Allocation of NTS (Non-Traffic Sensitive) Deficit in Telecommunications

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The cost in telecommunications industry can be divided into NTS (Non-Traffic Sensitive) cost and TS (Traffic Sensitive) cost. In principle, consumers bear the NTS cost by paying subscription charge and the TS cost by paying per-call charge. It is well known that when one considers network externality, it is socially optimal to charge subscription charge lower than the NTS cost and per-call charge higher than the TS cost.

The resulting NTS deficit has been conventionally compensated by the profits from the TS sector. If competition is introduced under this situation, it will necessarily be introduced into the TS sector (cf. cream skimming). In this case, the regulator confronts the question of whether new entrants should cross-subsidize incumbent's NTS deficit. If so, on what basis could it be shared among new entrants? Currently in Korea, NTS deficit is allocated amongst new entrants in proportion to access traffic. However, this method has been under controversy.

This paper explores the question of the optimal NTS deficit allocation. The conclusions are; first, it is appropriate for new entrants to bear the deficit; second, allocation according to demand elasticity and traffic is more efficient than the current method; and third, when the price is fixed by the regulator, allocation based on the traffic is justifiable. (*JEL* Classifications: D42, L51)

I. Prelude: Introducing Competition in Telecommunication Industry

The original purpose of regulation is to maximize social welfare by controlling the number of market entrants and price. Yet, in reality,

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regulation makes some groups advantageous and others disadvantageous. Thus interest groups try to exercise their possible influence over the regulator in order to enhance their own interests. Moreover, politicians and bureaucrats, who are able to influence regulation, might try to make their interest reflected in the regulation. Hence, there exists a possibility that price is influenced externally by interest groups. In this case, price will be distorted and this distorted price will result in distributional and productive inefficiency.

Since 1980s, competition has been globally introduced around the world to the public sectors including telecommunications industry in anticipation of positive efficiency gains. Why? First of all, competition can be a powerful measure to achieve productive efficiency and distributional efficiency. Competition can call forth diverse products, customer satisfaction, technological development, and long-term efficiency, while monopoly under regulation may not. For instance, a monopoly firm is usually inclined to devote much of its effort to exercise its influence over the regulatory body. If this effort succeeds, regulation would become inefficient. If it fails, the effort and funds themselves would be wasted by lobbying.

In belief of superiority of competition over regulation, Korea has actively introduced competition into her telecommunications market. The cost in the telecommunications industry can be divided into NTS (Non-Traffic Sensitive) cost and TS (Traffic Sensitive) cost, where the NTS cost refers to long-run fixed costs, while the TS cost refers to variable costs. In principle, consumers bear NTS cost through subscription charge and that of TS cost through per-call charge. It is well known that, to promote universal service and to achieve maximum consumer welfare under network externality, an optimal policy is to guide more consumers to join the network by charging subscription fee lower than the NTS cost. In order to compensate for the resulting NTS deficit,[1] the NTS sector is made up with the profit from the TS sector resulting from the higher per-call charge than the TS cost. If competition is introduced under this price structure, it will necessarily happen in the TS sector due to high profits from higher price. The regulator confronts the following problems; whether new entrants are responsible for the deficit or

[1]Methods to allocate the deficit are different in each country. In the UK, for instance, it is first divided on the basis of profits amongst services. And then it is divided on the basis of traffic between corporations within a service.

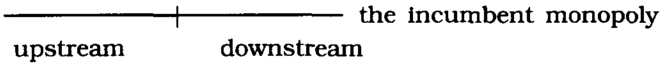

FIGURE 1

TELECOMMUNICATIONS MARKET BEFORE INTRODUCTION OF COMPETITION

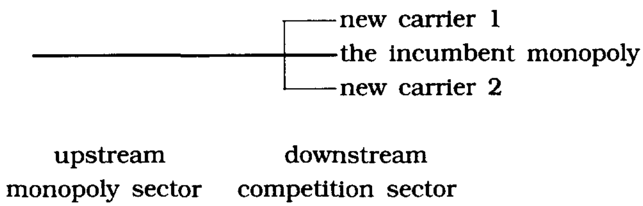

FIGURE 2

TELECOMMUNICATIONS MARKET AFTER INTRODUCTION OF COMPETITION

not, and if so, on what basis it could be shared.[2]

Let us explain this in more detail. Before the introduction of competition, the incumbent monopolizes the market as shown below in Figure 1. With the upstream (NTS sector) price lower than the cost and the downstream (TS sector) price higher than the cost, the telecommunications market is shaped in a form that the downstream sector cross-subsidizes the deficit of the upstream sector. When competition is introduced into the telecommunications market, new carriers necessarilly enter into the downstream sector[3] seeking higher profit from higher price. In other words, as shown in Figure 2, new carriers enter the downstream sector and do business by being interconnected with the incumbent's upstream sector. Here, a problem comes to arise whether the incumbent has any incentive to interconnect with the new entrants.

Once interconnection is achieved, one faces another problem whether

[2]Typically in telecommunications industry, marginal cost is low while fixed cost is high. NTS marginal cost is likely to be very low. If a carrier who installs and operates NTS sector should charge a marginal cost price, the deficit is likely to be the result in the NTS sector even without considering network externality. If the deficit is compensated by the profits of TS sector, it is important to search for an optimal method for allocation of the deficit.

[3]One of main reasons for active introduction of competition into telecommunciations market is that potential entrants has strongly insisted on opening the long distance call market.

new entrants in the downstream sector should be responsible for the NTS deficit incurred in the upstream sector. And if so, on what basis should it be allocated? By contrast, in monopoly age, the deficit in the upstream sector (no matter how it was generated; that is, in consideration of network externality or in consideration of equity such as universal service) was compensated with the profits from the downtream sector.

We will focus on the problems for relay interconnection[4] in this paper. We will assume that the problem of deficit in telecommunications industry should be solved within the industry.[5] In the next section, we will construct a simple model to examine the above-mentioned problems. In the Appendix, the existing system of access charge[6] in Korea will be presented.

II. A Model for the NTS Deficit Allocation

A simple model of telecommunications industry is constructed. First of all, we assume that there are three firms in the market, which produce a homogeneous final good; an incumbent monopoly firm and two new entrants.[7] We also assume that access to the upstream NTS sector is already allowed by the incumbent. We do not consider the case that incumbent provided access service directly to consumers

Let $C(q, z)$ be the cost function of the incumbent. It is the cost to supply q units of final goods and to supply z units of access to the new entrants ($z = z_1 + z_2$ where z_1 and z_2 mean the access services supplied to entrants 1 and 2 of the downstream TS sector). Hence, c_2 represents the incumbent's marginal cost in providing access service to new entrants and c_1 represents the incumbent's marginal cost in providing final good to customers.

For new entrants to provide one unit of final good to customers, it should purchase one unit of access services from the incumbent.

[4] This terminology is explained in the Appendix.

[5] It is an ideal method to deal with NTS deficit if the deficit is compensated with lump sum transfer by the government.

[6] It means the interconnection decree enacted in September, 1995. At present, revision of this decree is on the process.

[7] We consider two new entrants, because we need to analyze optimal allocation between these entrants. The incumbent plays a role to serve any residual demand.

When new entrants provide s units of services to customers after purchasing s units of access service, additional cost of $c(s)$ incurs. Also let us assume that the fixed cost which can influence the new entrant's market entrance is 0; i.e., $c(0)=0$. Marginal cost is assumed positive, $c'>0$. In addition, we assume that a, the price of access service, is a uniform price and that a new entrant is not able to influence the incumbent's access service price.

Suppose the price of final good of the incumbent is p. At this price, the incumbent should meet all the customer demands which new entrants do not satisfy. The incumbent should additionally meet the access service demand of new entrants. When access service price is a, the total cost for a new entrant providing s unit of final good is $as + c(s)$. Since new entrants are price-takers for access service price, supposing $m_i \equiv p - a_i$, $i = 1$ and 2, the objective profit functions of new entrants are as follows;

entrant 1 $\quad \pi_1(m_1) \equiv \max\ m_1 s_1 - c(s_1)$ s.t. $s_1 \geq 0$

entrant 2 $\quad \pi_2(m_2) \equiv \max\ m_2 s_2 - c(s_2)$ s.t. $s_2 \geq 0$

Here, we assume that consumer demand for the final good is $x(p)$. We also assume that at all reasonable prices, $s_1(m) + s_2(m) < x(p)$. In other words, there are enough demand for all three firms. Considering that $s_i(m)$, $i = 1, 2$, is an optimum output which maximizes new entrants' profit, the following relationship is true by the envelope theorem between two functions, $\pi_i(m)$ and $s_i(m)$;

$$\pi_i'(m) = s_i(m).$$

Since profit function $\pi_i(m)$ is a convex function, the envelope theorem says that supply function s_i is an increasing function of m. Let $v(p)$ be consumer surplus. Then its relationship with demand $x(p)$ is

$$v'(p) = -x(p).$$

On the other hand, the objective profit function of the incumbent is following.

$$\pi(p, m_1, m_2) = px(p) - m_1 s_1(m_1) - m_2 s_2(m_2) - c\{x(p) - s_1(m_1) - s_2(m_2),\ s_1(m_1) + s_2(m_2)\}.$$

Also, the social welfare function is following.

$$\text{Max } w(p, m_1, m_2) = v(p) + \pi_1(m_1) + \pi_2(m_2) + \pi(p, m_1, m_2)$$
$$\text{s. t. } \pi(p, m_1, m_2) \geq 0 \text{ (Ramsey constraint).}$$

The regulator, by solving the following maximization problem, chooses the price for the final product and the access price which can maximize the social welfare, thereby suggesting an optimal method of NTS deficit allocation.

$$\underset{p,\, m_1,\, m_2}{\text{Max}} \; v(p) + m_1 s_1(m_1) - c\{s_1(m_1)\} + m_2 s_2(m_2) - c\{s_1(m_2)\}$$
$$+ px(p) - m_1 s_1(m_1) - m_2 s_2(m_2)$$
$$- c\,\{x(p) - s_1(m_1) - s_2(m_2),\; s_1(m_1) + s_2(m_2)\}$$
$$\text{s.t. } px(p) - m_1 s_1(m_1) - m_2 s_2(m_2)$$
$$- c\,\{x(p) - s_1(m_1) - s_2(m_2),\; s_1(m_1) + s_2(m_2)\} = 0.$$

A first order condition for the above optimization problem is;

$$\frac{dw}{dp} = v' + x + px' - c_1 x' + \lambda\,(px' - c_1 x' + x) = 0$$

$$\text{If } \theta \equiv \frac{\lambda}{1+\lambda} \text{ and}$$

$$\eta_x = -\frac{x}{p} \cdot x',$$

$$\text{then } \frac{p - c_1}{p} = \frac{\theta}{\eta_x} \tag{1}$$

$$\frac{dw}{dm_1} = -c' s_1' - \{c_1(-s_1') + c_2 s_1'\} + \lambda\{-s_1 - m_1 s_1' + c_1 s_1' - c_2 s_1'\} = 0$$

$$\frac{m_1 - (c_1 - c_2)}{m_1} = \frac{s_1'(m_1 - c') - \lambda s_1}{m_1(1+\lambda)s_1'}$$

Since a profit maximization condition for entrant 1 is $m_1 = c'$,

$$\frac{m_1 - (c_1 - c_2)}{m_1} = \left(\frac{\lambda}{1+\lambda}\right) \cdot \left(-\frac{s_1}{m_1 s_1'}\right) \text{ is true.}$$

$$\text{Let } \eta_{s_1} \equiv -\frac{m_1}{s_1} \cdot s_1'.$$

$$\frac{m_1 - (c_1 - c_2)}{m_1} = -\frac{\theta}{\eta_{s_1}} \tag{2}$$

$$\frac{dw}{dm_2} = -c' s_2' - \{c_1(-s_2') + c_2 s_2'\} + \lambda\{-s_2 - m_2 s_2' + c_1 s_2' - c_3 s_2'\} = 0$$

Therefore, applying the same calculation method,

$$\frac{m_2 - (c_1 - c_2)}{m_2} = - \frac{\theta}{\eta_{s_2}}. \qquad (3)$$

Based on the result of the above calculatioin, we can induce the following result.

***Proposition* 1**
When the Ramsey constraint is not binding, marginal cost price maximizes social welfare.

Proof : When Ramsey constraint is not binding, $\lambda = 0$ is true. Applying this into θ, one can get a result of $\theta = 0$. Therefore, in expression (1), one can say $p = c_1$.

Next, in expression (2), because of $c_1 - c_2 = (m_1 = p - a_1 =) c_1 - a_1$, one can say $a_1 = c_2$.

Q. E. D.

The Ramsey constraint is not binding when the NTS deficit does not exist. The well known fact that efficient price is equal to marginal cost can be once again confirmed in Proposition 1.

***Proposition* 2**
When the Ramsey constraint is binding, optimum access charges for the entrants are as follows;

$$a_1 = p - \frac{\eta_{s_1}}{\eta_{s_1} + \theta} (c_1 - c_2)$$

$$a_2 = p - \frac{\eta_{s_2}}{\eta_{s_2} + \theta} (c_1 - c_2)$$

Proof : Simple substitutions of $m_i (= p - a_i,\ i = 1,\ 2)$, lead to the desired results.

Q. E. D.

When the Ramsey constraint is binding, implications can be drawn from the above two conditions as follows;

(A) If $\eta_{s_i} = 0,\ i = 1,\ 2$, then $a_i = p,\ i = 1,\ 2$.

When supplies of the new entrants are fully inelastic, it is optimal to set access charge equal to the price of the final service.

(B) If $\eta_{s_i}=\infty$, $i = 1, 2$, then $a_i = p - (c_1 - c_2)$, $i = 1, 2$

Hence,[8] $a_i > c_2$

In other words, when supplies of the entrants are fully elastic, the optimal access charge is shown higher than the marginal cost. Therefore, in both cases, it is appropriate for entrants to subsidize the NTS deficit.

Comparing (A) and (B), it is possible to revalidate the Ramsey's inverse elasticity rule; inelastic supply has an effect of raising the optimal price (access charge).

Next, let us examine the optimal method of NTS deficit allocation. For that, we will examine additional burden of new entrants over the optimal access charge (c_2) of the case that the Ramsey constraint is not binding (the first best solution).

$$a_i - c_2 = p - \frac{\eta_{s_i}}{\eta_{s_i} + \theta}(c_1 - c_2) - c_2, \; i=1, 2 \tag{4}$$

(a) If $\eta_{s_i}=\infty$, $i=1, 2$, then $a_1=a_2=p-(c_1-c_2)$ (from first order conditions (2) and (3))

Therefore, the amount of NTS deficit allocation for entrants are;

Entrant 1's allocated amount $= (p-c_1)\, s_1$
Entrant 2's allocated amount $= (p-c_1)\, s_2$

The amount of NTS deficit should be pseudo-profit.[9] The method for the optimal NTS deficit allocation should be based on the proportion of s_1 and s_2. In other words, the allocated amount of NTS deficit should be in proportion to the number of traffic.

(b) When $\eta_{s_i}=0$ and $i=1, 2$, the optimal allocation to each entrant is $(p-c_2)s_i$, $i=1, 2$

That is to say, entrants pay net revenue (=total revenue−access charge based on marginal cost) as the NTS deficit contribution and the allocation should be based on the traffic. In this case, entrants pay to the incumbent the total revenue as access charge and NTS deficit contribution.

[8] $p-c_1>0$

[9] pseudo-profit=(price−incumbent's marginal cost of final goods) × total traffic of an entrant.

(c) If the elasticities of entrants are different, the proportion of NTS deficit contribution from each entrant will be dependent upon both elasticity and traffic. One should notice that the NTS deficit allocation should be based on the traffic, only when the two entrants have the same elasticity.

(d) If price p is unchangeably fixed by the regulator and entrants make positive profits at that price, then $\theta = 0$. Therefore, $a_i - c_2 = p - c_1$, $i = 1, 2$. That is, entrant 1 should pay $(p - c_1)\ s_1$ and entrant 2 should pay $(p - c_1)\ s_2$. The result of case (d) is the same as that of case (a). The amount of entrants' appropriate NTS deficit contribution becomes their pseudo- profit.[10]

III. Conclusion

Summarizing the above discussion, one can lead to a conclusion that entrants interconnected with the incumbent should be responsible for the NTS deficit contribution. Also, when entrants' elasticities are identical, NTS deficit allocation among them should be based on traffic. When elasticities are not identical, it is optimal to take into consideration both elasticities and traffic as in equation (4).

In examining why demand elasticity of access service matters in reality, firstly one can think of technology. When there are close substitute technologies for local access (for instance, when there is telecommunication service by way of CATV), entrants can switch to the substitute technology (perhaps inferior technology) when the regulator raises the NTS deficit allocation. For the entrants' need for access service is not imperative. If so, an optimal choice of the regulator is not to raise the NTS deficit allocation to the entrants.

Secondly, if the incumbent raises the NTS deficit allocation, consumer price will rise. Here, if consumer's demand is very elastic, the demand for entrants will be radically decreased. In this case, since factor input ratio between the final service and access service is fixed as 1 : 1, new carriers' demand for access service will be hastily decreased, too.[11] Then, according to the Ramsey rule, consumer sur-

[10]Here, another important fact is that when $c_1 = c_2$, all the above (a), (b), (c) and (d) cases result in the same NTS deficit allocation.

[11]Consumer's demand elasticity here represents their evaluation of new entrants' services. For example, it can be inelastic in proportion to consumer royalty, service quality, marketing or attached services.

plus and access service provider's profit decrease and, therefore, the regulator should not raise new carrier's NTS deficit allocation.

The limit of this paper and future direction of further study are as follows; first of all, this paper considers the NTS deficit allocation based on uniform pricing of access charge. However, this method is somewhat restrictive in terms of generality. This method is meaningful in proving that access charge ratio can be different for each entrant. However, if a non-linear price instead of a uniform price is used in the model, a more general conclusion can be drawn. For example, two part tariff system can be applied to access charge so that marginal cost price can be applied to variable cost and lump sum transfer is used for NTS deficit.

Secondly, suppose that one can separate the cost of upstream production and that of downstream production from the incumbent's cost function. Then one can find out the method of the NTS deficit allocation between the incumbent and new entrants. In this case, one could achieve a result which reflect the reality.

Thirdly, the role of the incumbent is passive to regulation in this paper. In other words, the incumbent is assumed to have no means to manipulate or resist regulation. This assumption is not realistic. Hence, one could extend the model to reflect this interaction between the regulator and the incumbent or between the incumbent and the entrants. One way is to use game-theoretic approaches.

Appendix: An Access Charge in Korea

Interconnection can be divided into two types — relay interconnection and direct interconnection — in accordance with whether or not the two carriers who participate in the interconnection have subscribers' lines. Direct interconnection is the interconnection between two carriers who have subscriber's lines; for instance, a direct interconnection is the interconnection between independent networks or between an independent and a dependent network (interconnection between existing telephone network and paging network).

On the other hand, relay interconnection is the interconnection that a carrier relays long distance calls without lines for subscribers. In this case the trunking service provider pays access charge to the interconnection provider: For example, interconnection between a long distance service provider (e.g. Dacom) and the incumbent telephone service provider (e.g. Korea Telecom). In this paper, we will limit our concern to relay interconnection only.[12]

Access charge calculation methods and NTS deficit allocation methods in Korea is presented below. Access charge is composed of per-call access charge, NTS deficit charge, charge for value-added services, and access facilities charge. Charge for value-added services covers the cost of those services such as accounting. Access facilities charge is for access switchboard. Access charge calculation methods in Korea are following:

Access charge calculation method in Korea

- call access charge = call access charge rate × traffic
- call access charge rate = TS cost / total traffic of local call
- TS cost = opportunity cost + business expenses
- business expenses = (access service related) operating expenses + information development contribution + corporation tax
- opportunity cost = rate base × rate of return on investment (book value of fixed property + reasonable operating capital + other assets (rental deposit)) × rate of return on investment

* Investment reward rate is set by the Ministry of Information and Communication in consideration of public interest level, inflation rate, margin rate of facilities and productivity .

* Rate base is annual average book value of assets which contribute to the access service provision.
  - Book value of fixed property is the value which deducts depreciation allowance from aquisition cost.
  - Reasonable working capital means cash deposit and assets in stock.

NTS cost incurs regardless of telephone usage. It includes the cost of maintenance and repair of lines for subscribers and depreciation fee of related facilities. Although in principle, it is reasonable without network externality to appropriate the subscription fee for NTS cost. However, in reality subscription fee is too low to recover all NTS cost, while per-call charge exceeds TS cost.

[12]The model in this paper can be applied to the direct interconnection with dependent networks. For the direct interconnection with an independent networks, this model can also be applied when the network has low independency. However, it seems that a deeper study is necessary.

The NTS deficit is defined as the margin, from NTS cost exclusive of the NTS sector income, local TS sector profit and annual average of connection charge deposit, multiplied by interest rate which is set by the Minister of Information and Communication.

NTS deficit = NTS cost − NTS sector income − TS sector income − connecting charge deposit

Currently, a traffic is used as an allocation method for NTS deficit. That is to say, each competitor bears the expense of NTS deficit proportionally to its accessed traffic among the whole accessed telephone traffic. However, the weakness of this method is that it discolors the original meaning of dividing NTS and TS costs. That is, the method regards NTS sector deficit as if it were TS cost. In addition, even if the traffic standard method is chosen because there is no other alternative, it is necessary to examine whether there is an additional measure to increase economic efficiency.

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References

Armstrong, M., Doyle C., and Vickers J. "The Access Pricing Problem: A Synthesis." *Journal of Industrial Economics*, 1996.

Baumol, W. J., and Sidak, J. G. "The Pricing of Inputs Sold to Competitors." *Yale Journal on Regulation*, 1994.

Kim, Sang Taek, and Lee, Myeong-Ho. "About Efficient Component Pricing Rules." International telecommunications Society European Workshop, Vienna Austria, September 6-7, 1996

Tirole, J. *The Theory of Industrial Organization*. Boston MA.: MIT Press, 1988

Wenders, J. *The Economics of Telecommunications*. Ballinger, 1987.