a result the regulator has a broader knowledge about the possible outcomes that result from the competition between incumbent and new entrant. Hence, regulator can take the necessary measures in order to maximize social welfare and encourage the right amount of entry based on an elaborate analysis of the possible scenarios.

We have to note that our work also differs from previous works in another point:

Related works focus their attention on telephone services. They suppose that the incumbent supplies services in an upstream (local telephone service) market, while both the incumbent and the new entrant supply services in a downstream (long-distance telephone service) market. In the downstream market, new entrant needs access to upstream networks in order to supply services. Thus, it pays an access price for leasing the facilities. In this case, links A_1B, A_2B, etc. represent the upstream market whereas BC represents the downstream market. As a result, demand for long-distance services is independent to that of local services. On the contrary, our work focuses on broadband services and especially on charging the access to the local loop. Both incumbent and new entrant supply broadband services, but the new entrant needs access to the local loop, which is monopolized by the incumbent. In this case, there is a unique service (the broadband service) with its own demand.

The sections of the paper will assume the following:

- Each provider has its own network in order to supply internet services in the market. However, the entrant pays an access price α to the incumbent for having access to the local loop, which is monopolized by the incumbent.
- The regulator sets the optimal access price that maximizes social welfare W and then the providers determine their production levels that maximize their profits.
- One unit of the facilities is required to supply one unit of the final product.
- There is no outward parallel shift in demand due to an increase in the level of investment.
- The price of the through service ABC (and CBA) is not subject to direct price regulation.
- Since we focus on the access problem, the interconnections among peers are governed by "bill-and keep" arrangements; that is, they do not pay termination charges to each other [9].
- The final services supplied by the providers are homogeneous.
- We set up a linear model in order to derive intuitive implications of this game.

Our analysis proceeds as follows: In section II, we set up a basic model. In section III, we present the model of Stackelberg competition of an entry game when the incumbent is leader and when the new entrant is leader. In section IV, we analyze the outcomes under each type of competition. In section V, we draw regulatory implications from the interpretation of the results presented in section IV. The final section summarizes the above implications from regulatory point of view.

II. The Model

Let q_i, q_e be the quantity supplied by the incumbent and the new entrant respectively. The total quantity supplied by the providers is then $q = q_i + q_e$. The demand function is given by $P = P(q)$. The cost function of the incumbent is $C_i(q_i, q_e)$, whereas the cost function of the entrant is $C_e(q_e)$. Incumbent's profit is given by

$$\pi_i = P(q)q_i + aq_e - C_i(q_i, q_e) \tag{1}$$

and new entrant's profit is given by

$$\pi_e = P(q)q_e - aq_e - C_e(q_e) \tag{2}$$

According to the linear model, demand function is

$$P = A - Bq = A - Bq_i - Bq_e \tag{3}$$

where all parameters are strictly positive and cost functions are

$$C_i = c_b q_i + c_a q_i + c_a q_e \tag{4}$$

$$C_e = c_b q_e \tag{5}$$

where c_b is the marginal cost of providing the complementary component and c_a is the marginal cost of the access itself, and all are strictly positive. Note that since we focus on the effect of access price ($a \geq 0$) and the type of competition on the decisions of the providers, we have supposed that the providers have identical marginal cost of providing the complementary component.

We assume that regulator sets the optimal access price that maximizes social welfare W defined as the unweighted sum of profits and consumer surplus.

We then consider two cases according to the type of competition between incumbent and new entrant after knowing the optimal access price. In the first case, the incumbent is Stackelberg leader and the new entrant is Stackelberg follower, while in the second case the new entrant is Stackelberg leader and the incumbent is Stackelberg follower. The Stackelberg leader moves first (decide its optimal capacity/output) and then the follower provider moves sequentially.

III. Competition Between The two ISPs

A. The incumbent is Stackelberg leader

Substituting (3) and (4) in (1) gives the incumbent's profit function

$$\pi_i = Aq_i - Bq_i^2 - Bq_i q_e + aq_e - c_b q_i - c_a q_i - c_a q_e \tag{6}$$

The first-order condition is

$$\frac{\partial \pi_i}{\partial q_i} = \frac{A + c_b + a}{2} - Bq_i - c_b - \frac{c_a}{2} - \frac{a}{2} = 0 \tag{7}$$

which gives the level of output (q_i) that maximizes profits for the incumbent, the leader.

$$q_i = \frac{A - c_b - c_a}{2B} \tag{8}$$

The incumbent supposes that the entrant will follow its best response and hence subtract it away from the market demand to find its residual demand curve. Using this residual demand curve, the incumbent defines the price P .

$$P = \frac{A + 3c_b + c_a + 2\alpha}{4} \tag{9}$$

Total output q is the quantity that gives rise to price P using the market demand curve D.

$$q = \frac{3A - 3c_b - c_a - 2\alpha}{4B} \tag{10}$$

The entrant (the follower) produces the difference between total output (q) and the output produced by the leader.

$$q_e = \frac{A - c_b + c_a - 2\alpha}{4B} \tag{11}$$

Substituting (8), (9) and (11) in (1) gives the incumbent's profits π_i , whereas substituting (8), (9) and (11) in (2) gives the new entrant's profits π_e .

$$\pi_i = \frac{A^2 - 2Ac_b - 6Ac_a + 6c_a c_b + c_b{}^2 + c_a{}^2 + 4Aa - 4ac_b + 4ac_a - 4a^2}{8B} \tag{12}$$

$$\pi_e = \frac{A^2 - 2Ac_b + 2Ac_a - 2c_a c_b + c_b{}^2 + c_a{}^2 - 4Aa + 4ac_b - 4ac_a + 4a^2}{16B} \tag{13}$$

The function that gives the consumer surplus (CS) for every access price is given by:

$$CS = \frac{9A^2 - 18Ac_b - 6Ac_a + 6c_a c_b + 9c_b{}^2 + c_a{}^2 - 12Aa + 12ac_b + 4ac_a + 4a^2}{32B} \tag{14}$$

We have already mentioned that social welfare is defined as the unweighted sum of profits and consumer surplus. As a result, social welfare is the sum of (12), (13) and (14). Moreover, the change in social welfare caused by a marginal change in the access price is the sum of the changes in incumbent's profits, new entrant's profits and consumer surplus caused by a marginal change in the access price. The change in social welfare caused by a marginal change in the access price is given by:

$$\frac{\partial W}{\partial a} = \frac{-A + c_b + 3c_a - 2a}{8B} \tag{15}$$

The first order condition is $\frac{\partial W}{\partial a} = 0$ which gives the level of access price that maximizes social welfare.

$$\alpha^* = \frac{-A + c_b + 3c_a}{2} \tag{16}$$

Substituting (16) in (8) and (11) gives the optimal capacity decision of incumbent and new entrant respectively.

$$q_i^* = \frac{A - c_b - c_a}{2B} \tag{17}$$

$$q_e^* = \frac{A - c_b - c_a}{2B} \tag{18}$$

The sum of (17) and (18) gives the optimal level of total output which gives rise to the price in the market.

$$q^* = \frac{A - c_b - c_a}{B} \tag{19}$$

$$P^* = c_b + c_a \tag{20}$$

Then, substituting (16) in (12), (13) and (14) gives the incumbent's profits, new entrant's profits and consumer surplus when the access price is set to its optimal level.

$$\pi_i^* = \frac{-A^2 + 2Ac_b + 2Ac_a - 2c_a c_b - c_b{}^2 - c_a{}^2}{4B} \tag{21}$$

$$\pi_e^* = \frac{A^2 - 2Ac_b - 2Ac_a + 2c_a c_b + c_b{}^2 + c_a{}^2}{4B} \tag{22}$$

$$CS^* = \frac{A^2 - 2Ac_b - 2Ac_a + 2c_a c_b + c_b{}^2 + c_a{}^2}{2B} \tag{23}$$

B. The new entrant is Stackelberg leader

Substituting (3) and (5) in (2) gives the new entrant's profit function

$$\pi_e = Aq_e - Bq_e^2 - Bq_i q_e - aq_e - c_b q_e \tag{24}$$

The first-order condition is

$$\frac{\partial \pi_e}{\partial q_e} = \frac{A + c_b + c_a}{2} - Bq_e - c_b - a = 0 \tag{25}$$

which gives the level of output (q_e) that maximizes profits for the new entrant, the leader.

$$q_e = \frac{A - c_b + c_a - 2\alpha}{2B} \tag{26}$$

The new entrant supposes that the incumbent will follow its best response and hence subtract it away from the market demand to find its residual demand curve. Using this residual demand curve, the new entrant defines the price P.

$$P = \frac{A + 3c_b + c_a + 2\alpha}{4} \tag{27}$$

Total output q is the quantity that gives rise to price P using the market demand curve D.

$$q = \frac{3A - 3c_b - c_a - 2\alpha}{4B} \tag{28}$$

The incumbent (the follower) produces the difference between total output (q) and the output produced by the leader.

$$q_i = \frac{A - c_b - 3c_a + 2\alpha}{4B} \tag{29}$$

Substituting (26), (27) and (29) in (1) gives the incumbent's profits π_i, whereas substituting (26), (27) and (29) in (2) gives the new entrant's profits π_e.

$$\pi_i = \frac{A^2 - 2Ac_b - 14Ac_a + 14c_a c_b + c_b{}^2 + c_a{}^2 + 12Aa - 12ac_b + 12ac_a - 12a^2}{16B} \tag{30}$$

$$\pi_e = \frac{A^2 - 2Ac_b + 2Ac_a - 2c_a c_b + c_b{}^2 + c_a{}^2 - 4Aa + 4ac_b - 4ac_a + 4a^2}{8B} \tag{31}$$

The function that gives the consumer surplus (CS) for every access price is given by:

$$CS = \frac{9A^2 - 18Ac_b - 6Ac_a + 6c_a c_b + 9c_b{}^2 + c_a{}^2 - 12Aa + 12ac_b + 4ac_a + 4a^2}{32B} \tag{32}$$

Once again, the level of access price that maximizes social welfare is given by

$$\alpha^* = \frac{-A + c_b + 3c_a}{2} \tag{33}$$

Substituting (33) in (29) and (26) gives the optimal capacity decision of incumbent and new entrant respectively.

$$q_i^* = 0 \tag{34}$$

$$q_e^* = \frac{A - c_b - c_a}{B} \tag{35}$$

The sum of (34) and (35) gives the optimal level of total output which gives rise to the price in the market.

$$q^* = \frac{A - c_b - c_a}{B} \quad (36)$$

$$P^* = c_b + c_a \quad (37)$$

Then, substituting (33) in (30), (31) and (32) gives the incumbent's profits, new entrant's profits and consumer surplus when the access price is set to its optimal level.

$$\pi_i^* = \frac{-A^2 + 2Ac_b + 2Ac_a - 2c_a c_b - c_b{}^2 - c_a{}^2}{2B} \quad (38)$$

$$\pi_e^* = \frac{A^2 - 2Ac_b - 2Ac_a + 2c_a c_b + c_b{}^2 + c_a{}^2}{2B} \quad (39)$$

$$CS^* = \frac{A^2 - 2Ac_b - 2Ac_a + 2c_a c_b + c_b{}^2 + c_a{}^2}{2B} \quad (40)$$

IV. Results Interpretation

The analysis of the outcomes q_i^*, q_e^*, q^*, P^*, π_i^*, π_e^*, CS^* and W^* that stem from the access price that maximizes social welfare gives us the opportunity to draw the following propositions:

Proposition 1. *The type of competition between the providers does not affect the optimal level of the total output, the price of the service, the total profits and the consumer surplus. As a result, it does not affect the social welfare.*

Equations (19) and (36) give the total output when social welfare is maximized under each type of Stackelberg competition. It is obvious that the type of competition does not affect the total output.

Comparing (20) and (37) we infer that the type of competition does not affect the price of the service.

As a result, it is reasonable to assume that the consumer surplus would be the same under each type of competition. Comparing (23) and (40) we conclude that the previous assumption is true.

Last but not least, we note that the total profits are zero under each type of competition.

Since social welfare is the sum of profits and consumer surplus, we infer that the social welfare is the same regardless of the type of competition between the providers. The implication is that the regulator and the consumers are indifferent to the type of competition between the providers.

Proposition 2. *The profits of each provider, which stem from the optimal access price, are affected by the difference between the access price and the marginal cost of providing the access.*

We have already proven that under each type of competition the price of the broadband service that maximizes social welfare is given by $P^* = c_b + c_a$. As a result, incumbent's profits are also given by $\pi_i^* = (a^* - c_a)q_e$ and new entrant's profits are also given by $\pi_e^* = (c_a - a^*)q_e$. It is obvious that if incumbent's profits are positive (negative), new entrant's profits are negative (positive), unless both providers' profits are zero.

We have to note that when the optimal access price is equal to zero ($a^* = 0$) or the optimal access price is negative ($a^* < 0$), incumbent's profits are negative ($\pi_i^* < 0$) and new entrant's profits are positive ($\pi_e^* > 0$). However, when the optimal access price is positive ($a^* > 0$) we have to discriminate between three cases:

i. The level of the access price is higher than the marginal cost of providing the access, i.e. $a^* > c_a$. As a result, $a^* - c_a > 0 \Rightarrow c_b + c_a > A \Rightarrow P > A$. In this case the price is above the point that the demand curve intersects the price axis and as a result no one consumer is willing to buy the broadband service.

ii. The level of the access price is equal to the marginal cost of providing the access, i.e. $a^* = c_a$. As a result, $a^* - c_a = 0 \Rightarrow c_b + c_a = A \Rightarrow P = A$. In this case the price is equal to the point that the demand curve intersects the price axis and as a result the total quantity is zero. Of course, each provider's output and each provider's profits are zero. Furthermore, consumer surplus and social welfare are zero, too. Once again, no one consumer is willing to buy the broadband service.

iii. The level of the access price is lower than the marginal cost of providing the access, i.e. $a^* < c_a$. As a result, $a^* - c_a < 0 \Rightarrow c_b + c_a < A \Rightarrow P < A$. In this case the price is below the point that the demand curve intersects the price axis and as a result incumbent's profits are negative and new entrant's profits are positive. As we have already mentioned, the total profits are zero. In this case the social welfare is equal to the consumer surplus which is positive. The total output is positive as well. Moreover, when the new entrant is considered as leader, the new entrant serves the whole market, whereas when the incumbent is Stackelberg leader, the two providers have gained the same market share.

Proposition 3. *The incumbent's loss is minimized when the optimal access price is positive and the incumbent is Stackelberg leader.*

It is obvious that when $a^* > 0$, incumbent's loss is lower than when $a^* = 0$ or $a^* < 0$. The reason is that when $a^* > 0$, the difference between the access price and the marginal cost of providing the access is minimized.

However, from (21) and (38) we infer that the incumbent's loss is lower when the incumbent is the Stackelberg leader.

The reason is that when the incumbent is leader, it accepts an additional marginal cost of α/2 in order to continue to produce the same level of output regardless of the level of access price (see equation 8). By accepting this additional marginal cost, the incumbent achieves not only to minimize its loss but also to minimize new entrant's profits. In addition, it achieves to have the same market share with the new entrant, whereas under the other type of Stackelberg competition the incumbent produces nothing.

V. Regulatory Implications

The analysis of the above propositions leads to some very significant regulatory implications.

First of all, the regulator is interesting in maximizing the social welfare. However, we have proven that the optimal access price causes the total profits to be zero and the consumer surplus to its maximum level. Since, this level of consumer surplus is the same under each type of Stackelberg competition, we infer that the social welfare is the same under each type of Stackelberg competition, as well. Hence, the regulator is indifferent to the type of competition between the providers, since each type leads to the same level of social welfare. In addition, consumers are also indifferent to the type of competition because the optimal price and the optimal total output are the same under each type of competition.

Secondly, regulator intervenes in the market by setting the access price in order to prevent the incumbent from excluding the new entrant. It is obvious, that regulator aims at encouraging the right amount of entry that, in turn, increases the level of competition and the social welfare. However, from proposition 2 we infer that there are three cases in which the optimal price leads to a positive quantity demanded (there are consumers that are willing to buy the service): i) when $a^* = 0$, ii) when $a^* < 0$ and iii) when $a^* > 0$ and $a^* < c_a$. In all these cases the incumbent's profits are negative and as a result the incumbent exits the market. Hence, the new entrant is only one provider to supply the market. It is reasonable that the monopolist produces its profit maximizing quantity (monopoly quantity). In this case, the total output decreases, price increases and social welfare decreases. In conclusion, the final result is exactly the opposite of the initial aim of regulator. We have to note that this conclusion applies to all types of competition. As a result, the access price that maximizes social welfare fails to achieve an equilibrium point at which consumers are willing to buy the service and both providers' profits are positive.

In conclusion, the *unconstrained* maximization of social welfare is proved to be an inefficient instrument of setting the access price regardless of the type of competition between the providers. As a result, we have explained why regulators do not apply the *unconstrained* maximization of social welfare in order to set the access price that encourages the right amount of entry.

VI. Conclusion

The role of regulator in telecommunication industry is versatile. Among several problems that it has to regulate is the choice of the optimal charge for access to incumbent firm's network and especially to the local loop. The optimal access price should be the result of an elaborate analysis of the market structure, the type of competition, the objectives of regulator, the available instruments of setting the access price and their attributes. Usually, regulator sets the access price that encourages the right amount of entry, efficient network investment and network utilization, while being manageable and increases social welfare. However, none of the available instruments fulfill all the above objectives. Hence, regulator has to assess the possible outcomes of applying different instruments under different market conditions in order to choose the optimal access price.

In this paper we proved that the access price that maximizes social welfare is the same under each type of Stackelberg competition. This optimal level of access price causes the social welfare to be the same under each type. However, the *unconstrained* maximization of social welfare is an ineffective instrument of setting the access price since it leads the incumbent to have loss and as a result to exit the market. Therefore, the regulator should apply alternative instruments for setting the access price that fulfill its aims.

We have to note that this paper should be regarded as a complement to the existing ones that focus on other types of competition between the providers, such as Cournot and Bertrand competition, and other available instruments, such as the Efficient Component Pricing Rule (ECPR) and retail minus.

The authors already work on modifying the assumption that the providers have identical marginal costs of providing the complementary component. Then, the results will be compared to the results of the application of alternative instruments under different types of competition.

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