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Pricing, Quality-Setting, and Order of Plays in an Online Information Market

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Abstract

This paper considers the issue of quality differentiation in an online information market in which one network provider and two content providers compete over both prices and content qualities for the real-time network delivery of digital information products. We examine the order of plays in games of vertical product differentiation and show that sequential price choice of network providers reduces content differentiation among online information products, so that intense price competition among content providers results. However, sequential price competition reduces not only social welfare but also consumers' surplus.

Key words: sequential price competition; content differentiation; online information product
JEL classification: L1; D4

1. Introduction

The online information market is characterized by the real-time network delivery of digital information products. Information production means collecting, editing, packaging, storing, displaying, and so on. In this online environment, different categories of digital content from differentiated information product markets are emerging, each with competing content providers. Examples of differentiated products are online sports, movies on demand, news on demand, and so on. For detailed economic analysis of business strategies such as selling advertising, content versioning, and bundling in the online information market, see Shapiro and Varian (1999) and Kahin and Varian (2000).

In the industrial economics literature, these phenomena are called product (quality) differentiation. Since the seminal work of Gabszewicz and Thisse (1979) and Shaked and Sutton (1982), it has been well known that the existence of quality differences relaxes price competition among competing firms and can lead to posi-

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tive profits in equilibrium. Usually, quality differences are formalized in terms of a framework for preferences due to Mussa and Rosen (1978) in which individuals with identical preferences may choose different goods because their respective marginal utilities of income differ. However, one can find a simplified version of quality choices in a duopoly model of vertical product differentiation in Tirole (1988), Choi and Shin (1992), and Wauthy (1996). They introduce an alternative utility function which captures the spirit of the earlier papers and yet leads to similar solutions. That is, firms in the same market want consumers to believe that their products are highly differentiated from competing products for the purpose of increasing their profits.

However, the market structure of online information products is somehow different from the standard structure of the product differentiation model. In the online distribution environment, the lack of a delivery network of proper quality for certain information products discourages the interests of consumers. This issue of "quality of service" gives rise to the so-called "last mile problem." Put differently, the delivery of on-demand multimedia content is bottlenecked by only gradual increases in capabilities of last mile facilities to the home provided by network providers such as local exchange carriers (LECs), cable TV suppliers (CATVs), or internet service providers (ISPs). These NPs (network providers) interact with CPs (content providers) in such a way that information product demand is affected by the price of network delivery.

Therefore, one might ask whether the presence of this third party (NP) affects previous results in the standard product differentiation model. This question has not been addressed before; most researchers have paid attention to interactions *within* a market and have found that the decisive factor for product differentiation is the distribution of consumers' tastes or income in that market. That is, strategic interactions *between* markets in the context of product differentiation have not been investigated.

NPs and CPs in online markets comprise a vertical complementarity structure since NPs form upstream product providers and CPs form downstream product providers. In addition, NPs usually have a (local) monopolistic character due to the large costs of establishing their network facilities, while CPs are in a situation of competition. In this vertical relationship, NPs may not allow for maximal product differentiation among CPs. An NP wants to increase both its price level and its final market demand not only by reducing the prices of CPs but also by lessening the level of product differentiation. That is, lessened product differentiation has a similar strategic effect as reduced CPs' prices.

In the vertical relationship literature, to my knowledge, this point has been not investigated. Waterman (1993) demonstrates that the economy of scale in product distribution present in the information product market strengthens the well-known "double-markup" effect of vertical integration theory. Economides (1999) shows that independent, vertically-related monopolists provide products of lower quality than a single, integrated monopolist. Oh and Chang (2000) examine the economic situation where one NP and one CP can compete or collude on price levels and quality investment levels and show that the incentive of strategic vertical alliance depends on the relative market power. They also find that their result on quality levels is consistent with that in Economides (1999).

In this paper, we consider games of vertical product differentiation in an online information market in which a monopolistic NP and duopolistic CPs compete over both content qualities and prices for the real-time network delivery of digital information products. We pay special attention to the order of plays in the games of vertical differentiation. This is because, in general, the online business environment is largely determined by the NP who has bottleneck facility and market power. [For a theoretical discussion on the bottleneck facility and access charges, see Laffont and Tirole (2000) and Shy (2001).]

In particular, in a price competition situation, we compare two cases where the NP and CPs compete in price simultaneously or sequentially. The former describes a Nash competition model where the NP and CPs have symmetric information concerning the others' reaction to its own price decision, and thus they choose their optimal prices simultaneously and independently. The latter is a Stackelberg game with sequential price competition in which the NP with market power can accurately anticipate CPs' responses to its pricing decision and commit to its price level, whereas CPs do not have such information and market power. If the NP can commit in advance to its pricing strategy successfully, then the natural outcome will be Stackelberg leadership solution.

We then show that sequential price choice of the NP induces less content differentiation between online information products, so that intense price competition between CPs is the outcome of the game. In other words, in sequential price equilibrium, less product differentiation has a similar strategic effect as reducing CPs' prices. We also show that sequential price competition reduces not only social welfare but also consumers' surplus.

In the industrial economics literature, several papers consider the order of play in a game model and compare the results of Cournot and Stackelberg. Dowrick (1986) considers the choice of roles of leader and follower in a duopoly model and indicates that a firm's reaction functions are key determinants in choosing roles. Boyer and Moreaux (1987) analyze a differentiated model and find that price setting in a Stackelberg leadership situation is more profitable if the goods are complements. As a market equilibrium, Anderson and Engers (1992) examine a fixed m-firm model, and Economides (1993) investigates a free-entry model. In a vertically differentiated duopoly model, Lee (1996) considers sequential price competition and examines the leadership solutions when firms cover the full market. Aoki and Prusa (1997) consider the timing of investment and show that a game with sequential quality choice induces two firms to make smaller quality investment than they would in a game with simultaneous quality choice.

The organization of this paper is as follows. In Section 2, we construct a model of vertical product differentiation in an online information market. In Section 3, we analyze the market equilibrium by considering the order of play. Two cases are considered, one a simultaneous pricing game and the other a sequential pricing game. In Section 4, we compare the results between two compelling equilibria and show that price leadership of a NP induces less content differentiation between CPs' online information products, so that the price competition between two CPs becomes more aggressive. The final section provides conclusions.

2. A Model of the Online Information Market

Consider a simplified configuration of the online (electronic) information product market. There are three firms in this market: one NP and two CPs. At one end of the network for the information product, two competing CPs produce different information content and store them on a server. At the other end, consumers with varying valuations of the information product are connected to the CPs via the delivery network (e.g., a telephone line, a television cable, or a mobile phone system) operated by a dominant NP.

Each CP's information products have an average load size of s_i bits. Consumers are connected to the delivery network provided by the NP via an access channel of bandwidth capacity b (bits per second), which is assumed to be fixed on average. Then, the delivery time (i.e., the duration starting from the moment the consumer orders a product to the time she finishes acquiring it) is determined by the ratio between capacity and load. That is, the delivery time is the transmission delay of the network, which is expressed as $w_i = s_i / b$.

The NP charges a usage-based price P_0 per unit time w_i, and each CP in the content market sells its information goods at per-period price P_i, $i = 1, 2$. So, each consumer should pay a network usage charge $w_i P_0$ to NP and a fixed charge P_i to CP_i when she orders firm i's product. We also assume that there are no production costs for analytic simplicity.

Next, we consider a simple example of a vertical differentiation model for a consumer's selection behavior. We assume that the quality of network service perceived by consumers is only determined by the content size s_i of the information product. Then, a consumer's utility with type θ is described by $U(\theta) = \theta s_i - P_i - w_i P_0$, where θ denotes the consumer's preference for the information product. There is a continuum of consumers, and it is assumed that θ is uniformly distributed over the interval [0,1]. According to the interpretation of Tirole (1988), θ represents the inverse of the marginal rate of substitution between income and content size. Thus, wealthier consumers with a higher θ have a higher marginal utility of information contents. Each consumer has unit demand (i.e., she consumes at most one unit of the good) and does one of three things: buy from CP_1, buy from CP_2, or not buy at all. [That is, we restrict our attention to the uncovered market case, which Choi and Shin (1992) explored. On relevant issues to this point, see Tirole (1988, pp.96-97) and Wauthy (1996).] Finally, all relevant parameters are assumed to be public and common knowledge.

3. Two-Stage Game Analysis

We consider a situation where one NP and two CPs play a two-stage game, where CPs choose the content size level simultaneously and then the NP and CPs compete in prices. Specifically, in the first stage of quality choice, given the NP's bandwidth capacity *b*, each CP$_i$ chooses s_i from the interval $[0, \bar{s}]$ simultaneously and independently. That is, the NP does not play in the first stage, though it does play in the second stage for price choice.

In the second stage for price competition, we consider two cases of price competition between the NP and CPs. The first case is in Section 3.1, which examines a game played by setting prices simultaneously and independently. That is, in the first case, each player is symmetrically informed of how the opponent will react to his pricing decisions and maximizes respective profit with this information simultaneously to yield a Nash equilibrium solution.

The second case appears in Section 3.2, where the NP acts like a dominant player who picks his price while the two CPs play a Nash game after observing the price of NP. That is, in the second case, the NP with market power is endowed with information of the others' pricing decisions before making its own pricing decision, whereas CPs are not. However, CPs are symmetric in that they compete simultaneously in price. Hence, the NP is a price leader and the two CPs are price followers. This asymmetric structure will emerge as a Stackelberg equilibrium solution.

3.1 Simultaneous Price Competition

(1) Price Choice

Let us first examine a simultaneous price competition between one NP and two CPs. Notice that in the second stage of price choice, qualities are exogenous and thus we assume $s_1 > s_2 > 0$. That is, CP$_1$ is the top quality firm and CP$_2$ is the bottom quality firm. This is so because $s_1 = s_2$ cannot be an equilibrium since it yields Bertrand competition, i.e., zero profits in the price game. (It can be shown that $s_1 \neq s_2 \neq 0$ at equilibrium in the first stage, which will be discussed in the following analysis.)

In solving the game, consider the demand faced by each firm. If there are several qualities offered in the market, the consumers choose among these qualities as well as choosing whether to buy at all. Let a consumer with index θ_1 be indifferent between the two information contents, i.e., $\theta_1 s_1 - P_1 - w_1 P_0 = \theta_1 s_2 - P_2 - w_2 P_0$. Then, all consumers with $\theta \geq \theta_1$ (i.e., $\theta \in [\theta_1, 1]$) always prefer quality type 1 to quality type 2 if they purchase at all. Similarly, consumers with index greater than θ_2 and less than θ_1 (i.e., $\theta \in [\theta_2, \theta_1]$) will prefer to buy from firm 2 than not to buy at all. That is, a consumer with index θ_2 is indifferent between buying from firm 2 and not buying at all, so that $\theta_2 s_2 - P_2 - w_2 P_0 = 0$. However, any consumer with index less than θ_2 (i.e., $\theta \in [0, \theta_2]$) will not buy any product in this market configuration.

Thus, if the two CPs do not cover the market (i.e., there is any consumer who does not buy the product at all), the demand function for each CP's product is given as follows:

$$D_1(P,s) = 1 - P_0/b - (P_1 - P_2)/(s_1 - s_2)\,, \tag{1}$$

$$D_2(P,s) = (P_1 - P_2)/(s_1 - s_2) - P_2/s_2\,, \tag{2}$$

where $P = (P_0, P_1, P_2)$, $s = (s_1, s_2)$, and $s_i = bw_i$. [In order to have a complete equilibrium solution, it should be shown that $D_1(P,s) + D_2(P,s) = 1 - P_0/b - P_2/s_2 \geq 0$ at equilibrium. Below, we show that two CPs do not cover the market in equilibrium.] Notice that the demand function for firm 2 is not directly associated with P_0.

Since costs are zero, the profit function for a CP$_i$ is given by $\Pi_i(P,s) = P_i D_i(P,s)$. Taking s_i as given, the following reaction functions for CPs are obtained from the first-order conditions:

$$P_1 = \frac{bP_2 + (b - P_0)(s_1 - s_2)}{2b}\,, \tag{3}$$

$$P_2 = P_1 \frac{s_2}{2s_1}\,. \tag{4}$$

Then, solving (3) and (4) simultaneously, we have:

$$P_1 = \frac{2s_1(b - P_0)(s_1 - s_2)}{b(4s_1 - s_2)}\,. \tag{5}$$

It is noteworthy that the prices of the two CPs are strategic complements, while the prices of the NP and CP are strategic substitutes, i.e., $\partial P_i / \partial P_j > 0$, $\partial P_i / \partial P_0 > 0$, i, $j = 1,2$, and $j \neq i$. This implies that the profit-maximizing NP has an interest in raising P_0 and reducing P_i if possible. This is so because NP can increase its profit when the NP can re-balance between its price and the CPs' prices so that the demand size does not change. However, the NP can not do this under the simultaneous price competition situation.

In this simultaneous price competition, the NP has the profit function $\Pi_0(P,s) = P_0(w_1 D_1 + w_2 D_2)$. Then, we get the following price reaction function of the NP in the simultaneous game:

$$P_0 = \frac{b(s_1 - P_1)}{2s_1}\,. \tag{6}$$

It is also noteworthy that the NP price is directly related to the CP$_1$ price, which is a strategic complement of the CP$_2$ price.

By integrating (4), (5), and (6), we have the following Nash equilibrium solution in the second price competition stage:

$$P_0 = \frac{b(2s_1 + s_2)}{6s_1},\ P_1 = \frac{s_1 - s_2}{3},\ \text{and}\ P_2 = \frac{s_2(s_1 - s_2)}{6s_1}\,.$$

Then, the demand sizes of CP$_1$ and CP$_2$ are D_1= 1/3 and D_2= 1/6 respectively, so that total market size is 1/2 in equilibrium. (It completes the solution in the uncovered market configuration.) Note that the NP price depends on the sizes of differentiated information contents in equilibrium. In particular, the NP price level has a negative (positive) relationship with respect to the quality level of CP_1 (CP_2), i.e., $\partial P_0/\partial s_1 > 0$ and $\partial P_0/\partial s_2 > 0$. This implies that the NP can set a higher price under less content differentiation.

Anticipating the simultaneous price competition equilibrium, the profit functions can be expressed in terms of s:

$$\Pi_0 = \frac{(2s_1 + s_2)^2}{36s_1}, \ \Pi_1 = \frac{s_1 - s_2}{9}, \ \text{and } \Pi_2 = \frac{s_2(s_1 - s_2)}{36s_1}. \tag{7}$$

(2) Quality Choice

Next, we consider the choice of quality levels by firms in the interval $[0, \bar{s}]$. We develop the analysis of firm *i*'s best response to s_j, $j \neq i$, and a symmetric analysis prevails for firm *j*. Intuitively, given s_j, choosing $s_i = s_j$ cannot be a best response to firm *i* since it yields Bertrand competition, i.e., zero profits in the price game. Then, the best response to s_i differs according to whether we consider a response $s_i > s_j$ or $s_i < s_j$. In the former region, firm *i* is the high quality firm and this allows her to sell to high θ consumers, in the latter region firm *i* is the low quality firm and sells to low θ consumers.

First, best responses in the domain $s_i > s_j$ are easily determined. Since firm *i* is the high quality firm, we can consider this firm *i* to be CP_1. Then, profits of the top quality firm Π_1 in (7) are increasing in its quality, so that the best response for firm *i* against any $s_i > s_j$ is to set $s_i = \bar{s}$, i.e., to choose the best available quality.

On the other hand, best responses in the domain $s_i < s_j$ are also easily determined. Given s_j, firm *i* is the low quality firm; we can consider this firm *i* to be CP_2. The best response of the bottom quality firm can be obtained from its profits function, denoted Π_2. The first-order condition for the maximization of Π_2 in (7) yields $s_2 = s_1/2$.

In sum, at equilibrium, the top quality firm chooses $\bar{s}$ while the bottom quality firm chooses $\bar{s}/2$. However, it is not determinate which firm has top or bottom quality since the two CPs are symmetric in the first stage.

Without predetermined asymmetry between firms, each firm prefers top quality firm if the other will comply. Thus, we can anticipate that there is always a conflict over the choice of quality; this is a kind of preemption game. If one of the firms enters first, that firm would choose high quality and other firm low quality, so the equilibrium would be unique. Otherwise, the equilibrium would not be unique. [On this point, see Dowrick (1986), Tirole (1988), and Lee (1996).] Nevertheless, we can see that any subgame perfect equilibrium at which the two firms enjoy positive profits entails product differentiation in which one firm chooses the best available quality $\bar{s}$ and the other firm chooses half of the best quality $\bar{s}/2$.

In the case of $s_1 > s_2$, as assumed for the price stage, we have $s_1^N = \bar{s}$ and $s_2^N = \bar{s}/2$ in Nash equilibrium. Thus, the maximum principle of product differentiation does not hold in the online information product market. Furthermore, we can get that $P_1^N = \bar{s}/6$ and $P_2^N = \bar{s}/24$, so that $P_1^N = 4P_2^N$ and $P_0^N = 5b/12$. It is noteworthy that content size difference relaxes price competition between competing content providers, so that they command positive profits in equilibrium. In particular, from (7) we have $\Pi_1^N = \bar{s}/18$, $\Pi_2^N = \bar{s}/144$, and $\Pi_0^N = 25\bar{s}/144$. However, as stated above, because the profit level of the NP has a positive relationship with respect to the quality level of CP$_2$, i.e., $\partial\Pi_0/\partial s_2 > 0$, the NP might get higher profits under less content differentiation.

3.2 Sequential Price Competition

(1) Price Choice

Now, let us examine the second case of a Stackelberg price-setting game. Contrary to the first case of simultaneous price competition, the NP has information and market power and thus can commit to its price level in the sequential price competition situation. That is, the NP is the price leader and the CPs are price followers in the second stage. As shown in (5), the NP has an incentive to increase its price, and thus decrease the price levels of the CPs. In addition, the NP has an interest in less product differentiation. To show this, we find a Stackelberg equilibrium solution below. Again, we assume that $s_1 > s_2 > 0$.

Taking the CPs' reaction functions in (3) and (4) as given, the NP chooses that P_0 which maximizes its profit. In particular, the NP directly considers the reaction of firm 1 in (5) when maximizing its profit, $\Pi_0(P,s) = P_0(w_1D_1 + w_2D_2)$. Using the first-order condition under the constraint in (5) yields $P_0 = b/2$. Notice that the optimal price of the NP does not directly depend on the degree of differentiation between information content firms in the first stage equilibrium when the NP has market power in deciding the prices. This is so because equilibrium quality levels s_i are directly dependent on b, i.e., $s_i = s_i(b)$, at equilibrium and thus the NP can always find the optimal price as a function of b only.

In particular, we have the following Stackelberg equilibrium solution in the second stage:

$$P_0 = \frac{b}{2},\ P_1 = \frac{s_1(s_1 - s_2)}{4s_1 - s_2},\ \text{and } P_2 = \frac{s_2(s_1 - s_2)}{2(4s_1 - s_2)}.$$

The demand sizes of CP$_1$ and CP$_2$ are D_1= 7/24 and D_2= 7/48 respectively, so that total market size is 7/16 in equilibrium. (It completes the solution in the uncovered market configuration.) Then, the profit functions can be expressed in terms of s:

$$\Pi_0 = \frac{s_1(2s_1 + s_2)}{4(4s_1 - s_2)},\ \Pi_1 = \frac{s_1^2(s_1 - s_2)}{(4s_1 - s_2)^2},\ \text{and } \Pi_2 = \frac{s_1 s_2(s_1 - s_2)}{4(4s_1 - s_2)^2}. \quad (8)$$

Still the profit level of the NP has a positive relationship with respect to the quality level of CP$_2$, i.e., $\partial\Pi_0/\partial s_2 > 0$, and the NP can get higher profit under less content differentiation. However, the NP is a second mover when the CP chooses its content size. That is, the NP cannot fully internalize the effect of content differentiation so that it cannot obtain the maximized profit level in the vertical structure.

(2) Quality Choice

Analogous to simultaneous case, we can decide the choice of quality levels of each firm at the first stage by considering the best responses in an interval $[0, \bar{s}]$. Again, given s_j, choosing $s_i = s_j$ cannot be a best response since it yields Bertrand competition.

The best responses of firm *i*, which is the top quality firm in the domain $s_i > s_j$, are easily determined. The profit of the top quality firm in a differentiated market is Π_1 in (8), and it is increasing in its quality, so that the best response for firm *i* against any $s_i > s_j$ is $s_i = \bar{s}$, i.e., choosing the best available quality.

On the other hand, the best responses of firm *i*, which is the bottom quality firm in the domain $s_i < s_j$, are determined by the first-order condition for profit maximization. Since the profit of the bottom quality firm in a differentiated market is Π_2 in (8), the first-order condition for the maximization of Π_2 yields:

$$(4s_1 - s_2)(s_1 - 2s_2) + 2s_2(s_1 - s_2) = 0\,,$$

which simplifies to $s_2 = 4s_1/7$.

In sum, at equilibrium, the top quality firm chooses $\bar{s}$ while the bottom quality firm chooses $4\bar{s}/7$. By symmetry between the two CPs, however, it is again indeterminate which firm is the top or bottom quality firm. Nevertheless, we can see that any subgame perfect equilibrium at which the two firms enjoy positive profits entails product differentiation in which one firm chooses the best available quality $\bar{s}$ and the other firm chooses a quality level 4/7 of the best quality, or $4\bar{s}/7$.

In the case of $s_1 > s_2$, we have $s_1^A = \bar{s}$ and $s_2^A = 4\bar{s}/7$ in equilibrium. Again, the maximum principle of information content differentiation does not hold in sequential competition equilibrium. But the degree of product differentiation is less than that in simultaneous competition equilibrium. Furthermore, we get $P_1^A = \bar{s}/8$ and $P_2^A = \bar{s}/28$, so that $P_1^A = 7P_2^A/2$ and $P_0^A = b/2$. Since the degree of content differences is less in sequential competition equilibrium, the two CPs compete more intensely in prices, so that their prices and profits levels decrease. In particular, from (8) we have $\Pi_1^A = 7\bar{s}/192$, $\Pi_2^A = \bar{s}/192$, and $\Pi_0^A = 3\bar{s}/16$. However, the price and profit levels of the NP increase under sequential price competition equilibrium. In sum, less product differentiation drives the strategic effect of reducing downstream prices.

4. Discussion

We now examine the economic consequences to welfare and consumers' surplus in each equilibrium. The welfare function can be defined by the sum of producers' surplus (the NP's profits plus the CPs' profits) and consumers' surplus. Since costs are zero, we have the following welfare function in an online information market configuration:

$$\begin{aligned} W(s) &= W_1(s_1) + W_2(s_2) \\ &= \int_{\theta_1}^{1} \theta\, s_1 d\theta + \int_{\theta_2}^{\theta_1} \theta\, s_2 d\theta \\ &= \frac{s_1 D_1(2 - D_1)}{2} + \frac{s_2 D_2(2 - D_1 - D_2)}{2}. \end{aligned} \tag{9}$$

Substituting the equilibrium solutions into (9) yields $W_1^N = 5\bar{s}/18$ and $W_2^N = 7\bar{s}/144$ in simultaneous price equilibrium, and $W_1^A = 287\bar{s}/1152$ and $W_2^A = 61\bar{s}/1152$ in sequential price equilibrium. Thus, total social welfare in simultaneous price equilibrium is greater than that in sequential price equilibrium, i.e., $W^N = 376\bar{s}/1152 > W^A = 348\bar{s}/1152$. Therefore, the sequential price competition by the NP with market power reduces the social welfare.

Furthermore, by definition, the consumers' surplus in each market can be obtained as $CS_i = W_i - \Pi_i - P_o w_i x_i$. Then, we have $CS_1^N = 96\bar{s}/1152$ and $CS_2^N = 8\bar{s}/1152$ in simultaneous equilibrium and $CS_1^A = 77\bar{s}/1152$ and $CS_2^A = 7\bar{s}/1152$ in sequential equilibrium. Therefore, consumers' surplus also decreases under the presence of a dominant position of the NP. We then conclude that if the NP can commit to its price level, the equilibrium is inefficient from the viewpoint of social welfare. This result is similar to that of Boyer and Moreaux (1987) who compare Nash and Stackelberg equilibria in a differentiated products model. They find that both consumer surplus and welfare are larger in the simultaneous price equilibrium than in the sequential price equilibrium.

Finally, we compare our results in sequential price competition and that in Choi and Shin (1992). They considered a duopoly model of vertical differentiation where the firms do not cover the market and found that maximal product differentiation does not hold. This is so because consumers' tastes are sufficiently diverse so that some consumers do not buy from either firm. Put differently, there exists an outside option. This result is the exactly same as our result for CPs.

The difference between our model and their model is the presence of the network access provider (NP) as a strategic agent. Our analysis answers the question raised in the introduction: Does the presence of this third agent affect previous results in the vertical differentiation model? We find that it depends on the economic relationship between the third agent and competing firms. Specifically, we have shown that the level of product differentiation depends on the ability of the NP to set prices in the online information market.

Intuitively, we immediately note that the presence of the NP affects consumers' utility by $U(\theta) = \theta\, s_i - P_i - w_i P_0 = (\theta - P_0/b)s_i - P_i$. In other words, the presence of the NP affects the marginal willingness of consumers to pay for quality exactly by the price per bandwidth capacity. Then, if the NP cannot commit to its price, both the degree of content differentiation and the price levels of CPs depend on the strategic effect of complementary prices. In particular, CPs can raise their prices through more differentiation in a simultaneous competition equilibrium. Therefore, we can conclude that if the NP commits to its price before the CPs, its presence does not affect quality choice, whereas if they all set prices simultaneously, it does so and leads to more differentiation.

5. Concluding Remarks

This paper examines games of vertical product differentiation in an online information market, in which the NP and CPs compete over prices for the real-time network delivery of digital information products. We have shown that the degree of information content differentiation depends on the competition environment in the online information market. More information content differentiation arises when the NP acts as a follower in the price choice game. The NP, however, can get more profit when it acts as a leader. Thus, if the NP who establishes a bottleneck facility in real-time network delivery has market power in its favor and incentives for acting as a leader, less content differentiation occurs. This lessened product differentiation has a strategic effect similar to reducing the CPs' prices. As a result, the CPs choose their prices more competitively in the sequential competition equilibrium, so that the prices and profits of the CPs decrease, while the price and profit of the NP increases. However, price leadership reduces not only social welfare but also consumers' surplus in this online information market.

Our results demonstrate that further research is necessary before one can be sufficiently confident to design appropriate antitrust laws for online information markets. For example, for more general parameterization of θ , we can obtain the relationship between the pricing behavior of the NP and the distribution of consumers' willingness to pay for quality or market coverage. This treatment is in line with Wauthy (1996). In addition, the robustness of our results can be examined by incorporating more general forms of quality costs and capacity investment. On this point, see Oh and Chang (2000). Furthermore, as an interesting future research, it is worthwhile to extend our policy-relevant results to the model of competing NPs and investigate the capacity investment in network architecture or/and compatibility incentives of two NPs in implementing interconnection. For instance, Mackie-Mason et al. (1996) explore the potential impact of architectural differences in the distribution network on the types of the content provided. Foros and Hansen (2001) analyze economic issues of network competition and compatibility strategies.

Finally, it is noteworthy that we do not consider the vertical integration and foreclosure problems, where the NP integrates with one of the CPs. This is so because producers and distributors in the information product market maintain separate ownership and business activities due to different requirements for business strategies, different expertise, and antitrust laws. For example, the NP may choose to specialize in high-quality services and thus attract customers preferring these services. However, we can also observe that vertical integration in online information product markets occurs frequently. Therefore, it is also worthwhile to consider alliances between the NPs and CPs as a source of product differentiation. Extending our model in these directions is left for future research.

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