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【Summary】

Unlike general goods, broadcasting service is financed not only by consumer's direct payment but also by advertisement revenue. In other words, broadcasting service is supported by direct and indirect financial sources. However, rate of dependence on those financial sources are different by each media type; Terrestrial broadcasting carrier primarily depends on advertisement revenue while cable TV carrier and satellite carrier, which is called as pay-TV primarily depend on payment from audience in addition to small amount of advertisement revenue.

In this paper, we examine broadcast market, where carriers with different financial sources compete in the market, and analyze market performance as a result of competition. Especially, we focus on the effect of competition in the mixed market which includes advertising supported media and subscription fee supported media.

We made economic model and analyze the difference on several types of market. Our principle results of Case III, the market that an advertisement supported carrier and a subscription supported carrier compete in the market, are as follows;.

(1) The greater the substitutability is, the number of channels supplied by advertisement supported media increases while those supplied by subscription fee supported carrier decreases.
(2) Total number of channels supplied by advertisement supported carrier and subscription fee supported carrier is equal to the number of channels supplied by an advertisement supported carrier (Case II).
(3) Total TV watching time of Case III is equal to Case II.
(4) Because the amount of payment by consumer increases compared to Case II, consumer surplus decreases.

General economic model predicts that the increase of the number of entrants brings the increase of consumer surplus. However, in our model, we show here that the increase of the number of entrants does not necessarily bring the increase of consumer surplus.

Keywords: broadcast service, market performance, consumer welfare, advertisement supported /subscription fee supported media.

(JEL Classifications: D40, D60, L50, L82)

1. Introduction

Unlike general goods, broadcasting service is financed not only by consumer's direct payment but also by advertisement revenue. In other words, broadcasting service is supported by direct and indirect financial sources. However, rate of dependence on those financial sources are different by each media type; Terrestrial broadcasting carrier primarily depends on advertisement revenue while cable TV carrier and satellite carrier, which is called as pay-TV primarily depend on payment from audience in addition to small amount of advertisement revenue.

In this paper, we examine broadcast market, where carriers with different financial sources compete in the market, and analyze market performance as a result of competition. Especially, we focus on the effect of competition in the mixed market which includes advertising supported media and subscription fee supported media[1]. There are some previous researches from the similar viewpoint that focus on the relationship between different financial sources and service quality (or program substitutability / complementarity) (e.g. Spence and Owen (1977), Armstrong (2004) and Choi (2006)). However, we analyze the impact of different financial sources on economic welfare based on theoretical model here. As far as we know, this topic has rarely been treated in previous researches. General economic model predicts that the increase of the number of entrants brings the increase of consumer surplus. However, in our model, we show here that the increase of the number of entrants does not necessarily bring the increase of consumer surplus.

2. Utility Function and Demand Function

When we evaluate the consumer surplus of broadcasting service, (1) the number of channels and (2) watching time are considered to be quite important components. Here, we assume that consumer decide the number of available channels, $1, 2, \cdots, N$ and watching time of each channels, $x_1, x_2 \cdots, x_N$, and maximize his utility based on combination of these two factors. Further, we consider that consumer can watch channels which is closer to his preference (in other words, lineup or alternative increases) as the number of channels, N, increases, and assume the following utility function[2].

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[1] In this paper, we treat that "pay-TV carrier" and "subscription fee supported media (carrier)" have the same meaning for simplicity, although pay-TV carrier depends on both advertisement revenue and subscription fee practically.

2 Dixit and Stiglitz (1977) used this utility function in order to express the relationship between consumer utility and product variety.

$$U=\left[\int_0^N \left(x(z)\right)^\rho dz\right]^{\frac{1}{\rho}} \quad \left(U=\left[\sum_i^N x_i^{\ \rho}\right]^{\frac{1}{\rho}} \text{ in discrete form}\right)$$

z shows other leisure time and ρ is within the range of $0<\rho<1$. If we assume $x_1=x_2=\cdots=x_N=x$, then $\sum x_i = Nx = X$ and $U=N^{\frac{1-\rho}{\rho}}X$ are derived. We find consumer utility is expressed as the function of the number of available channels, total watching time and total leisure time[3].

If each consumer decides watching time X and the number of available channels N under two constraints (time constraint and budget constraint). The utility maximization problem is formulated as follows.

$$\begin{aligned} &Max \qquad U = AN^\alpha X^\beta \\ &X+L=T \qquad \text{(time constraint)} \\ &p_1{}'X + p_3{}' \times N = w \times L \quad \text{(budget constraint)} \end{aligned}$$

Note that two constraints can be transformed as follows;

$$T=(1+p_1)X+p_3N \quad \text{(Full-Income constraint)}, \quad p_1 = p_1{}'/w\text{、} \quad p_3 = p_3{}'/w$$

Resolving above maximization problem, we obtain two independent demand functions on watching time and the number of channels, $X=\frac{\beta}{2\alpha}\frac{T}{1+p_1}$, $N=\left(1-\frac{\beta}{\alpha}\right)\frac{T}{p_3}$.

3. Model Specification

In our model, we assume one carrier can offer only one channel for simplicity. In this case, the number of available channels is equal to the number of operating carrier in the market. In addition, we assume two linear demand functions: One is demand function on

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[3] Speaking of $\delta=(1-\rho)/\rho$, if we assume $0<\delta<1$ (marginal utility is positive and diminishing), $0.5<\rho<1$ are derived.

watching time, $X=\alpha-\beta p_1$, and the other is demand function on channels, $N=\delta-\gamma p_3$. Note that p_1, $\overline{p}_2$, p_3 show usage fee, advertisement price and price for purchasing channel respectively. Under this setting, let's consider competitive situation and welfare change in each market, with respect to the following three cases.

Case I: The market that an advertisement supported carrier supply one channel as a monopolist.

A profit function of advertisement supported carrier is shown as follows, assuming that marginal cost per watching time is constant.

$$\pi=(1/N_A)\left\{\left(p_1+\overline{p}_2\right)X-c\left(X\right)\right\}$$

Note that N_A shows the number of advertisement supported carrier.

Broadcasting carrier decides price p_1 in order to maximize above profit function. Social welfare is defined as sum of consumer utility and firm profit. Profit increase of advertisement placement firm and utility decrease of audience caused by the existence of advertisement are ignored[4]. If broadcasting carrier is monopoly, $N_A=1$ and profit function is expressed as $\pi_1=\left(p_1+\overline{p}_2\right)X-c\left(X\right)$. Following the first-order condition, we obtain the relationship that the equilibrium price, p_1^*, depends on the level of advertisement price, p_2. When advertisement price exceeds a certain value, p_1^* is equal to zero and watching time is maximized at $x^*=\alpha$. In short,

In the case of $\overline{p}_2\geq(\alpha/\beta)+c_x$,

$$p_1^*=0, \quad X^*=\alpha,$$

$$\pi_1^*=\overline{p}_2\alpha-c_x\alpha-c_0$$

In the case of $\overline{p}_2<(\alpha/\beta)+c_x$,

$$p_1^*=\frac{1}{2}\left(\frac{\alpha}{\beta}+c_x-\overline{p}_2\right), \quad X^*=\frac{1}{2}\left\{\alpha+\beta\left(\overline{p}_2-c_x\right)\right\},$$

[4] These two effects are not so clear, and we have to use general equilibrium analysis in order to evaluate social welfare. Therefore, in this paper, we assume these two effects are zero. However, the loss caused by this

$$\pi_1^* = \frac{1}{4}\left\{\beta \overline{p}_2^{\,2} + 2\left(\alpha - \beta c_x\right)\overline{p}_2 + \left(\frac{\alpha^2}{\beta} - 2\alpha c_x - \beta c_x^2 - 4c_0\right)\right\}$$

To sum up an analysis of case I, we can show the following three result.

(1) Optimal price level depends on the level of advertisement price. When advertisement price exceeds a certain value, broadcasting service fee for consumer is equal to zero and watching time is maximized. This result is consistent to current business model.
(2) Producer's surplus increases up to infinity as advertisement price, $\overline{p}_2$, increases.
(3) However, consumer's surplus is not maximized because the number of supplied channels is fixed as 1 ($N = 1$).

Case II: The market that multiple advertisement supported carriers exist and compete in the market.

In case I, an advertisement supported carrier model, the number of supplier and the number of channels are set by 1. Here, in case II, we develop the model on free entry market and analyze the number of entrant (= channels) at equilibrium level.

In the case of free entry, we assume that audience watch each channels at the same rate. Therefore watching time of each channels is $x = (1/N)X$. Further, we assume symmetrical property on demand and cost structure of each carrier[5]. Then, demand function and profit function of each carrier are $x = (1/N)\left(\alpha - \beta p_1\right)$, $\pi = p_1 x + \overline{p}_2 x - C\left(x\right)$, respectively. Note that boundary condition of price strategy is independent from the number of carriers, N_A[6]. The optimal price strategy of broadcasting carriers is the same

simplification seems not to be so large.

[5] We ignore the interdependent relationship of price strategy that each carrier takes.

[6] The reason why boundary condition is independent from the number of carriers are caused by our assumption that some functions are expressed as linear form;

(1) We assume marginal cost is constant to scale (boundary condition should be the function of the number of entrants if we assume marginal cost increases to scale).

(2) We assume advertisement price is constant (boundary condition is not independent if advertisement

as monopoly (case I). Therefore, price, output and the number of entrant at the equilibrium, N_A^*, are derived as follows;

In the case of $\overline{p}_2 \geq (\alpha/\beta)+c_x$,

$$p_1^* = 0, \quad x^* = \frac{1}{N_A}\alpha,$$

$$\pi_1^* = \frac{1}{N_A}\left[\alpha\overline{p}_2 - \alpha c_x\right] - c_0,$$

$$N_A^* = \frac{\alpha\overline{p}_2 - \alpha c_x}{c_0}$$

In the case of $\overline{p}_2 < (\alpha/\beta)+c_x$,

$$p_1^* = \frac{1}{2}\left(\frac{\alpha}{\beta} + c_x - \overline{p}_2\right), \quad x^* = \frac{1}{N_A}\left[\frac{1}{2}\left\{\alpha + \beta\left(\overline{p}_2 - c_x\right)\right\}\right],$$

$$\pi_1^* = \frac{1}{N_A}\left[\frac{1}{4}\left(\frac{\alpha^2}{\beta} - 2\alpha c_x - \beta c_x{}^2\right) + \frac{1}{2}\left(\alpha - \beta c_x\right)\overline{p}_2 + \frac{1}{4}\beta\left(\overline{p}_2\right)^2\right] - c_0,$$

$$N_A^* = \frac{\frac{1}{4}\left(\frac{\alpha^2}{\beta} - 2\alpha c_x - \beta c_x^2\right) + \frac{1}{2}\left(\alpha - \beta c_x\right)\overline{p}_2 + \frac{1}{4}\beta\left(\overline{p}_2\right)^2}{c_0}$$

These results imply that once advertisement price is determined, one of two financial strategies is adopted by broadcasting carriers; (a) the strategy based on advertisement revenue only, or (b) the strategy based on mixed financial sources of advertisement revenue and consumer payment. On the other hand, output level of each carriers, x^*, should be $1/N_A$. Speaking of equilibrium entrant level, N_A^*, broadcasting carriers enter the market until profit decreases to zero. Total watching time is calculated as product of the number of channels and watching time of each carrier, $N_A x$. In short, Total watching time is the same as monopoly (case I). On the other hand, consumer's surplus increases because the number of channels is the same as the number of entrants, N_A.

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price changes to the scale).

Case III: The market that an advertisement supported carrier and a subscription fee supported carrier compete in the market.

Based on case I and case II, here in case III, we examine the effect of market entry by subscription fee supported carrier. Suppose that firm 1 and firm2 indicate advertisement supported carrier and subscription fee supported carrier respectively. With respect to advertisement supported carrier model, the number of channels is determined based on advertisement price and cost structure. If consumer's marginal utility is positive under this equilibrium channel number, consumer's surplus increases by adding channels. Because demand function of channels is $N = \delta - \gamma p_3$, demand for pay-TV service (= subscription fee supported carrier) is shown as $N_P = N - N_A$, assuming the number of channels offered by advertisement supported carrier is N_A.

Note that channels are assumed to be differentiated to some extent between advertisement supported carrier and subscription fee supported carrier, and demand function of pay-TV service is supposed to be $N_P = \delta - \phi N_A - \gamma p_3$. ϕ is a parameter which indicates the degree of substitutability and means perfect substitute if $\phi = 1$. The condition which broadcasting service is provided is $\delta - \phi N_A > 0$. Cost function and profit function of pay-TV carrier are denoted as $C_2 = c_0 + c_n N_p$, $\pi_2 = p_3 \times N_P - C_2$ respectively. Pay-TV market is supposed to be competitive, and equilibrium is achieved at the level that price for broadcasting service is equal to marginal cost. The equilibrium price and the number of channels are determined as $p_3 = c_N$, $N_P = \delta - \phi N_A - \gamma c_N$.

The model setting with respect to advertisement supported carrier is the same as case I and case II, but watching time (=demand function) depends on total number of channels, which means $x_1 = (1/N)X$, $N = N_A + N_P$. Because cost function, profit function and the number of entrant at the equilibrium, N_A^*, are the same as previous case, the result is shown as follows;

In the case of $\overline{p}_2 \geq (\alpha/\beta) + c_x$,

$$p_1^* = 0, \quad x^* = \frac{1}{N}\alpha,$$

$$\pi_1^* = \frac{1}{N}\left[\alpha \overline{p}_2 - \alpha c_x\right] - c_0,$$

$$N_A^* = N^* - N_P^* = \frac{\alpha \overline{p}_2 - \alpha c_x}{c_0} - N_P^*$$

In the case of $\overline{p}_2 < (\alpha / \beta) + c_x$,

$$p_1^* = \frac{1}{2}\left(\frac{\alpha}{\beta} + c_x - \overline{p}_2\right), \qquad x^* = \frac{1}{N}\left[\frac{1}{2}\left\{\alpha + \beta\left(\overline{p}_2 - c_x\right)\right\}\right],$$

$$\pi_1^* = \frac{1}{N}\left[\frac{1}{4}\left(\frac{\alpha^2}{\beta} - 2\alpha c_x - \beta c_x{}^2\right) + \frac{1}{2}\left(\alpha - \beta c_x\right)\overline{p}_2 + \frac{1}{4}\beta\left(\overline{p}_2\right)^2\right] - c_0,$$

$$N_A^* = \frac{\frac{1}{4}\left(\frac{\alpha^2}{\beta} - 2\alpha c_x - \beta c_x^2\right) + \frac{1}{2}\left(\alpha - \beta c_x\right)\overline{p}_2 + \frac{1}{4}\beta\left(\overline{p}_2\right)^2}{c_0} - N_P^*$$

At the equilibrium, the number of channels offered by advertisement supported carrier depends on those supplied by pay-TV carrier. They are indicated $N_A^* = 1/(1-\phi)\left(A - \delta + \gamma c_N\right)$, $N_P^* = \delta - \phi/(1-\phi)\left(A - \delta + \gamma c_N\right) - \gamma c_N$, respectively. Note that A denotes the number of carriers (which is equal to the number of channels) when pay-TV service is not provided. As the same as before, A depends on advertisement price, $\overline{p}_2$.

The principle results of Case III are summarized as follows;

(1) The greater ϕ is, in other words, the greater the substitutability is, the number of channels supplied by advertisement supported media increases while those supplied by subscription fee supported carrier decreases.

(2) Total number of channels supplied by advertisement supported carrier and subscription fee supported carrier, $N_A^* + N_P^*$, is equal to the number of channels supplied by an advertisement supported carrier (Case II).

(3) Total TV watching time of Case III is equal to Case II.

(4) Because the amount of payment by consumer increases compared to Case II, consumer's surplus decreases.

Because the entry of pay-TV carrier doesn't change total TV watching time and total number of available channels, but increases only user payment, it decreases consumer's surplus. This result is caused by the assumption that the number increase of offered channels decreases TV watching time per each carrier. In other words, because advertisement supported carrier and pay-TV carrier compete with respect to TV watching time in the market, if the number of channels is increased by pay-TV carrier, watching time for advertisement supported carrier decreases and the number of channels offered by advertisement supported carrier also decreases.

4. Conclusion

In this paper, we examine broadcasting market, where carriers with different financial sources compete, assuming two independent demand functions with respect to watching time and channels. Note that our theoretical model depends on many assumptions. To construct more realistic model is our future task. For example, we should incorporate interdependent relationship on demand between watching time and channels, or should consider interdependent relationship on strategy between advertisement supported carrier and subscription fee supported carrier, or should consider carrier who depends on both financial sources.

However, our contribution in this paper is to formulate the broadcasting market competition by carriers with different financial sources, considering two major factors of broadcasting demand, such as watching time and channels. We hope our paper provide the basic framework for economic analysis on broadcasting market.

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