Market Efficiency Analysis between Facility-Based and Service-Based Competition

Il Won Seo, Duk Hee Lee, and Byung Woon Kim

Facility-based competition (FBC) in the telecommunications market is considered to have lower static efficiency in the short term and higher dynamic efficiency in the long term. Under service-based competition (SBC), the entrant can reduce its setup costs by leasing network facilities from the incumbent, which makes the entrant viable, pushes the market price down and promotes static efficiency. This paper attempts to measure static efficiency by comparing the profits of the incumbent and entrant in terms of consumer surplus and social welfare under each competition type by extending the Stackelberg model. The results, assuming a linear demand function and variation in regulatory level, show that FBC results in higher social welfare than SBC on the whole. However, SBC accompanied by strong regulation is also shown to have the potential to be superior over FBC. It is also revealed that FBC exhibits a higher producer surplus (particularly, the incumbent's producer surplus) and is, therefore, more desirable in terms of dynamic efficiency. When the entrant's cost is high in FBC, social welfare is shown to be lowered, implying that cost competitiveness is a necessary condition for social welfare.

Keywords: Network competition, facility-based competition, service-based competition, market efficiency.

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I. Introduction

The telecommunications industry is characterized by high risks of heavy initial investment and strong network externalities so that a monopolized market structure emerges, which makes it difficult for regulatory agencies to adopt proper competition policies. For instance, there is the potential risk of incumbents monopolizing the market under a weak regulatory framework. In contrast, a strong regulatory regime within the market might affect the viability and potential of firms to implement further investments [1]. Facility-based competition (FBC) and service-based competition (SBC) models have given rise to controversy in the search for an efficient competition policy. Most studies regarding competition policies focus on specific cases. The purpose of this research is to provide a desirable intramodal competition policy pattern with theoretical reasoning [2]-[5].

The FBC policy permits facility-based providers to enter the market. A facility-based provider is an infrastructure provider that constructs or buys raw transmission facilities, connects transmission equipment to them, and runs the necessary operations to provide telecommunications transmission capacity on these links [1], [6]. The SBC regime allows various business models and lowers the entry barrier by leasing an incumbent's facilities. A telecommunications service provider is an operator that purchases or leases transmission capacity from an infrastructure provider and adds switches or other communications equipment in order to offer telecommunications services to customers. A reseller is an entity that purchases traffic on a wholesale basis from a service provider. The reseller carriers out retail functions including marketing and billing and sells the service under its own brand name [6].

The rapid growth in the Korean broadband Internet market is largely due to the early adoption of an FBC policy by the regulatory agency. However, since the market has matured, the regulatory agency has been considering the adoption of an SBC policy to prevent excess and duplicate investment and skewing of the market by incumbents. Contrary to Korean policy patterns, the US adopted a strong SBC policy at first, but recently changed to an FBC policy. Japan, on the other hand, has maintained an SBC policy in its broadband Internet market. Considering the variation of policy patterns adopted by countries, it is difficult to evaluate which competition policy path is most desirable [7].

SBC enables entrants to penetrate the market due to lower entry barriers, thus, promoting effective competition with incumbents. In the long run, however, SBC is likely to deter incumbents from additional investment. Moreover, allowing entrants to lock-in to the incumbent's facilities creates obstacles to further technology innovation and market growth.

In contrast, although FBC imposes an entry barrier to entrants in the short run, in the long run, it effectively forms platform competition that satisfies diverse consumer needs. Therefore, coordinating these two competition policies depending on market variables or environmental factors is preferred over using just one policy. However, it is still necessary to find a proper policy pattern that is based on a robust theoretical model.

This paper analyzes and compares the market efficiency of FBC and SBC by extending the Stackelberg model. It also suggests a desirable competition policy pattern that enables the continuous diffusion of telecommunications services and the continuous investment of service providers, and promotes sustainable market growth via competition, and so on. In section II, we compare FBC and SBC in the literature review. In section III, we analyze and compare the profits of service providers, as well as the consumer surplus and social welfare of the two types. In section IV, we compare the two types in terms of dynamic and static market efficiency and discuss policy cases. Section V concludes the paper.

II. Market Efficiency Comparison: Literature Review

Numerous attempts have been made to examine the optimal choice between these two competition types. In general, FBC is considered to have the advantage of promoting technological competition between incumbents and entrants, which then leads to market growth and induces price and quality competition. However, it has the disadvantage of bringing excess investment or overcapacity to the market. In contrast, while SBC is passive in innovation and new technology, it promotes effective competition within the market. Since there are many arguments for both sides, it is difficult to say which is more desirable.

An efficient market is required to establish a workable competitive structure so that no monopolies exist. The high level of entry barriers in the telecommunications industry gives incumbents significant market power as monopolists. Thus, introducing SBC policies may provide entrants with viability by lowering the entry barrier level and forming a workable competitive market [8]. As such, SBC is more desirable from the viewpoint of promoting workable competition, since entrants under SBC are free from heavy investment costs and marketing risks. Under SBC, the profit level of entrants is directly affected by the access price charged by incumbents. Low access charges decrease the profit level of incumbents and weaken their incentive to build additional facilities or upgrade service quality. On the other hand, high access charges may impose a price-squeeze on entrants and ultimately drive them out of the market. In short, SBC is more effective to promote workable competition in the short run, but its long run limitation is that entrants are heavily dependent upon the incumbent.

In terms of service quality and product differentiation, FBC provides more flexibility in targeting consumer needs and in setting up the incumbent and the entrant's own cost structure. Under SBC, the limitation placed on the entrant that they must share the incumbent's facilities restricts the entrant's ability to launch new products or differentiate its products from the incumbent. In addition, incumbents have lower incentive to upgrade service quality because they are mandated to lease their facilities to entrants. Moreover, the regulatory agency is hampered by the intangible service quality level, so that it has no way to manage or control the quality of service of facilities [9].

On the consumer side, the severe competition under SBC generally increases consumer welfare through offering a lower price level. On the other hand the very severe competition, leads companies to invest excessively in metropolitan areas with concentrated demand. We can expect the same price competition to occur under SBC; however, situations may vary according to regulation level or the entrant's dependency on the incumbent's facilities. From the cost minimization aspect, SBC is more efficient with low probability of excessive investment [10].

Considering investment, both incumbents and entrants under FBC tend to expand service capacity and facilities, thus, accelerating market growth and service diffusion via continuous investment activities. Woroch's study [11] on the US telecom market from 1983 to 1992 also suggests that incumbents do not start investment until entrants do [10]. However, the excessive investment of entrants in facilities elevates the level of the break-even point they have to achieve, and this holds the potential risk of bankruptcy. Incumbents hardly see the attraction of investing more dollars in facilities under SBC since they are under unbundling or sharing network elements obligations [12].

These points regarding investment have been discussed in other studies. According to Bourreau and Dogan's study [13], incumbents spontaneously lower their unbundling or interconnection price to avoid the threat of facility-to-facility competition with entrants. This is the so-called "lock-in" strategy and is considered an obstacle which deters market growth. A study on Deutch Telecom also reveals that entrants under SBC with low interconnection fees enjoy the present cost structure and show a negative attitude toward building their own facilities, even if they can [14]. Therefore, an efficient competition policy under FBC may depend on the interconnection price level and business strategies of companies [15].

Let us compare the two types in terms of technological innovation. Under SBC, entrants have little flexibility in handling facilities so that we can hardly expect active innovations and technology competition. The counter argument to this point is, however, that SBC permits entrants to adjust the types and adoption time of new technology with excess profits under the assumption of decreasing costs of new technology adoption [9].

In terms of market growth, FBC is more effective in diffusion of services by promoting facility investment and competition among companies. In the early stage of service in particular, FBC is likely to induce companies to implement aggressive marketing and price competition for market preoccupation, which accelerates market growth. On the other hand, SBC does not drive fierce initial competition among companies the way FBC does [10], [16], [17]. However, in his study about Japan's broadband Internet market [18], Fuke revealed that introduction of a strong SBC policy at the initial stages triggered price competition and directly contributed to total service expansion [2].

We can categorize these various viewpoints into static efficiency and dynamic efficiency. Static efficiency deals with workable competition, service quality and differentiation, and consumer surplus, which is mainly related to minimizing production cost and setting a reasonable price. Dynamic efficiency is mainly related to total market growth elements, such as investment incentives, technology innovations, and market growth.

Summarizing all of these aspects into the two categories of dynamic and static efficiency,[1] SBC is considered relatively more effective in static aspects, such as workable competition, increase in consumer surplus, and the protection of entrants. In contrast, FBC is generally superior to SBC in the aspects of higher incentives for investment, market growth, and innovation. In determining an optimal policy in the actual market, we should be cautious and consider complicated factors, such as demand size, the existence of alternative services, interconnection price level, the gap between incumbents and entrants, market maturity, and so on.

Many studies have analyzed the two competition types, mainly focusing on the regulatory policies of specific markets or countries [6], [10], [18]. What seems to be lacking, however, is any analysis of market efficiency based on an explicit economic model. Bourreau and Dogan [13] attempted to build a model but only dealt with the strategies of the individual company and replacement effects, not whole market efficiency viewpoints. This paper is intended to provide a guideline for establishing a proper competition policy by developing a competitive model (namely, the Stackelberg model) and by comparing the types of competition.

III. Theoretical Model

1. Stackelberg Model[2]

This chapter analyzes company behavior and social welfare under each competition type through the development of a model.

A. Basic Assumptions

There are several aspects to the telecommunications market. Initial investment cost, which works as an entry barrier in the telecommunications market, induces the incumbent to be a monopolist. The incumbent takes first-mover advantage in using its own facilities. Moreover, the entrant is strongly dependent on the incumbent's behavior and market information. Considering such characteristics, we rely on the Stackelberg model.

The Stackelberg model describes the differences between best response functions of the incumbent and entrant, which are caused by the information gap. It is true that the model assumes that only quantity determines price and profit levels, but it is still a reasonable model to derive price, consumer surplus, producer surplus, and social welfare, reflecting the gap between the incumbent and the entrant.

Under FBC, the incumbent provides services at period 1 using the facilities built in the previous period (period 0), whereas the entrant builds facilities and provides services

1) Kiessling and Blondeel [6] introduced "dynamic and static efficiency" as criteria of market efficiency, using the telecommunications & Internet market as examples.

2) The basic Stackelberg model is based on Pepall and others [19], pp. 271-275.

simultaneously in period 1. The incumbent and the entrant are basically independent decision makers, although their decisions do affect each other. Under SBC, entrant behavior is subject to that of the incumbent since the former does business based on the latter's facilities. Moreover, the incumbent is informed of the best response function of the entrant, and the entrant also knows that the incumbent will act on the entrant's best response function.

The variables in our model are defined as follows. Product price is denoted by P. The total market quantity (Q) is composed of the incumbent's production quantity (q_1) and the entrant's production quantity (q_2) where $Q=q_1+q_2$. Let C_1 and C_2 be the marginal cost of transporting the call and terminating it for incumbent and entrant. The entrants pay usage fees or unbundling network element costs (UNECs) to the incumbent to lease the incumbents' network. Let F be the entrant's facility investment cost under FBC.

The items listed here are basic assumptions of the Stackelberg model.

Assumption 1. No companies except the incumbent and the entrant are allowed to join the market.

Assumption 2. The products that the incumbent and the entrant make are so homogenous that the sum of q_1 and q_2 equals total market quantity ($Q=q_1+q_2$).

Assumption 3. The linear demand function is assumed ($P = A - B \cdot Q$).

Given the characteristics of the telecommunications market, the following additional conditions are assumed:

Assumption 4. Under FBC, the marginal costs of incumbents and entrants are identical. Entrants do not start new businesses if they are not convinced that their marginal cost does not exceed that of incumbents ($C=C_1=C_2$).

Assumption 5. Entrants have to undertake some investment to construct their own facilities under FBC (F).

Assumption 6. The marginal cost of entrants is not same as that of incumbents under SBC ($C_1 \neq C_2$). The marginal cost of entrants is assumed to be approximately the same as that of incumbents ($C_2 \approx UC$).

Assumption 7. Incumbents' network unbundling cost under weakly regulated SBC includes not only network maintenance costs (C_1) but also their own profits so that marginal cost is higher (under weak regulation, $C_1 < C_2 \approx UC$).

Assumption 8. The regulatory agency keeps incumbents' unbundling cost below network maintenance cost (C_1) to protect the viability of entrants under strongly regulated SBC (under strong regulation, $C_1 > C_2 \approx UC$).

Assumption 9. Depending on the level of the network unbundling cost, incumbents realize network unbundling gains under the weakly regulated SBC and losses under the strongly regulated SBC.

B. Facility-Based Competition Model

Scenario 1. Equivalent marginal cost structure between incumbents and entrants ($C_1=C_2$)

Under FBC, the incumbent (leader, firm 1) utilizes its previously built facilities, while entrants (follower, firm 2) build their own. Entrants, however, penetrate into the market with confidence that their marginal levels do not exceed those of the incumbent (assumption 4). The incumbent profit is only determined by marginal cost (C_1) and quantity (q_1). The entrant's profit is determined by marginal cost (C_2), quantity (q_2), and initial fixed costs (F) to build facilities.

We apply the Stackelberg model to find the optimum quantity and price level. The incumbent decides the optimum quantity level given the best response function of the entrant. Here, we first derive the entrant's best response function and then the incumbent optimum quantity level.

As the total quantity level (Q) is the sum of q_1+q_2, the demand function is $P=A-B \cdot (q_1+q_2)$. Applying $MR_2 = MC_2$, the entrant's best response function is

$$q_2^* = \frac{A-C}{2B} - \frac{q_1}{2}. \tag{1}$$

Given q_2^*, by substituting (1) into $P=A-B \cdot (q_1+q_2)$, we then have $P = (A+C)/2 - Bq_1/2$. Under this price level, the incumbent's optimum quantity is determined by applying $MR_1=MC_1$. Therefore, the incumbent's optimal quantity is

$$q_1^* = \frac{A-C}{2B} \quad . \tag{2}$$

Now, the entrant's optimal quantity is obtained by substituting (2) into (1).

$$q_2^* = \frac{A-C}{4B} . \tag{3}$$

We have the equilibrium price by substituting (2) and (3) into the demand function:

$$P_{FBC} = \frac{A+3C}{4} . \tag{4}$$

According to our assumptions, the incumbent's profits and the entrant's profits are calculated as

$$\pi_1 = \frac{(A-C)^2}{8B} . \tag{5}$$

$$\pi_2 = \frac{(A-C)^2}{16B} - F. \quad (6)$$

The social welfare of FBC is obtained by adding the consumer surplus, $(A-P)^2/2B$, to the incumbent and entrant's profits:

$$SW_{FBC} = \frac{3(A-C)^2 + 8(A-P_{FBC})^2}{16B} - F. \quad (7)$$

Scenario 2. Marginal cost structures of incumbents and entrants ($C_1 < C_2$)

A previous model clued by Bourreau and Dogan [9] assumes that entrants jump into the market only when they have lower or equal marginal cost as well as equivalent quality of service. However, in real telecommunications markets, the incumbent is likely to enjoy economy of scale as well as economy of scope which force entrants to have higher marginal costs. Therefore, it is also reasonable to consider a simulation in which the entrant has higher marginal cost than the incumbent ($C_1 < C_2$). Under different marginal cost structures, equilibrium equations are

$$q_1 = \frac{A+C_2-2C_1}{2B},\ q_2 = \frac{A+2C_1-3C_2}{4B},\ p = \frac{A+2C_2+C_2}{4}, \quad (8)$$

$$\pi_1 = \frac{(A-2C_1+C_2)^2}{8B},\ \pi_2 = \frac{(A+2C_1-3C_2)^2}{16B} - F, \quad (9)$$

$$SW = \frac{11A^2 - 2(8P+2C_1+C_2)A + 12C_1{}^2 - 20C_1C_2 + 11C_2{}^2 + 8P^2}{16B} - F. \quad (10)$$

C. Service-Based Competition Model

Social welfare under SBC is affected by how strict the regulation is, since the incumbent is able to realize network unbundling gains or losses according to the levels of unbundling cost ($UC \approx C_2$). Here, we classify and analyze SBC according to the cases of weakly regulated SBC and strongly regulated SBC.

In the case of weakly regulated SBC, the incumbent sets the unbundling cost by adding some profits to the network maintenance cost ($C_1 < UC \approx C_2$).[3)] Accordingly, their profit is composed of sales revenue and network unbundling revenue ($\pi_1 = (P-C_1)\cdot q_1 + (C_2-C_1)\cdot q_2$). According to assumption (6) that the marginal cost of the entrant is approximately identical to the network unbundling cost, the entrant's profit is $\pi_2 = (P- C_2)\cdot q_2$.

The Stackelberg model is also applied in SBC, but it is assumed that there is a difference between the marginal costs of two companies (assumption 6). The total quantity is the sum of q_1 and q_2, and the linear demand function is defined. To derive the best response function n, $MR_2 = MC_2$ is applied. We then have $(A-B\cdot q_1)-2B\cdot q_2 = C_2$ and the following best response function:

$$q_2^* = \frac{A-C_2}{2B} - \frac{q_1}{2}. \quad (11)$$

The Stackelberg model assumes that the incumbent already knows the entrant's response function. By substituting (11) into $P = A-B\cdot(q_1+q_2)$, we then obtain the market demand function:

$$P = \frac{A+C_2}{2} - \frac{1}{2}Bq_1. \quad (12)$$

Since $C_1 = C_2$, the incumbent's optimum quantity is set as with $MR_1 = MC_1$ as

$$q_1^* = \frac{A+C_2-2C_1}{2B}. \quad (13)$$

The entrant's optimum quantity (14) is obtained by substituting (13) into the best response function of (11), producing the equilibrium price or (15):

$$q_2^* = \frac{A-3C_2+2C_1}{4B}, \quad (14)$$

$$P_{SBC} = \frac{A+C_2+2C_1}{4}. \quad (15)$$

The incumbent realizes network unbundling gains in the amount of $(C_2-C_1)\cdot q_2$. Since total profit of the incumbent is $\pi_1 = (P-C_1)\cdot q_1 + (C_2-C_1)\cdot q_2$, we obtain the incumbent's profit through manipulation, using the equilibrium price and quantity:

$$\pi_1 = \frac{(A+C_2-2C_1)^2 + 2(C_2-C_1)(A+2C_1-3C_2)}{8B}. \quad (16)$$

Similarly, we can obtain the profit level of the entrant based on $(P-C_2)\cdot q_2$:

$$\pi_2 = \frac{(A-3C_2+2C_1)^2}{16B}. \quad (17)$$

The addition of both companies' profits and consumer surplus ($(A-P)^2/2B$) produces social welfare:

$$SW_{SBC} = \frac{(A+C_2-2C_1)(3A-2C_1-C_2) + 8(A-P_{SBC})^2}{16B}. \quad (18)$$

Under strongly regulated SBC, the regulatory agency

3) If double marginalization is considered under this assumption, the price level of the entrant is likely to rise, which makes the entrant less competitive with the incumbent. This case represents the transfer of the incumbent's dominant market power to the entrant according to the weak regulatory policy.

restricts the network unbundling cost below the network maintenance cost to enable the entrant to compete with the incumbent. Therefore, the loss in the incumbent's network unbundling revenue is expected in the amount of $(UC\text{-}C_1)\cdot q_2$.

If the same procedures are applied that are used in the case of weak regulation, we obtain the following equilibrium values:

$$q_1^* = \frac{A+C_2-2C_1}{2B},\; q_2^* = \frac{A-3C_2+2C_1}{4B},\; P_{SBC} = \frac{A+C_2+2C_1}{4}, \quad (19)$$

$$\pi_1 = \frac{(A+C_2-2C_1)^2+2(C_2-C_1)(A+2C_1-3C_2)}{8B}, \quad \pi_2 = \frac{(A-3C_2+2C_1)^2}{16B}, \quad (20)$$

$$SW_{SBC} = \frac{(A+C_2-2C_1)(3A-2C_1-C_2)+8(A-P_{SBC})^2}{16B}. \quad (21)$$

2. Simulation

To compare the two competition types, we subtract the social welfare of SBC from that of FBC:

$$SW_{FBC}-SW_{SBC} = \frac{3(A-C_2)^2+8(A-P_{FBC})^2-(A+C_2-2C_1)(3A-2C_1-C_2)-8(A-P_{SBC})^2}{16B} - F. \quad (22)$$

However, (22) has too many variables to compare the social welfare of the two competition types directly. Moreover, various technology and regulation environments in addition to country specific factors need to be considered to make more reasonable comparisons between the two competition types. Therefore, in this section, we focus on social welfare comparisons in terms of regulation level. Given the marginal cost difference between the incumbent and the entrant, two conditions are simulated.

A. Regulation Level and Social Welfare Comparison ($C_1 = C_2$)

The entrant considers network interconnection price, technology factors, and regulation conditions when deciding whether to enter the market. Among these factors, we select regulation level as the primary factor affecting the entrant's viability. In this model, the regulatory agency is able to set the marginal cost of the incumbent according to its purpose.

Competitors are assumed to have equivalent marginal cost levels, which implies the entrant joins the market only when it is cost competitive [9].

Condition 1. Demand function is P=120-Q (A=120, B=1).

Condition 2. Initial investment cost of network facility is 40 (F=40).

Condition 3. Marginal cost of the incumbent is 15 (C_1=15). In the case of FBC, marginal cost of the entrant and incumbent are the same (C_1=C_2=15).

Condition 4. Entrant's marginal cost ranges from 9 to 29. By the assumptions 7 and 8, strong regulation is applied to intervals from 9 to 14 (C_1>C_2) and weak regulation to the rest of the intervals from 16 to 29 (C_1<C_2).

First, using condition (1), the social welfare of FBC and SBC are

$$SW_{FBC} = \frac{\frac{15}{2}C_1 - 1800C_1 + 108000}{16} - F, \quad (23)$$

$$SW_{SBC} = \frac{6C_1 - 1680C_1 - \frac{1}{2}C_2^2 - 120C_2 + 2C_1C_2 + 108000}{16}. \quad (24)$$

Subtracting (24) from (23) gives

$$SW_{FBC} - SW_{SBC} = \frac{1}{32}(C_1 - C_2)(3C_1 - C_2 - 240) - 40. \quad (25)$$

Substituting the numerical values of conditions 1, 2, and 3 into (25) yields the results shown in Fig. 1. It shows that SW_{FBC} – SW_{SBC} increases with C_2 given fixed C_1. This indicates that SBC generates greater social welfare with strong regulation, while FBC generates greater social welfare with weak regulation.

Another interesting point is that FBC becomes superior to SBC from 21 of C_2. This shows that SBC can be superior to FBC even under weak regulation. The F value (facility cost) seems to be an important factor in this phenomenon. When F is low, the SW_{FBC} – SW_{SBC} line shifts to the left and the FBC dominant range increases; in contrast, when F is high, the SBC

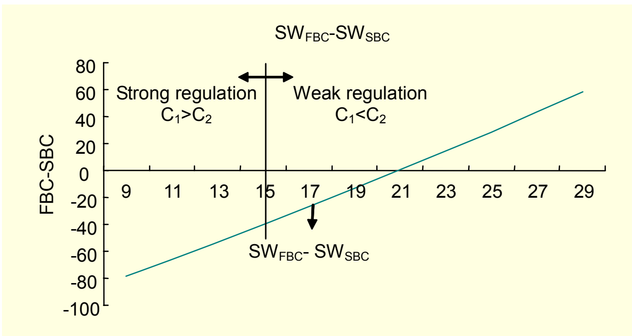

Fig. 1. Social welfare under different regulations (SW_{FBC}-SW_{SBC}).

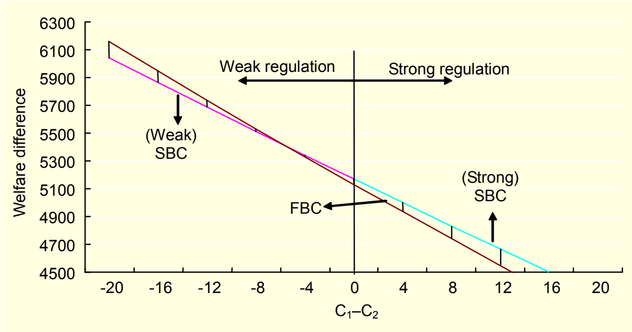

Fig. 2. Social welfare comparison of competition types (with *F*).

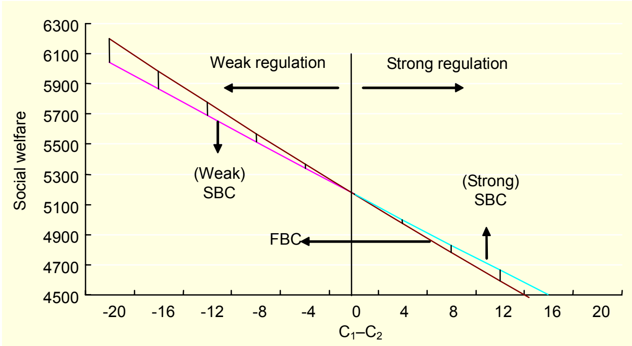

Fig. 3. Social welfare comparison of competition types (without *F*).

Table 1. Social welfare comparison of competition types.

Marginal cost		Competition structure		
Incumbent C_1	Entrant C_2	Weak SBC ($C_1<C_2$)	FBC ($C_1=C_2$)	Strong SBC ($C_1>C_2$)
5	25	6,043.0	6,159.2	
7	23	5,864.5	5,945.5	
9	21	5,687.7	5,735.5	
11	19	5,512.7	5,529.2	
13	17	5,339.5	5,326.7	
15	15	5,168.0	5,128.0	5,168.0
17	13		4,933.0	4,998.2
19	11		4,741.7	4,830.2
21	9		4,554.2	4,664.0
23	7		4,370.5	4,499.5
25	5		4,190.5	4,336.7

dominant range increases.

Now, let us compare social welfare in terms of both regulation levels and variations of *F* value. For this, we set up a situation of steadily stronger regulation levels in which C_1 increases from 5 to 25 and C_2 decreases from 25 to 5 simultaneously.

Figure 2 visually illustrates the results given in Table 1. Axis *X* represents the degree of regulation by subtracting C_2 from C_1. The regulation becomes stronger as $C_1 - C_2$ increases. The left side of the zero point is under weak regulation and the right side is under strong regulation. As shown in Fig. 2, the FBC line is located above the SBC line over a large portion of the weak regulation section, but it remains below the SBC line as the regulation grows stronger. This indicates that FBC is more effective with weak regulation, and SBC is more effective with strong regulation. The reason the FBC and SBC lines intersect at the left side of axis *Y* is related to the existence of facility construction cost (*F*). The existence of *F* under FBC becomes an entry barrier to entrants so that the FBC dominant range on the left side is encroached upon by SBC. It can be expected, therefore, that as F increases, the interconnection point shifts further to the left, increasing the SBC dominant range.

This reasoning becomes persuasive when we consider that fixed costs tend to diminish as the market matures. In the early stage of service, entrants under FBC have high *F* value, and as the market becomes more saturated, the *F* value decreases. For further analysis, another simulation is conducted using a completely matured market; that is, F=0.

Figure 3 demonstrates that two lines cross at point 0 when F=0. Figures 2 and 3 indicate that regulation intensity and the market influence the optimal choice of competition type.

The simulation results demonstrate that the social welfare difference between competition types depends on the regulation intensity and the facility investment costs paid by entrants. SBC creates more social welfare than FBC as the regulation becomes stronger, which means the government strictly controls unbundling costs (UC). Moreover, the FBC dominant range increases with market maturity, that is, as facility investment costs diminish. Thus far, these findings are based on static optimization. The optimal policy choice will be viable in reality if dynamic efficiency is also considered.

B. FBC under Entrant's High Marginal Cost ($C_1 < C_2$)

Condition (3) of previous conditions, has changed to reflect entrant's high cost level.

Condition 3. Marginal cost of the incumbent is lower than that of the entrant ($C_1 < C_2$). Initial C_1 is 5 and increases by 2, whereas initial C_2 is 5 but increases by 3, which increases the cost difference.

Under this condition, the area SBC dominates increases. This shows that social welfare associated with FBC worsens as the difference increases. In other words, the entrant which is not fully cost competitive has a lower total producer surplus and a higher market price. This eventually lowers social welfare.

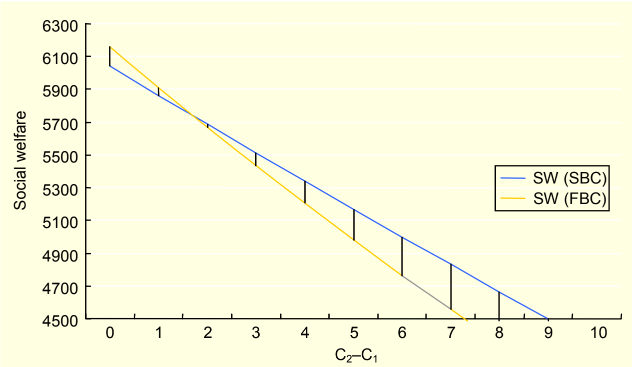

Fig. 4. Social welfare comparison under various marginal costs ($C_1 < C_2$).

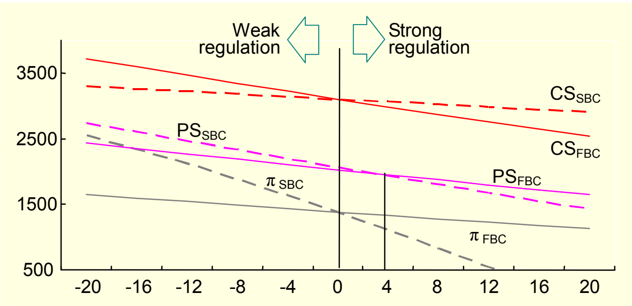

Fig. 5. Consumer surplus (CS), producer surplus (PS), and incumbent profit (π) comparison between competition types.

IV. Static vs. Dynamic Efficiency

According to the literature, FBC is considered to be desirable for dynamic efficiency while SBC is desirable for static efficiency. This section discusses those concepts in relation to the results of the previous simulation.

Figure 5 shows details of the social welfare data presented in Fig. 2. Social welfare is broken down into consumer surplus (*CS*), producer surplus (*PS*), and incumbent profit (π). As seen in Fig. 5, consumer surplus shows similar pattern with social welfare in Fig. 2, which indicates that social welfare is largely dominated by consumer surplus. However, the pattern of producer surplus is the opposite of the social welfare pattern, meaning that the FBC line is located under the SBC line in the case of weak regulation. The incumbent's profit, like the producer surplus, reveals that SBC is dominant with weak regulation and FBC is dominant with strong regulation. The incumbent's profit level is thought to be one of the important proxies to measure the dynamic efficiency of the market. The reason for this is that facility investment for market growth or R&D expenditure for innovation activities largely rely on the incumbent's profit [20], [21]. The US broadband Internet market provides a meaningful lesson about the incumbent's profitability. The incumbent's unprofitability due to strong regulation (as, for example, a low unbundling network element price) eventually reduces their willingness to invest in facilities. Thus, their market is likely to be encroached upon by the alternative service, namely, cable modem service [22].

The producer surplus (*PS*) and the incumbent profit (π) of SBC have a strong hold over those of FBC under weakly regulated SBC because incumbents impose additional profits on the unbundling price and realize excess profits. However, this case lacks reality in that entrants are likely to suffer a price squeeze on service in the market, and SBC accompanied by weak regulation generally does not occur. The main motivations for the regulatory agency's adoption of SBC are to prevent the incumbent's continuous market dominance and remove entry barriers for entrants [23].

Taking all of this into account, FBC is more effective than SBC for dynamic efficiency in financing investment for market growth and technological innovation. Figure 5 indicates that producer surplus under FBC (PS_{FBC}) is superior to that under SBC (PS_{SBC}) between 2 and 4. Also, the incumbent's profit under FBC (π_{FBC}) is superior to that under SBC (π_{SBC}) from 0. This argument is supported by the fact that π_{FBC}'s dominant range over π_{SBC} becomes larger on the right side of 0, with the exception of the unrealistic left side.

Consumer surplus maximization is more concerned with static efficiency. As seen in Fig. 5, the superiority of CS_{SBC} over CS_{FBC} gradually increases as the regulation intensity increases. This demonstrates that SBC is more effective in reducing price levels and making the market more competitive.

In addition, under the simulation of different marginal cost, social welfare decreases as the cost difference increases. This result supports the view that FBC is desirable only if technology is developed enough to lower the cost level of the entrant; otherwise, SBC seems more desirable.

V. Conclusion

We analyzed the market efficiency of FBC and SBC by applying the Stackelberg model and found that neither competition type is superior to the other under all circumstance. FBC generates greater social welfare under weak regulation, while SBC generates greater social welfare under strong regulation. Moreover, FBC can be desirable for the promotion of dynamic efficiency, although the social welfare resulting from its use is lower than that seen with SBC. The choice of policy is more complicated in the real telecommunications market. Many regulatory agencies that adopt one competition type at first gradually combine it with the other type later. Of all the factors influencing the policies adopted by various countries, service maturity, and the existence of alternative services seem to be critical to policy choice.

The US telecommunications market is a good example which demonstrates that a policy performs differently in a matured market (such as local telephone service) and an emerging market (such as broadband Internet service). In 1996, the FCC imposed a wide range of strong unbundling network element (UNE) obligations which forced incumbents to charge lower UNE costs, even below the network maintenance cost. The market share of competitive local exchange carriers (CLECs) in the local telephone service market was around 1% in 1996, but after the UNE obligations were imposed, this steadily increased to 14.7% by 2002. This suggests that strong SBC accelerated competition within the market and improved the competitiveness of entrants. However, strong SBC caused no substantial changes in the entrants' market share in the broadband Internet market, which stands at around 5% [24]. On the contrary, the Korean broadband Internet market adopted FBC from the early stage. The incumbent (KT) responded to the entrant's aggressive investment in xDSL by promptly expanding xDSL service facilities. Consequently, the highest penetration ratio of Korean broadband Internet services was achieved due to severe facility competition between the incumbent and the entrant. This somewhat contradicts our findings from the model in which FBC is not that efficient in the early market stages (high F). This is mainly because we adopted a static model and considered other relevant factors such as the existence of alternative services.

The existence of alternative services differentiates Japan from the US in the broadband Internet market. Japan, like the US, introduced strong SBC based on total element long-run incremental cost (TELRIC) from the early stage. In contrast with the US, however, Japan brought growth momentum with severe price competition, high consumer surplus, and the establishment of an effective competitive market structure. Different results came out of the same policy because of the existence of alternative services.

The main difference lies in the competitiveness of the cable modem (CM) broadband Internet service of the two countries as a strong alternative service of xDSL. In the US, CM companies took the initiative in the broadband Internet market based on 97.1% of cable TV penetration ratio. Japanese CM broadband Internet service providers struggled to expand their market share with a low penetration ratio of 27.1% in 2001. In other words, the CM platform was not a major competitor with xDSL in Japan [2], [25]. Strongly regulated SBC under such environments works effectively and leads to lower consumer price levels reflecting the low wholesale price offered by incumbents. The Japanese incumbent, NTT, offered a UNE price of $3.41/month to entrants in 2000, and this number decreased to $1.43/month in 2003. The decrease in the wholesale price triggered consumer prices to fall, thereby increasing the number of subscribers from 0.15 million in 2001 to 8 million in 2003. As a result, market shares of NTT, Softbank (entrant), and other entrants recorded 37.2%, 34.2%, and 28.6%, respectively, showing a stable competitive structure [18], [26].

As there are many other factors to consider besides market maturity and the existence of alternative services, and despite the fact that SBC or FBC are the two policies most adopted, policy objectives are attainable through combining various policy variables in given situations. By analyzing and comparing the market efficiency of the two competition types based on the theoretical model, we were able to provide a guideline for making the optimal choice between the two policies.

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