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Competitive Strategies of Products with Network Externality

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Abstract: The initial market size plays an important part in customer's utility when durable goods with network externality are consumed. Considering initial market size, this study analyzed competition strategies between oligopolistic firms by using of Hotelling model and two-stage game. Results show that initial market size affects competition strategies and makes strategies are different with general products' strategies. It is forecasted that unequal initial market sizes will eventually lead to monopoly. Then, an empirical analysis is used to exemplify theory analysis.

Key words: Network externality, durable product, two-stage game, hotelling model

INTRODUCTION

It is network externality that the consumer's utility increases with the number of consumers of this good and its compatibility goods (Laffont *et al*., 1998). Nowadays, there are more and more network externalities products and the intensity of which is more and more obvious. The research focusing on competition strategies of network externalities products mainly based on differentiation theory (Hermalin and Katz, 2007; Cheng *et al*., 2011).

Some literature studied the effect of network externalities on firm's competitive strategy from the view of vertical differentiation. For example, Baake and Boom (2001) proved that main competition strategies of network externalities products is pursuit market share. Some other literature studied it from the point of horizontal differentiation. Katz and Shapiro focused on the firms' competition when product market is fully compatible or completely incompatible (Katz and Shapiro, 1985). Results show that firms providing products with high intensity of network externalities has uncertainty favor about compatibility or incompatibility. But with low intensity firms prefer compatibility. Incompatibility strengthens the leading firm's market position and intensifies price competition. Thereafter, more and more study expanded this study from market entry strategy (Jonard and Schenk, 2004) and asymmetric information (Kim, 2002) etc.

Network externalities gender demand-side economies of scale and firms have fierce competition for consumers. Competition among firms is based on not only the capital, technology and some other factors, but market shares. For durable goods, market share is the number of consumers including the new number and the existing. There is a shortage study of the existing consumers in the existing literature. Durable goods with network externalities include software, mobile communication products and other common products (Dou *et al*., 2012). Therefore, the study about competition strategies considering initial market scale has practical significance.

In this study, firm's initial market size is introduced and Hotelling model and two-stage game are adopted to discuss horizontal differentiation competition for durable goods with network externalities. The influence of initial market scale and network externalities intensity on competitive strategy is analyzed, too. Some advices are giving to firms according to results. At last, China's mobile communications market is taken as an example to verify the positive relationship between the initial network size and new market share and the future of China mobile communications market is forecast.

ASSUMPTIONS AND MODELS

Assumptions:

- Consumers are uniformly distributed in linear market. Oligopoly firms A and B provide alternative durable goods with network externalities to consumers. Each purchaser only consumes a good. Because of high switching costs, the consumer will not turn to another firm. Developing market make there are n new consumers every new stage. Proportions of consuming A and B are q_1 and q_2 ($q_1+q_2 = 1$), respectively. Prices of A and B are p_1 and p_2, respectively. They have the same marginal cost c. A

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and B locate in a and b. a and b are the degree of product differentiation. Without loss of generality, it is assumed that $0 \geq a \geq b \geq 1$

- The consumer in x has transportation cost $t(x-a)^2+F$ (or $t(x-b)^2+F$) when he buy from the firm A (or B). In order to make the analysis simple, assume t = 1 and F = 0. Reservation utility of consuming per unit product is r. r is high enough to make the linear markets be completely covered
- Firm A and B have the same intensity of network externalities k and linear network externalities function $k(Q_1+q_1n)$ (or $k(Q_2+q_2n)$). Q^1 and Q^2 are the initial market size of firm A and B, respectively. The existing literature assumed the intensity of network externality is between 0 and 1. And the market size is proportion. In this study, assume $k(Q_1+Q_2+n)$ because the market size is the number of consumers

MODELS AND ITS SOLUTION

The whole decision process concludes firms' two-stage game and consumers' choice of goods. Specifically, in the first stage, firm A and B choose their differentiation competitive strategies. In the second stage, firm A and B choose their price competitive strategies. In the third stage, new consumers choose buying products from A or B. The inverse method is adopted to get the solution.

- **The third stage:** Consumers choose goods

Consumer in has utility function as following when he consumes A or B:

$$\begin{cases} U_a = r - p_1 - (x-a)^2 + k(Q_1 + nq_1) \\ U_b = r - p_2 - (x-b)^2 + k(Q_2 + nq_2) \end{cases}$$

The indifference $\bar{x}$ spot of consuming A or B can be got from $u_a(\bar{x}) = u_b(\bar{x})$. It is easy to prove $\bar{x}$ is between a and b. According to the hypothesis that consumers have rational expectations, there are q_1 $\bar{x}$ and q_2 $1-\bar{x}$ as following:

$$q_1 = \frac{p_2 - p_1 + b^2 - a^2 + k(Q_1 - Q_2) - kn}{2(b-a-kn)} \quad (1)$$

$$q_2 = 1 - \frac{p_2 - p_1 + b^2 - a^2 + k(Q_1 - Q_2) - kn}{2(b-a-kn)} \quad (2)$$

- **The second stage:** Price competition

Two firms' profit functions are Eq. 3 and 4, respectively without considering firm's fixed cost.

$$\pi_1 = (p_1 - c)q_1 n \quad (3)$$

$$\pi_2 = (p_2 - c)q_2 n \quad (4)$$

According to Eq. 1-4, equilibrium prices can be get as Eq. 5 and 6 by first order conditions of Eq. 3 and 4:

$$p_1 = [k(Q_1 - Q_2) + b^2 - a^2 + 2(b-a) - 3kn + 3c]/3 \quad (5)$$

$$p_2 = [-k(Q_1 - Q_2) - b^2 + a^2 + 4(b-a) - 3kn + 3c]/3 \quad (6)$$

If equilibrium prices exist, the second order condition which can be simplified as b-a-kn>0 must be satisfied. So, firms' profit functions can be written as Eq. 7 and 8:

$$\pi_1 = [k(Q_1 - Q_2) + (b^2 - a^2) + 2(b-a) - 3kn]^2 n/[18(b-a-kn)] \quad (7)$$

$$\pi_2 = [k(Q_1 - Q_2) + (b^2 - a^2) - 4(b-a) + 3kn]^2 n/[18(b-a-kn)] \quad (8)$$

- **The first stage:** Differential competition

First order partial derivatives of Eq. 7 on a and Eq. 8 are as following. It is closely related to $k(Q_1-Q_2)$ that Eq. 9 and 10 is positive or negative:

$$\frac{\partial \pi_1}{\partial a} = \frac{\begin{Bmatrix} [k(Q_1 - Q_2) + (b-a)(b+a+2) - 3kn] * \\ [k(Q_1 - Q_2) + (b-a)(b-3a-2) + kn + 4akn]n \end{Bmatrix}}{18(b-a-kn)^2} \quad (9)$$

$$\frac{\partial \pi_2}{\partial b} = -\frac{\begin{Bmatrix} [k(Q_1 - Q_2) - (b-a)(4-b-a) + 3kn] * n \\ [k(Q_1 - Q_2) + (b-a)(4-3b+a) - 5kn + 4bkn] \end{Bmatrix}}{18(b-a-kn)^2} \quad (10)$$

Proposition 1: Firms' differentiation strategies change with initial market shares of both of them.

If there is no network externality (k = 0), it is obvious $\partial\pi_1/\partial a<0$ and $\partial\pi_2/\partial b>0$. So, firms will choose the biggest differentiation strategies that a = 0 and b = 1. This is proved by much study (D'Aspremont *et al*., 1979). To focus on the initial market scale, the biggest differentiation strategy is adopted as many other literatures. Then, Eq. 1-2 and Eq. 5-8 can be simplified as following:

$$p_1 = [k(Q_1 - Q_2) + 3(1-kn) + 3c]/3$$

$$p_2 = [-k(Q_1 - Q_2) + 3(1-kn) + 3c]/3$$

$$q_1 = [3(1-kn) + k(Q_1 - Q_2)]/6(1-kn)$$

$$q_2 = [3(1-kn) - k(Q_1 - Q_2)]/6(1-kn)$$

$$\pi_1 = [k(Q_1 - Q_2) + 3 - 3kn]^2 n/[18(1 - kn)]$$

$$\pi_2 = [-k(Q_1 - Q_2) + 3 - 3kn]^2 n/[18(1 - kn)]$$

EFFECT OF INITIAL MARKET SCALE ON THE COMPETITION

Effect on price: From the solution of the model above, some partial derivatives can be got as $\partial p_1/\partial Q_1 = \partial p_1/\partial Q_2 = \partial p_1/\partial(Q_1\text{-}Q_2) = \partial p_2/\partial(Q_2\text{-}Q_1) = k/3$ and $\partial p_1/\partial Q_2 = \partial p_2/\partial Q_1 = -k/3$. Obviously, proposition 2 can be got as following.

Proposition 2: The price is positive collated with firm's own initial market scale and his minus the other's, negative collated with the other firm's initial market scale.

Consumer obtains more utility when network and the initial market scale are large. So, firms can increase the price. When the initial market is small the firm should decrease the price to attract more consumers. In a word, firms make their price decision should consider their initial market scale.

Effect on market shares: From the solution some partial derivatives can be got as:

$$\frac{\partial q_1}{\partial Q_1} = \frac{\partial q_2}{\partial Q_2} = \frac{\partial q_1}{\partial(Q_1 - Q_2)} = \frac{\partial q_2}{\partial(Q_2 - Q_1)} = \frac{k}{6(1 - kn)} > 0$$

and:

$$\frac{\partial q_1}{\partial Q_2} = \frac{\partial q_2}{\partial Q_1} = -\frac{k}{6(1 - kn)} < 0$$

It can be found that firm's new market share increases with his own initial scale and his minus the other's increasing, decreases with the other firm's initial scale increasing.

Proposition 3: The new market share is positive collated with firm's own initial market scale and the gap between his and the other's, negative collated with the other firm's initial market scale.

The greater the initial market size is, the larger the consumer's utility of consuming the product is. The number of consumers consuming the product will grow. So, the firm's new demand grows with his initial market scale. From the proposition 3, it can be seen that the initial market scale has very important effect on the competition of new market demand and firms should accumulate the initial market scale to get more demand in the future.

Effect on the effect of network externality on the competition: The partial derivatives of firms' price on the intensity are:

$$\frac{\partial p_1}{\partial k} = \frac{Q_1 - Q_2 - 3n}{3}$$

and:

$$\frac{\partial p_2}{\partial k} = \frac{Q_2 - Q_1 - 3n}{3}$$

Partial derivatives of new market shares on network intensity externality are:

$$\frac{\partial q_1}{\partial k} = \frac{Q_1 - Q_2}{6(1 - kn)^2}$$

and:

$$\frac{\partial q_1}{\partial k} = -\frac{Q_1 - Q_2}{6(1 - kn)^2}$$

Obviously, their plus-minuses are affected by their initial market scale.

Proposition 4: The effect of the intensity of network externality on the competition strategies depends on the initial market scale.

FORECAST THE COMPETITION

Firms can get positive profit only if the retail price is higher than the cost. So, the condition of getting positive profit in the new market for firm A is $p_1\text{-}c \geq 0$. Simplified it as $Q_1\text{-}Q_2 \geq -3(1\text{-}kn)/k$. Homoplastically, the condition for firm B is $Q_1\text{-}Q_2 \leq -3(1\text{-}kn)/k$. Firm A's market share minus firm B's market share in the new market is $q_1\text{-}q_2 = k(Q_1\text{-}Q_2)/[3(1\text{-}kn)]$. Firm A's profit minus firm B's profit is $\pi_1\text{-}\pi_2 = 2nk(Q_1\text{-}Q_2)/3$.

Nodes above can be drawn in Fig. 1.

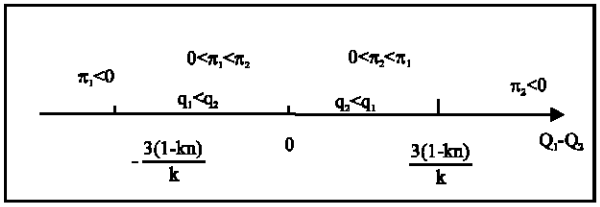

Fig. 1: Comparison of two firms' profits and new market shares respectively in different initial market shares

- When, Q_1-$Q_2 \leq$-3(1-kn)/k firm A will not enter the new market. When, Q_1-$Q_2 \geq$-3(1-kn)/k firm B will not enter the new market. Both situation will make the firm with higher initial market share monopolizes the new market
- When, -3(1-kn)/k $\leq Q_1$-Q_2<0 firm A's share in the new market is smaller than firm B will make Q_1-Q_2 smaller and firm A's share in next new market is smaller than firm B again. This cycle will lead to Q_1-$Q_2 \leq$-3(1-kn)/k at last and according to situation (1) firm B will monopolize the new market
- When, Q_1-Q_2 = 0 firm A and B have the same share in the new market. And they have the same initial market scale and new market share in the next new market. They have the same profit, too. Therefore, this state is maintained as a stable state
- When, 0<Q_1-Q_2<3(1-kn)/k, q_2<q_1 makes Q_1-Q_2 grow higher in the next time. Firm A's new share in the next new market will higher than B's new share. This cycle will lead to Q_1-Q_2>3(1-kn)/k. According to situation (1), firm A will monopolize the new market

Proposition 6: The firm with larger initial market scale will become a monopolist in the market.

Network externality is a positive externality of consumers and consumers are locked in the network. This is demand-side economies of scale. And it makes the strong stronger and the weak weaker by competing. Therefore, firms with smaller initial market scale should strive to develop new technologies, new business and open up new markets in order to avoid being squeezed out of the market.

EMPIRICAL ANALYSIS

The existence of network externalities in the communications industry by empirical study of the communications industry was proved in Germany (Doganoglu and Grzybowski, 2007). It was proved that the network externality is significantly positive by using of dater of Japanese mobile communications market (Lee and Cho, 2007). So, there are sufficient proofs to believe communications industry has network externalities. Users will not change phone number frequently, so it can be regarded as durable goods. Data of China Mobile and China Unicom from 2003 to 2007 is from China Mobile and China Unicom performance report in Table 1.

According to numbers of all users, it is clear that China Mobile's initial market scale is higher than China Unicom's in each year. The proportion of new users of China Mobile is higher than that of China Unicom every year, too. The number that the number of all users of China Mobile minus that of China Unicom is growing year after year. The proportion of China Mobile is growing higher year after year. The proposition 3 is proved qualitatively.

Table 1: The number of users and the proportion of mobile communications enterprise in China (CM is China Mobile. CU is China Unicom)

	2003		2004		2005		2006		2007	
Parameters	CM	CU	CM	CU	CM	CU	CM	CU	CM	CU
No. of all users (hundred million)	1.77	0.92	2.23	1.12	2.66	1.28	3.01	1.42	3.69	1.60
No. of new users (hundred million)	0.39	0.24	0.46	0.20	0.43	0.16	0.35	0.14	0.68	0.18
Proportion of new users (%)	61.9	38.1	69.7	30.3	72.9	27.1	71.4	28.6	79.1	20.9
CM's No. of users min that of CU's (hundred million)	0.85		1.12		1.38		1.59		2.09	

According to the data of Table 1, the gap of the total number of users between two firms will further increase as this cycle going on. It can be expected according to the proposition 5 that China Unicom will be forced to exit the new market if he does not adopt new technologies or open up new markets. If he wants to change the situation, China Unicom should adopt new technologies, open up new markets and seek policy dependent.

CONCLUSION

The initial market scale is introduced to analyze the competition between oligopoly firm by using of Hotelling model and the two-stage game. Results show that the oligopolistic firms' differentiation strategies are affected by the initial market scale of both sides. Under the maximum differentiation circumstances, firms' initial market size affects the equilibrium prices, the new market shares, profits and the effect of intensity of network externality on competition. The unequal initial market scale will eventually make the firm with larger initial market size monopolize new market. When firms make differentiation and price decision they should consider their initial market scale. According to the empirical analysis about the mobile communications industry in China, the positive relation of initial market share and the new market share is proved, the prediction that if there is no external interference monopoly will appear is given.

Conclusions in this study are got under some restrictions. Constraints may be relaxed in the future, such as the same marginal costs and network externalities intensity. The situation that the user can switch to the other product after he pays a certain cost is worth to discuss. Due to the limited industry data, only the initial

market share's importance is proved and the conclusion about profit and price is ignored. So, collecting data to do the empirical analysis can be done in the future research.

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