Revenue-Sharing Regulation of Interconnection Charges

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Abstract

In this paper, we explore the economic principle behind the revenue-sharing rule for interconnection charges. First, we assert that firms can collude by splitting the revenues equally i.e., choosing the revenue-sharing ratio equal to 1/2. Also, we characterize the optimal revenue-sharing ratio in a model of horizontal interconnection and discuss the relation between the optimal ratio and the optimal access price.

1 Introduction

As competition has been promoted in the telecommunications industry during last two decades, the way the industry operates has also been significantly changed. Among other

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things, since interconnection dispenses with unneccesary network duplication and maximizes network externalities, interconnection among networks becomes necessary and mandatory everywhere. Naturally, the determination for the interconncetion charge has been an important and a subtle issue among operators and regulators. Usually, a high access charge has been used for the purpose of an anti-competitive activity, say, market foreclosure in case of vertical (or one-way) interconnection, or for the purpose of collusion in case of horizontal (or two-way) interconnection. This makes it inevitable for the regulatory authority to regulate the access charge in some way.

There are several approaches to setting interconnection charges. It is useful to categorize them as three types by and large.[1] The first category is to reflect neither costs incurred nor revenues accrued by interconnecting the networks. Such type of pricing rule is free of charge as "bill-and-keep" or "sender-keep-all" arrangements.[2] The second category is to reflect costs incremented by interconnecting the networks, which is most widely used. This type of pricing rule is frequently called "cost-based". The third type is to reflect revenues from interconnection. Many inteconnect arrangements between fixed and mobile operators are based on revenue sharing.[3] Typically, the mobile operator takes 80% of the revenue from a call and the fixed operator takes 20%.[4]

Revenue sharing has been used mainly for two reasons. First, it is relatively simple to understand and to operate. Second, it rebalances returns of the operators when retail prices are distorted in a way.[5] However, as far as we know, no one has so far investigated the economic principle behind the revenue-sharing rule. In this paper, we will examine how this

[1] In fact, there is another approach to determining interconnection charges, which is based on retail prices. For example, when TCNZ in New Zealand negotiated its first interconnect agreement with the entrant Clear, it set interconnection charges close to the 1991 retail prices for business customers.

[2] This category of the access charge is found in interconnection between paging service providers and LECs or in settlements of international calls.

[3] See Lewin and Kee (1997) p. 88.

[4] In Malaysia, Indonesia and the Czeck Republic, revenue sharing is used among fixed network operators as well.

[5] Revenue sharing has demerits as well. First, it may reduce the incentive for the incumbent to rebalance retail prices to underlying costs. Second, it does not give the right price signals to entrants who have to decide whether to build their own facilities or rent from the incumbent. Third, revenue sharing in proportion to costs could lead to the perverse situation where an operator can increase its profits by increasing its costs.

rule works and find the optimal revenue-sharing ratio in a model of horizontal inteconnection. Also, we can reasonably conjecture that the revenue-sharing rule is equivalent to the cost-based rule if the revenue-sharing ratio is properly chosen. In this light, we will explore the relation between the optimal ratio and the optimal access price.[6]

2 Model and Analysis

There are two networks which are interconnected with each other. Two networks are operated by two independent firms i, $i = A, B$ respectively. We can think of network A as fixed and of network B as mobile. Each network has a certain number of subscribers. We assume that switching between networks incurs considerable switching costs, so that two networks are ex post not effective substitutes to each other.[7]

A firm takes in revenues from calls originating from it. For analytic simplicity, we assume that subscribers to network i make calls only to subscribers to network $j(\neq i)$, that is, there are no inbound calls. For a firm to operate the network, therefore, it is essential to use the other network as well as its own network. In other words, the access service is required for the operation.

Making a call costs $2c$, where c is the common cost of originating a call and of terminating a call. Besides, each firm incurs a fixed cost $f > 0$. We assume that interconnection charges are levied on the basis of the revenue-sharing rule and that they are reciprocal in the sense that they agree on a common revenue-sharing ratio.[8] If we denote the common

[6]There have been many articles on access pricing in horizontal inteconnection. (See Armstrong (1998), Laffont, Rey and Tirole (1998a. 1998b), Carter and Wright (1996), Economides, Lopomo and Woroch (1998), Doyle and Smith (1998), Kim and Lim (1999), etc.)

[7]It may be a more realistic model to assume that consumers can switch their network affiliation so that two networks are effective substitutes, but the analysis of such a model essentially adds nothing to the prediction of the outcome, although it is quite complicated. A detailed analysis can be available upon request from the authors.

[8]We may consider an alternative model of nonreciprocity in which each operator sets its own revenue-sharing ratio, α_i, simultaneously and then sets its price. In this model, however, it turns out that $\alpha^*_A = \alpha^*_B = 0$ in equilibrium, since the profit of firm i is monotonically increased as α_i is decreased, which yields an unrealistic outcome that both firms lose money. The intuitive reason why double marginalization does not appear is that the buyer determines the price for the access service in this model.

revenue-sharing ratio by $\alpha \in (0,1)$, firm i pays $\alpha p_i q_i$ as the interconnection charge, where p_i is the price firm i charges for a call and q_i is the quantity of calls originating from network i. Here, αp_i corresponds to the typical access price per call.[9] The assumption of no substitutability between two networks implies that the demand for calls originating from network i is independent of p_j. The demand function is $q_i = D(p_i)$ where $D'(p) < 0$.

It is natural to assume that firms choose their prices simultaneously in a noncooperative fashion after the reciprocal revenue-sharing ratio α is chosen (either by the firms or by the regulator). Below, we will see price decisions of the firms given that α is set.

The profit function of firm i is given by

$$\pi_i(p_i, p_j) = (1-\alpha)p_i q_i - c(q_i + q_j) + \alpha p_j q_j - f, i = 1, 2, j \neq i \tag{1}$$

Since π_i is additively separable in p_i and p_j, the optimal price for firm i, p_i^*, is determined independent of the price of the other firm p_j, and it satisfies

$$\frac{\partial \pi_i}{\partial p_i} = (1-\alpha)[D(p_i^*) + p_i^* D'(p_i^*)] - cD'(p_i^*) = 0, \tag{2}$$

as long as the second order condition is satisfied. Consequently, the symmetric equilibrium[10] given α is $(p^*(\alpha), p^*(\alpha))$ where $p^*(\alpha)$ satisfies

$$D(p^*(\alpha)) + (p^*(\alpha) - \frac{c}{1-\alpha})D'(p^*(\alpha)) = 0, \tag{3}$$

and this yields the relation

$$\frac{(1-\alpha)p^*}{c} = \frac{\eta}{\eta - 1}, \tag{4}$$

where η is the price elasticity of demand. Then, we can establish the following propositions.

Proposition 1 *$p^*(\alpha)$ is strictly increasing in α.*

Proof. See the appendix.

The intuition is crystal clear. If α is increased, profit-maximizing prices are increased due to an increase in the access charge expenditures. This implies that firms can collude by agreeing on a higher α, just as they can collude by agreeing on a higher access price per call. (See Armstrong (1998) and Laffont et al. (1998a).)

[9] Notice, however, that αp_i is not constant over calls, since p_i is varied with q_i.

[10] The Nash equilibrium is meant by "the equilibrium".

Proposition 2 *$p^*(\alpha) \geq p^m$ if and only if $\alpha \geq 1/2$, where $p^m = \arg\max(p - 2c)D(p)$.*

Proof. This is clear from (3) and proposition 1.

This implies that, if $\alpha = 1/2$, the resulting profit-maximizing price will be the monopoly price p^m.

Now, let us turn to the determination of α. If two firms set α cooperatively, they will choose α maximizing the joint profit, expecting that they will charge prices according to $p^*(\alpha)$. The joint profit of two firms is $\Pi = \pi_A + \pi_B = 2(p^*(\alpha) - 2c)D(p^*(\alpha)) - 2f$. Thus, the collusive revenue-sharing ratio, α^*, must satisfy $\frac{d\Pi}{d\alpha} = \frac{d\Pi}{dp}\frac{dp^*}{d\alpha} = 0$. Since $\frac{dp^*(\alpha)}{d\alpha} > 0$ by proposition 1, α^* must satisfy $\frac{d\Pi}{dp} = 0$ i.e. $p^*(\alpha^*) = p^m$, which implies that $\alpha^* = \frac{1}{2}$ and consequently both firms charge the monopoly price p^m in equilibrium. However, we can easily infer that this ratio is far from socially optimal. If it is in fact, there will be a need for the intervention of the government in the process of negotiating over α.

One of the guiding principles in determining the optimal ratio will be Ramsey pricing. To define the Ramsey revenue-sharing ratio, let us first define Ramsey pricing in this context.

Ramsey pricing is defined as regulatory prices that maximize the social welfare subject to the constraint that the costs of the monopolistic firm do not exceed its revenues. This definition can be naturally adapted to the oligopolistic context as in our model in the following way. A Ramsey price p^R is a linear symmetric price that maximizes the social welfare (W) defined as the sum of the consumers' surplus (CS) and the industry profits (Π), subject to the requirement that the industry profits are nonnegative. Formally, p^R solves

$$\max_p W(p) \equiv CS(p) + \Pi(p) = 2[\int_0^{D(p)} D^{-1}(q)dq - pD(p)] + \Pi(p) \tag{5}$$

$$\text{subject to } \Pi(p) \geq 0, \text{ where } \Pi(p) \equiv \pi_A(p,p;\alpha) + \pi_B(p,p;\alpha).$$

The Lagrangian function for this optimization problem can be defined as $L(p,\lambda) = CS(p) + (1+\lambda)\Pi(p)$. The first-order conditions are

$$\frac{\partial L}{\partial p} = \lambda D(p^R) + (1+\lambda)(p^R - 2c)D'(p^R) = 0 \tag{6}$$

$$\frac{\partial L}{\partial \lambda} = \Pi(p^R) \geq 0, \ \lambda \geq 0, \ \lambda\frac{\partial L}{\partial \lambda} = 0 \tag{7}$$

From (6), it is implied that

$$\frac{(p^R - 2c)}{p^R} = \frac{\lambda}{1 + \lambda}\frac{1}{\eta}. \tag{8}$$

If $\lambda = 0$, we have $p^R = 2c$ from (8), so that firms suffer losses by fixed costs. This implies that $\lambda > 0$ and thus $\frac{\partial L}{\partial \lambda} = \Pi(p^R) = 0$. That is, the constraint must be binding and the Ramsey price can be selected as the smallest p that makes the constraint binding, since the consumers' surplus is strictly decreasing in p. Thus, p^R must satisfy

$$\Pi(p^R) = 2[(p^R - 2c)D(p^R) - f] = 0 \text{ , or equivalently, } (p^R - 2c)D(p^R) = f \tag{9}$$

Notice that $p^R < p^m$, assuming that $\Pi(p^m) > 0$. (See figure 1.)

Now, the Ramsey revenue-sharing ratio α^R can be defined as

$$\max_{\alpha} W(p^*(\alpha)) \text{ subject to } \Pi(p^*(\alpha)) \geq 0, \tag{10}$$

Or, alternatively, we can define the Ramsey revenue-sharing ratio as α satisfying $p^*(\alpha^R) = p^R$. Since $\Pi(p^R) = 0$ and $\frac{\partial p^*(\alpha)}{\partial \alpha} > 0$ by proposition 1, we can easily see that the two alternative definitions of α^R are equivalent. Then, α^R can be characterized by (4) as

$$\frac{(1 - \alpha^R)p^R}{c} = \frac{\eta}{\eta - 1}, \tag{11}$$

where $(1 - \alpha^R)p^R$ is the average revenue net of the access charge. This is a variation of the standard markup formula. This formula says that there ought to be a lower markup if the demand is more elastic. Furthermore, we have

Proposition 3 $\alpha^R < 1/2$

Proof. Since $p^R < p^m$, this is clear from proposition 2.

This proposition simply implies that the revenue-sharing ratio should be regulated below a half to counteract the incentive of firms to collude by setting a high ratio equal to 1/2.

Meanwhile, Ramsey optimality in this model of revenue sharing does not require that the interconnection charge expenditure is below the access cost, unlike in models of the linear access price. This can be seen from the following counterexample.

Example: Suppose the demand function is $D(p) = p^{-2}$. This yields a constant price elasticity of demand equal to 2. Then, from (11), we have $\frac{\alpha^R p^R}{c} = \frac{p^R}{c} - 2$. Also, equation (9) implies that $2c < p^R < 4c$ and that $p^R \approx 4c$ if $f \approx \frac{1}{8c}$, which means that $\frac{\alpha^R p^R}{c} \approx 2$, if $f \approx \frac{1}{8c}$. Therefore, $\alpha^R p^R > c$.

Our analysis hitherto tells us that the regulatory authority can achieve the social optimum in Ramsey's sense by regulating the reciprocal revenue-sharing ratio, even though prices are set in a noncooperative way.

Finally, we will compare the result with that in the case where access prices are linear as in Armstrong and Laffont et al. If reciprocity of the access charge is assumed and the reciprocal access charge is denoted by a, the profit of firm i is

$$\pi_i = (p_i - c - a)D(p_i) + (a - c)D(p_j) \tag{12}$$

Then, the first-order condition implies that

$$D(p^{**}) + (p^{**} - c - a)D'(p^{**}) = 0, \tag{13}$$

where p^{**} is the symmetric equilibrium price. If the regulator is to implement the Ramsey price. Ramsey price p^R must satisfy this equation, which gives us the formula for the Ramsey access price,

$$\frac{p^R}{c + a^R} = \frac{\eta}{\eta - 1}. \tag{14}$$

Comparison of (11) with (14) establishes the following relation between the Ramsey revenue-sharing ratio and the Ramsey access price

$$1 - \alpha^R = \frac{c}{c + a^R}, \text{ or equivalently, } \alpha^R = \frac{a^R}{c + a^R}, \tag{15}$$

which implies that the ratio of the access charge expenditures out of the total revenues in the revenue-sharing rule should be equal to the ratio of the access charge expenditures out of the total costs in the cost-based rule.

3 Conclusion and Caveats

In this paper, we characterized the Ramsey revenue-sharing ratio yielding the constrained social optimum in a symmetric model of horizontal interconnection.

Although it is no doubt that this paper does contribute to literature on regulation of access charges in the sense that it is the first paper dealing with the revenue-sharing rule, it is also apparant that the model is quite restrictive. The model could be extended to an asymmetric one of horizontal interconnection. Also, a similar analysis could be made in a model of vertical interconnection. Despite the complexities involved, these issues are worth to be addressed.

Appendix

Proof of Proposition 1:

Let the LHS of (2) be $\Delta(p^*, \alpha)$. Total differentiation of (2) gives us $\Delta_1 dp^* + \Delta_2 d\alpha = 0$ where Δ_k is the partial derivative of Δ with respect to the k-th variable. Notice that $\Delta_1 < 0$ by the second order condition. On the other hand, $\Delta_2 = -D(p^*) - p^* D'(p^*) = -\frac{c}{1-\alpha} D'(p^*) > 0$. Therefore, $\frac{dp^*}{d\alpha} = -\frac{\Delta_2}{\Delta_1} > 0$.

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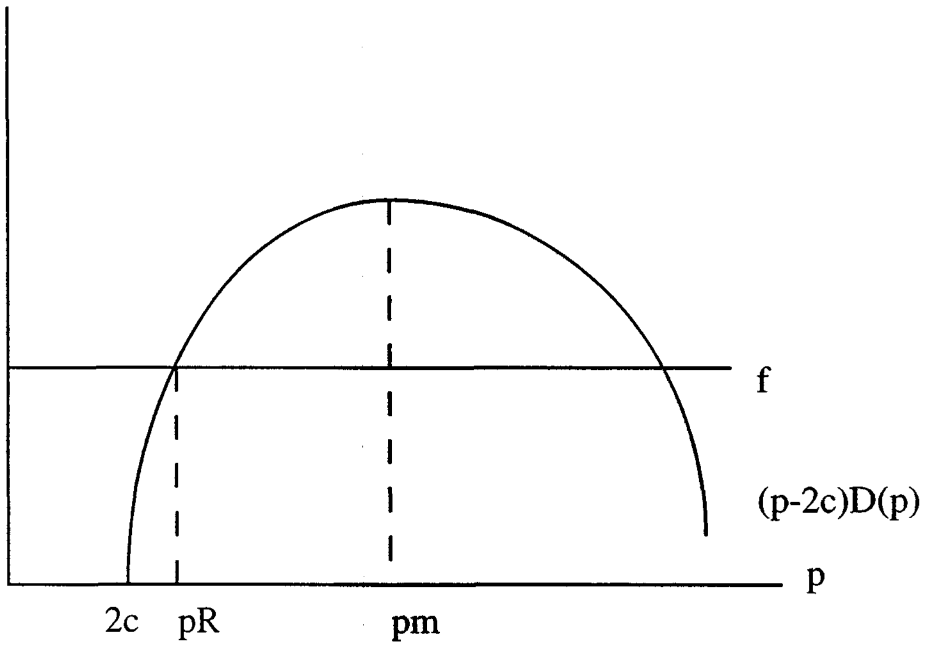

figure 1