The Korean Economic Review
Volume 39, Number 2, Summer 2023, 495-516.
DOI : 10.22841/kerdoi.2023.39.2.007

Sequential Pricing in Successive or Bilateral Monopolies with Separate Consumer Groups*

Jong-Hee Hahn** · Youngjun Lee***

This paper considers vertical bilateral monopolies facing two consumer groups with different demands for the final product composed of two perfect complements. In contrast to traditional theories, second-mover advantages may appear, and sequential pricing is superior to simultaneous pricing in terms of welfare. This phenomenon occurs because the standard first-mover advantage is eroded in the bilateral pricing game due to the follower's threat of shutting down the smaller market. The follower may wish to commit to uniform pricing to take advantage of its strategic position.

JEL Classification: L11, L13
Keywords: Bilateral or Successive Monopolies, Vertical Markets, Second-mover Advantages, Cournot Complements

I. Introduction

Traditional oligopoly models, such as Cournot and Stackelberg, suggest that a first-mover advantage exists in sequential-move games, leading to larger equilibrium quantities and higher social welfare compared with simultaneous moves. Similar results apply to pricing in successive or bilateral monopolies selling perfect complements due to the duality argument of Cournot complements. That is, the price–cost margin and profit are higher for the first mover than for the second mover. Moreover, the sum of the prices of two complements is higher and social welfare is lower in sequential-move games compared with simultaneous-move games.

Received: Feb. 14, 2022. Revised: Oct. 28, 2022. Accepted: Dec. 16, 2022.
* We thank Jay Pil Choi and Sang-Hyun Kim for insightful comments.
** Corresponding Author, Professor, School of Economics, Yonsei University, Seoul 03722, Korea, E-mail: hahnjh@yonsei.ac.kr
*** First Author, Ph.D. Student, Simon Business School, University of Rochester, Rochester 14627, USA, E-mail: ylee141@simon.rochester.edu

We show that the above results can be reversed if the market is divided into two groups with different demands for the final product. When the demand difference between the two groups is moderate, the first-mover advantage diminishes due to the follower's threat of closing the weak market. In this case, the follower can enjoy higher prices and larger profits than the leader, contrasting the standard single-market model where the price leader generally has a greater price–cost margin than the follower. In our model, a larger margin can negatively affect the leader's strategic position against the follower. The follower with a lower margin is more likely to shut down the weak market, and the leader who loses more from the closure of the weak market has to lower its price to encourage the follower to sell in both markets. Sequential pricing results in lower final product prices and higher social welfare when such an effect is sufficiently strong. This result can occur when the weak market, which will be excluded under simultaneous pricing, is served under sequential pricing. Hence, the main driver of the welfare reversal is the demand expansion effect of sequential pricing relative to simultaneous pricing. The weak market is more likely to be excluded under simultaneous pricing because both firms do not consider the negative externality their pricing has on the complementary good seller. Conversely, under sequential pricing, the leader can internalize the externality by lowering its price to entice the follower to serve both markets. In this manner, the leader can increase joint profit, but the follower also benefits from the increment.

The presentation of complementary goods prices to consumers and the determination of prices in a vertical chain are important policy issues. Typically, consumers can purchase a system good comprised of complementary components in two ways. One is to buy a final good from a producer who assembles its own component with complementary parts from other producers; the other is to buy each of the complementary component separately from independent producers. In terms of the structure of pricing decisions, the former corresponds to sequential pricing, whereas the latter relates to simultaneous pricing. Understanding which approach is more desirable in terms of social welfare is essential. For example, the issue of bundling mobile phones with mobile services has been prevalent in many countries. The Finnish government prohibited tying arrangements for mobile service and mobile handsets in wireless broadband markets in 1997, ending this regulation in 2006.[1] Similarly, the Japanese government passed a law banning mobile service plans bundled with handsets in 2018. In addition, a law prohibiting mobile network operators from selling mobile handsets is currently being considered in South Korea. In handset bundling, network operators purchase mobile phones from OEM (Original Equipment Manufacturer) and sell the bundle to consumers, corresponding to the sequential pricing of mobile phones and

[1] See Hazlett et al. (2018) for more detail.

network service. Conversely, banning handset bundling changes the pricing game to simultaneous moves. Our results suggest that the relative merit of the two pricing regimes depends on the structure of market demand; thus, we need to exercise caution in policymaking on handset bundling.

Although our analysis is based on bilateral monopolies of perfect complements, all the results can also be applied to vertical supply chains and the licensing of complementary patents owned by independent inventors. The question remains: Should bilateral licensing agreements be processed sequentially or simultaneously? According to our analysis, sequential licensing will be better for society if the producers of final products using complementary patents are moderately asymmetric, and vice versa.

The remainder of Section 1 reviews related literature. In Section 2, we establish the model. In Section 3, we analyze the sequential pricing game. In Sections 4 and 5, we consider the simultaneous pricing game and compare the two pricing regimes in terms of social welfare, respectively. Section 6 concludes this paper.

Literature review: Our research is closely connected to the literature on second-mover advantages. Gal-Or (1985) showed that in a sequential-move game involving two identical players, the second mover earns higher profits than the first mover if their reaction functions have an upward slope (e.g., during price competition). Dowrick (1986) expanded this result to include asymmetric firms and non-concave profit functions, revealing that a player with a downward-sloping reaction function prefers the leader role, regardless of its rival's reaction function slope. In our model, the reaction functions of both firms remain downward sloping, but the follower's reaction function experiences a jump due to the presence of distinct consumer groups, which serves as the primary driver for the second-mover advantage. Gal-Or (1987) established a second-mover advantage in a quantity game with stochastic demand and private information. Similarly, Rasmusen and Yoon (2012) demonstrated that a second-mover advantage may arise if the leader possesses better information about new market profitability. Some authors have explored how cost asymmetry between the leader and follower affects the firms' profit rankings. Ono (1978) reported that a firm with a lower (higher) cost prefers the leader (follower) role if the cost difference is sufficiently large in a homogeneous product market, a result that holds true in differentiated product markets as well, as shown by Van Damme and Hurkens (2004), Amir and Stepanova (2006), and Hirata and Matsumura (2011). Hirose et al. (2017) found that the opposite might be true if the follower's price is endogenized, unlike Ono's assumption that the follower undercuts the leader's price and the leader meets residual demand.[2] Our work

[2] Another strand of research explores the endogenous timing of moves (see Hamilton and Slutsky (1990), Amir (1995), and Amir and Stepanova (2006), among others).

differs from these earlier works in that we analyze the possibility of second-mover advantage and the welfare implications of sequential and simultaneous pricing when two distinct consumer groups have different demands for the final product.

Second-mover advantages may also occur when the market demand function exhibits log-convexity (Bresnahan and Reiss, 1985; Adachi and Ebina, 2013; Amir and Grilo, 1999). Bresnahan and Reiss (1985) showed that increased demand schedule convexity tends to reduce the first mover's margin relative to the second mover's margin. Our result shows that a second-mover advantage can emerge even when the demand function is not log-convex, provided it is moderately kinked. The kink in the demand function due to multiple consumer groups produces an effect similar to the one induced by the log convexity of the market demand. Kinkedness and log convexity are also related to the non-monotonicity of marginal revenues. If a demand curve segment exhibits strong convexity, the corresponding marginal revenue curve increases in that segment, potentially intersecting the marginal cost curve multiple times and resulting in a profit function with several peaks (Formby et al., 1982). The peak selected depends on the marginal cost level. Our model exhibits similar behavior, with the follower's marginal revenue jumping due to the kinked demand, and the leader's price being perceived by the follower as a marginal cost. Therefore, when the leader sets its price above a certain threshold, the follower reacts with a sudden, sharp price increase. This aggressive response from the follower prevents the leader from charging a high price, and if the effect is large enough, then a second-mover advantage follows.

Convexly kinked demand curves typically arise when two or more consumer groups have different reservation prices, or in other words, distinct markets. For example, homogeneous markets located at different distances from a single-product monopolist can be considered consumer groups with different reservation prices after accounting for transportation costs, as in Greenhut and Ohta (1972). Consumer groups with different demands also arise when a product serves multiple purposes, such as electricity and oil (Walters, 1980; Hoel, 1984). Another common scenario involves multiple user types, where households and business customers consume the same product but have different preferences for product quality (Johnson and Myatt, 2003). Empirical evidence for convex kinked demand curves exists. Bontemps et al. (2002) and Berbel et al. (2011) showed that estimated water demand curves for agricultural irrigation commonly feature at least one or multiple convex kinked points. In line with Walters (1982), these papers demonstrate that kinked demand curves are neither anomalies nor specific cases but rather widespread phenomena.

II. Simple Model

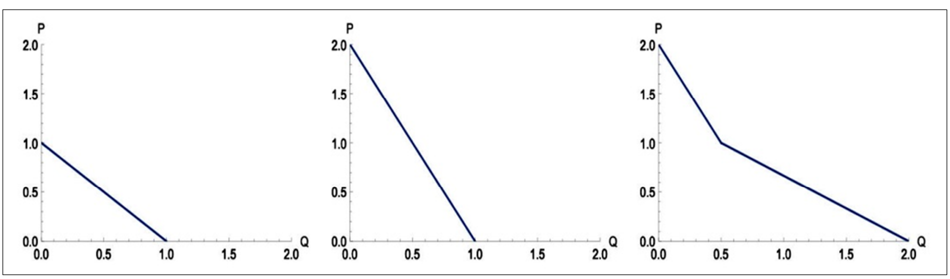
Consider two firms U and D, each selling one of two perfectly complementary goods. Alternatively, the two firms are upstream and downstream entities in a vertical market, where a unit of input is used to produce a unit of a final good. For simplicity, we assume zero production cost for both firms. Each firm independently sets price p_i, $i = U, D$, when it comes to its turn.

The final good comprised of two perfect complements has two separate Markets 1 and 2. One can think of the aggregate demand being divided into two groups. Inverse demand is $p_1 = 1 - q_1$ for Market 1 and $p_2 = a - bq_2$ for Market 2. Here, $a \geq 1$ represents the degree of vertical (quality) stretching of the inverse demand for Market 2. We normalize the mass of Market 1 to unity and allow the mass of Market 2 to vary according to parameters a and b with the restriction $a \geq b > 0$. A larger level of b implies a smaller mass for Market 2. Thus, Market 1 is *weak*, whereas Market 2 is *strong*. The aggregate inverse demand function is given as:

$$P(Q) = \begin{cases} \frac{1}{b+1}(a+b-bQ), & Q \geq \frac{a}{b} - \frac{1}{b} \\ a - bQ, & Q < \frac{a}{b} - \frac{1}{b} \end{cases}, \tag{1}$$

where $Q = q_1 + q_2$ denotes the total quantity.

[Figure 1] Inverse demand curves ($a = b = 2$)



Single-market benchmark: Assuming that $a = b = 1$, which implies that both markets are identical and thus can be considered one market with a mass of 2. Then, the standard Cournot complements result arises in the simultaneous-move game, whereas the Stackelberg leadership outcome emerges in the sequential-move game. The sum of the equilibrium prices is lower and social welfare is higher under simultaneous moves than under sequential moves.

III. Sequential Pricing Game

Suppose firm U (leader) initially sets its price p_U. Then, after observing p_U, firm D (follower) sets its price p_D. We use backward induction to derive subgame perfect equilibria. Assuming for the moment that the firms cannot price discriminate between the two markets.

Follower's best response given the leader's price: The follower faces two separate markets with different demands and has to decide whether to sell in both markets or only in the strong one. The weak market will not be served if $p_U + p_D > 1$. Firm D's profit function is

$$\pi_D(p_D; p_U) = \begin{cases} p_D[(1+\frac{a}{b}) - (1+\frac{1}{b})(p_U + p_D)] & \text{for } p_D \le 1 - p_U \text{ (both serving)} \\ p_D[\frac{a}{b} - \frac{1}{b}(p_U + p_D)] & \text{for } p_D > 1 - p_U \text{ (single serving)} \end{cases}. \quad (2)$$

Given p_U, the problem of choosing p_D is equivalent to choosing Q. Then, firm D's profit can be rewritten as

$$\pi_D(Q; p_U) = \begin{cases} [\frac{1}{b+1}(a+b-bQ) - p_U]Q & \text{for } Q \ge \frac{a}{b} - \frac{1}{b} \text{ (both serving)} \\ [(a-bQ) - p_U]Q & \text{for } Q < \frac{a}{b} - \frac{1}{b} \text{ (single serving)} \end{cases}, \quad (3)$$

where p_U is the virtual marginal cost of firm D.

We proceed with Q instead of p_D in solving the follower's optimization problem, which gives us a more intuitive explanation for the profit-maximizing behavior. For a given Q, the profit margin of the follower, $p_D = P(Q) - p_U$, is expressed as the vertical distance between $P(Q)$ and p_U, as shown in Figure 2. The marginal revenue of firm D can be expressed as

$$MR_D(Q) = \begin{cases} \frac{1}{b+1}(a+b-2bQ) & \text{for } Q \ge \frac{a}{b} - \frac{1}{b} \text{ (both serving)} \\ a - 2bQ & \text{for } Q < \frac{a}{b} - \frac{1}{b} \text{ (single serving)} \end{cases}, \quad (4)$$

Which is non-monotone and has a jump up at $Q = \frac{a}{b} - \frac{1}{b}$ due to the convex kink of the inverse demand curve. The first part ($Q < \frac{a}{b} - \frac{1}{b}$) of the marginal revenue curve corresponds to the case of serving the strong market only, and the second part ($Q \ge \frac{a}{b} - \frac{1}{b}$) to the case of serving both markets.

The first-order condition for profit maximization requires that $MR_D(Q) = p_U$. If p_U is sufficiently large or small, then the optimal Q is uniquely determined. More interesting is the case where p_U satisfies $2 - a < p_U < \frac{2-a+b}{1+b}$, such that p_U intersects both parts of the marginal revenue curve. We obtain two local maxima for

π_D in this case. Let Q^S and Q^B denote the quantity chosen by firm D when serving the strong market only and serving both markets, respectively. That is,

$$Q^S(p_U) = \frac{a}{2b} - \frac{1}{2b} p_U , \tag{5}$$

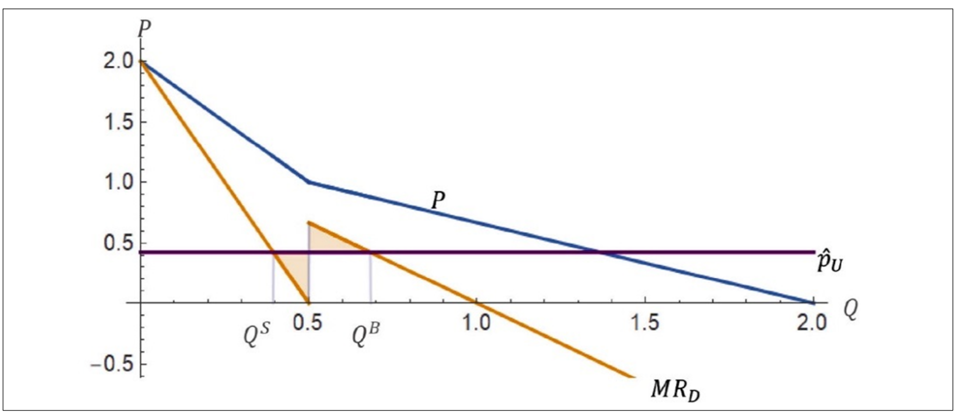
$$Q^B(p_U) = \frac{a+b}{2b} - \frac{b+1}{2b} p_U . \tag{6}$$

In this case, the profit function of firm D is bimodal with two peaks at Q^S and Q^B. To determine which of the two is the global maximum, we define the net gain of increasing total quantity from Q^S to Q^B as

$$S(p_U) = \int_{Q^S}^{Q^B} [MR_D(Q) - p_U]\, dQ , \tag{7}$$

which is the difference between the two colored regions in Figure 2. When the marginal revenue curve of a monopolist intersects the marginal cost at two points, the optimum depends on the area between the marginal revenue and the virtual marginal cost p_U.

[Figure 2] Follower's optimal quantity choice for $a = b = 2$



The optimal choice is Q^S if $S(p_U) < 0$ and Q^B if $S(p_U) > 0$. The sign of $S(p_U)$ depends on the level of p_U. When p_U is small, choosing the larger quantity Q^B is better for firm D due to the high profit margin. The opposite holds when p_U is large. Define the threshold value $\hat{p}_U = 1 - \frac{a-1}{\sqrt{b+1}}$ for which firm D is indifferent between Q^S and Q^B. Assume that firm D chooses Q^B if $S(p_U) = 0$. $\hat{p}_U$ is decreasing in a and increasing in b; single serving becomes more profitable as the size of the strong market increases. A necessary condition for

Q^B to be optimal is $\hat{p}_U \geq 0$, which is equivalent to the condition $a \leq \min\{1+\sqrt{b+1}, 3\}$.

Using the notations defined above, we can write firm D's best response in terms of Q as

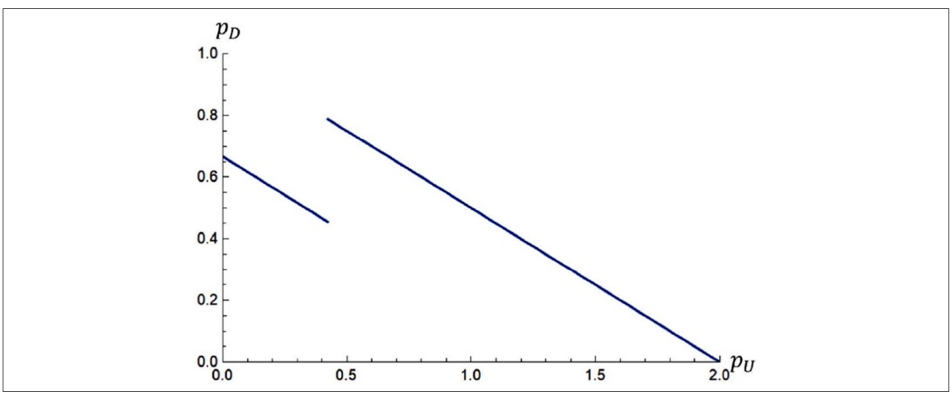
$$Q^R(p_U) = \begin{cases} \frac{a+b}{2b} - \frac{b+1}{2b} p_U & \text{for } a \leq 3 \text{ and } p_U \leq \hat{p}_U \text{ (both serving)} \\ \frac{a}{2b} - \frac{1}{2b} p_U & \text{for } p_U > \hat{p}_U \text{ (single serving)} \end{cases}. \tag{8}$$

Plugging in $Q^R(P_U)$ into the aggregate demand function, firm D's best response in terms of p_D is given by

$$p_D^r(p_U) = \begin{cases} \frac{a+b}{2(b+1)} - \frac{p_U}{2} & \text{for } a \leq \min\{1+\sqrt{b+1}, 3\} \text{ and } p_U \leq \hat{p}_U \text{ (both serving)} \\ \frac{a}{2} - \frac{p_U}{2} & \text{for } p_U > \hat{p}_U \text{ (single serving)} \end{cases}, \tag{9}$$

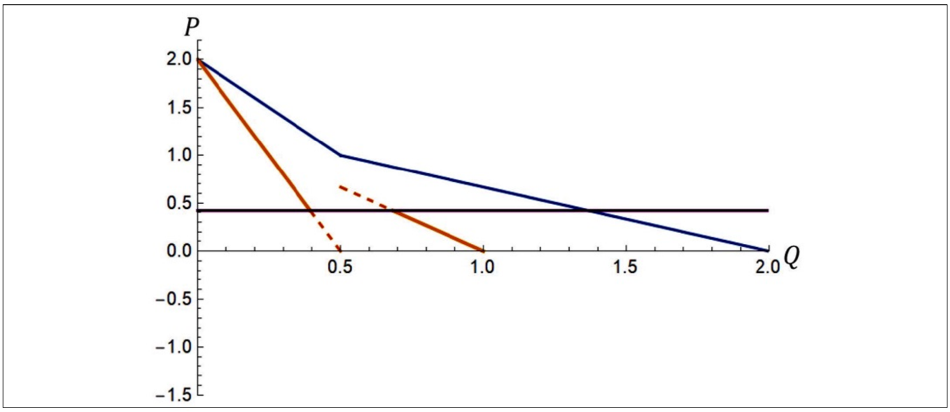
which is downward sloping with a jump down at $\hat{p}_U$ for $a \leq \min\{1+\sqrt{b+1}, 3\}$ (Figure 3). Two prices p_U and p_D are strategic complements in the continuous parts of the reaction function, but they become strategic substitutes on the discontinuous point at $\hat{p}_U$.

[Figure 3] Follower's best response ($a = b = 2$)



Leader's optimal pricing: Recall that firm D chooses Q^S (single serving) for $p_U > \hat{p}_U$ and Q^B (both serving) for $p_U \leq \hat{p}_U$. Thus, firm U's effective demand schedule is derived from firm D's marginal revenue curve after eliminating the part below $\hat{p}_U$ for the first MR and the part above $\hat{p}_U$ for the second MR, as depicted in Figure 4. Note that there is a discontinuity in firm U's demand schedule.

[Figure 4] Leader's effective demand curve for $a = b = 2$

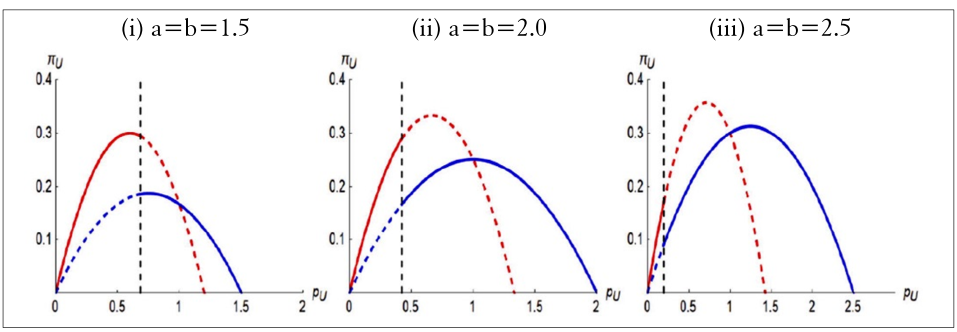


Plugging in firm D's best response, firm U's profit is given as

$$\pi_U(p_U) = \begin{cases} p_U\left(\frac{a+b}{2b} - \frac{b+1}{2b}p_U\right) & \text{for } a \le \min\{1+\sqrt{b+1}, 3\} \text{ and } p_U \le \hat{p}_U \text{ (both serving)} \\ p_U\left(\frac{a}{2b} - \frac{1}{2b}p_U\right) & \text{for } p_U > \hat{p}_U \text{ (single serving)} \end{cases}, \quad (10)$$

which is discontinuous with a jump down at $\hat{p}_U = 1 - \frac{a-1}{\sqrt{b+1}}$ whenever $a \le \min\{1+\sqrt{b+1}, 3\}$. Otherwise, the profit function is smooth and concave. The profit function can take three possible shapes depending on the levels of a and b, as shown in Figure 5.

[Figure 5] Leader's optimal pricing decision



The parabolas on the left and right sides of each profit function correspond to the profits achieved when firm U chooses to serve both markets and the strong market only, respectively. The dotted parts of the parabolas are unattainable by firm U, due to firm D deviating from both-serving or single-serving. The optimal price of firm U is $p_U = \hat{p}_U$ in Figure 5(ii), where the values of a and b are moderate. Firm U's optimal price also takes three forms depending on parameters

a and b. Let three regions be denoted as follows:

$$\text{Both serving region I} = \left\{(a,b)\,|\,1 \le a < \frac{1+\sqrt{5}}{2} \text{ and } b > \overline{b}(a)\right\},$$
$$\text{Both serving region II} = \{(a,b)\,|\,1.522 \le a \le 2.127 \text{ and } \underline{b}(a) \le b \le \overline{b}(a)\},$$
$$\text{Single serving region} = \{(a,b)\,|\,a > 1.823 \text{ and } b < \underline{b}(a)\},$$

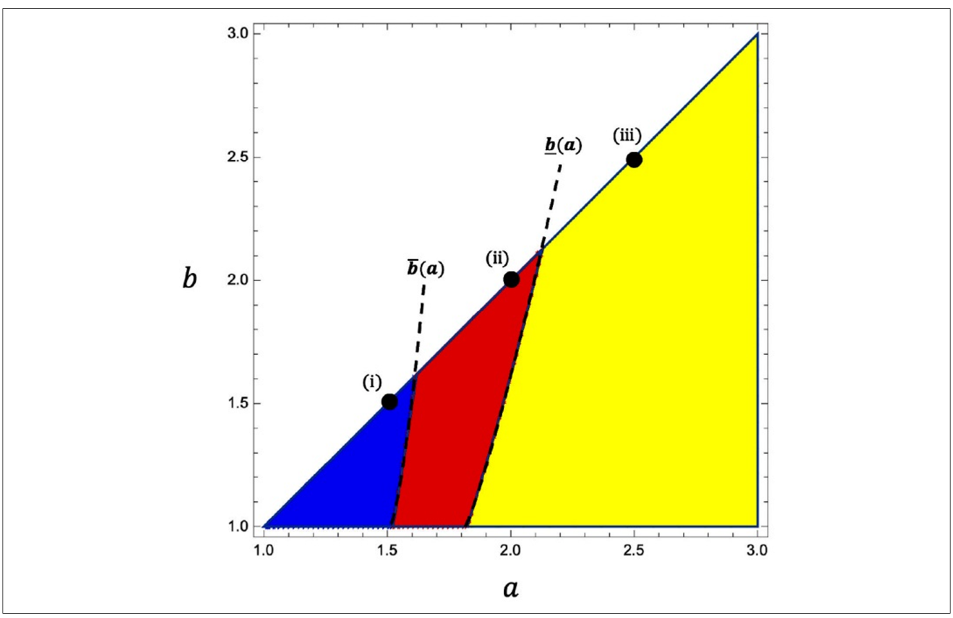
where $\underline{b}(a) = \frac{-32a+96a^2-88a^3+25a^4+a(8-12a+5a^2)\sqrt{32-56a+25a^2}}{32(a-1)^2}$, and $\overline{b}(a) = 2(a^2+(a-1)\sqrt{a(a-1)}) -3a$.

Then, the leader's optimal price is derived as

$$p_U^* = \begin{cases} \frac{a+b}{2(1+b)} & \text{in both serving region I} \\ 1-\frac{a-1}{\sqrt{b+1}} & \text{in both serving region II}. \\ \frac{a}{2} & \text{in single serving region} \end{cases} \tag{11}$$

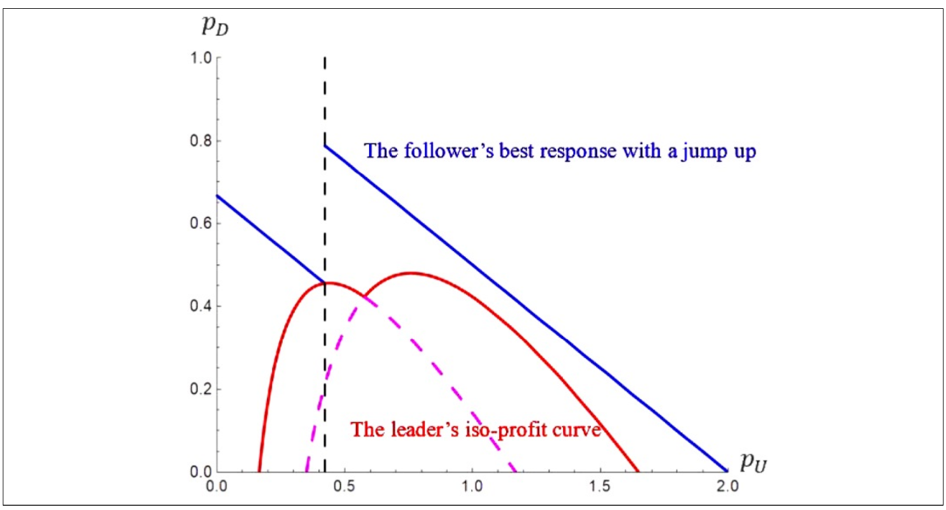
Figure 6 demonstrates the three regions with boundaries $\underline{b}(a)$ and $\overline{b}(a)$ in the (a,b) space. The three representative cases in Figure 5 are denoted as points (i), (ii), and (iii).

[Figure 6] Three regions of both serving (I and II) and single serving



Intuitively, firm U would prefer to serve both markets when the surplus extractable in the strong market is not that large relative to the one in the weak market (for a being small and b being large). Indeed, firm U prefers both serving for $a \leq \min\{1+\sqrt{b+1},3\}$ and single serving for $a > \min\{1+\sqrt{b+1},3\}$ if it can force firm D to follow suit. The only way firm U can control firm D's behavior is through $\hat{p}_U$. Particularly, if firm U wants both markets to be served in equilibrium, then it must set its price equal to or lower than $\hat{p}_U$. This pricing constraint does not bind in the Single-serving Region, where the strong market is extremely small that firm U's optimal price is less than $\hat{p}_U$. It does not bind in Both-serving Region I as well, where the strong market is sufficiently large, such that firm U's unconstrained optimal price is larger than $\hat{p}_U$. However, in Both-serving Region II, firm U wishes to serve both markets while firm D will deviate to single serving at the unconstrained optimal price $p_U = \frac{a+b}{2(1+b)} > \hat{p}_U$. In this case, firm U's optimal choice is to lower the price down to $\hat{p}_U$ to make firm D indifferent between single serving and both serving (Figure 7). Although firm U moves first, its first-mover advantage is eroded due to firm D's option of excluding the weak market.

[Figure 7] Leader's optimal price choice inducing both serving ($a = b = 2$)



Plugging in p_U^*, firm D's equilibrium price is given as

$$p_D^* = \begin{cases} \frac{a}{4(a+b)} & \text{in both serving region I} \\ \frac{(a-1)(1+\sqrt{1+b})}{2(1+b)} & \text{in both serving region II}. \\ \frac{a}{4} & \text{in single serving region} \end{cases} \tag{12}$$

Then, the equilibrium profits of the two firms are

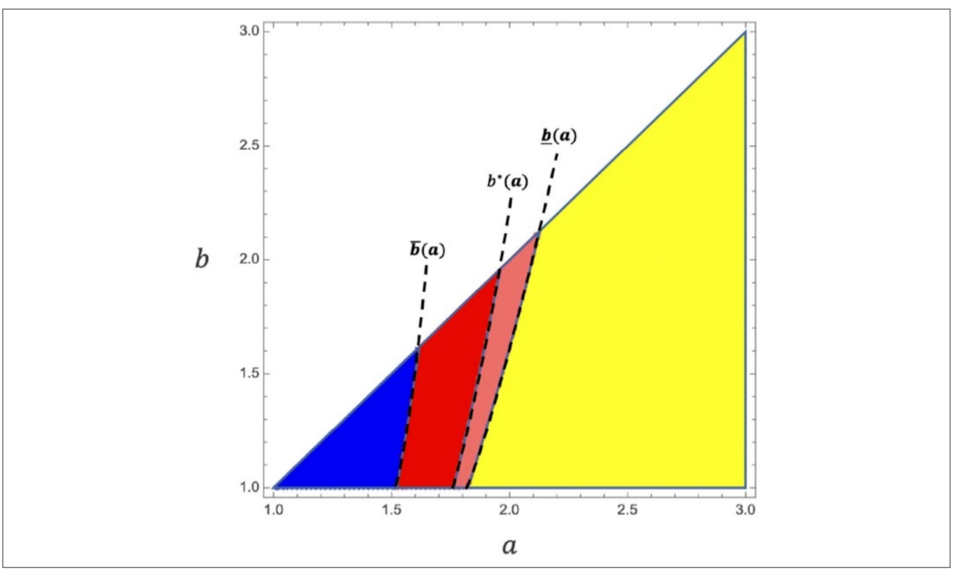
$$\pi_U^* = \begin{cases} \frac{(a+b)^2}{8b(1+b)} & \text{in both serving region I} \\ \frac{(a-1)(1-a+\sqrt{1+b})(1+b+\sqrt{1+b})}{2b(1+b)} & \text{in both serving region II}, \\ \frac{a^2}{8b} & \text{in single serving region} \end{cases} \tag{13}$$

and

$$\pi_D^* = \begin{cases} \frac{(a+b)^2}{16b(1+b)} & \text{in both serving region I} \\ \frac{(a-1)^2(2+2\sqrt{1+b}+2b+b\sqrt{1+b})}{4b(1+b)^{3/2}} & \text{in both serving region II}. \\ \frac{a^2}{16b} & \text{in single serving region} \end{cases} \tag{14}$$

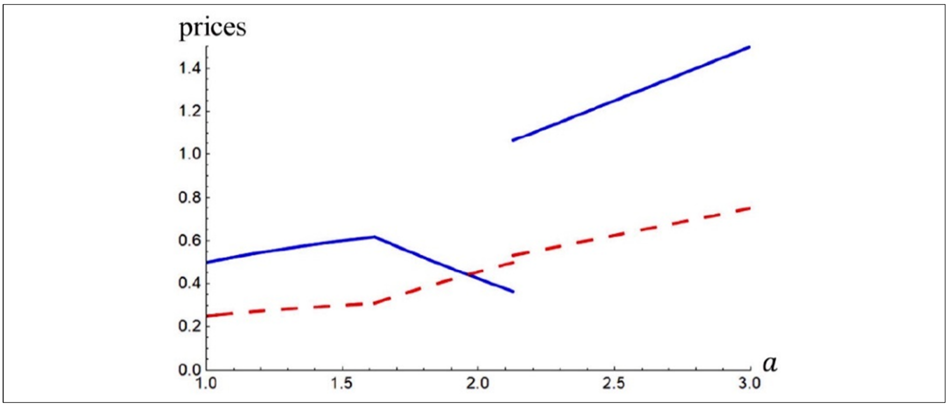
Second-mover advantage with margin and profit reversals: In this section, we analyze the conditions for second-mover advantage to occur. By comparing π_U^* and π_D^*, we can show that $\pi_D^* > \pi_U^*$ holds in the parameter region $\Omega = \{(a,b) \mid 1.763 < a < 2.127$ and $\underline{b}(a) \le b \le b^*(a)\}$, where $b^*(a) = \frac{1}{8}(9a^2 + 3(a-1)\sqrt{(a-1)(9a-1)} - 3 - 14a)$ (Figure 8).

[Figure 8] Region of second-mover advantage with price and profit reversals

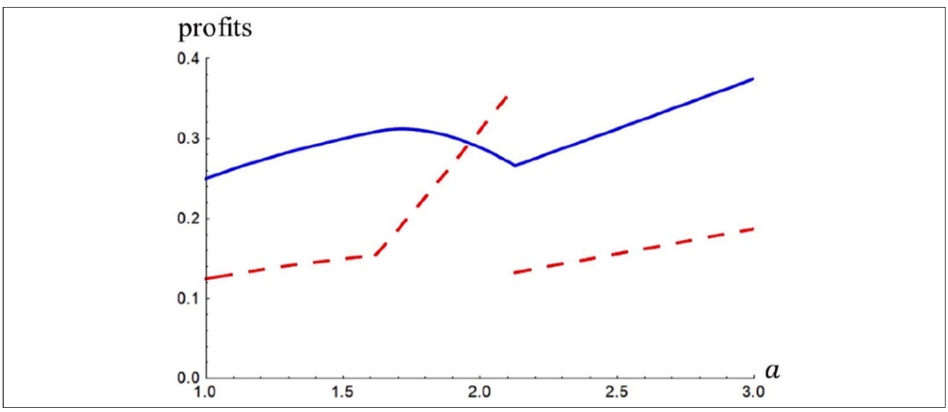


When the mass of both markets are equal (i.e., $a = b$), the equilibrium prices and profits of the leader and the follower change as a increases. Figures 9 and 10 show the respective prices and profits of the leader and the follower.

[Figure 9] Prices of the leader (solid) and the follower (dashed) when b=a



[Figure 10] Profits of the leader (solid) and the follower (dashed) when b=a



In Both-serving Region II, firm U has the incentive to lower its price to induce firm D to serve both markets. Firm D can set a higher price and make a larger profit due to strategic complementarity. In the region defined by Ω, this strategic effect is sufficiently strong to make the follower's price and profit larger than the leader's. That is, a second-mover advantage appears, which will not occur in the case of a single market.

For expositional purposes, we assume $a = b$ in the remaining sections.

IV. Simultaneous Pricing Game

Now, suppose firms U and D set prices p_U and p_D simultaneously. Under cost symmetry, both firms face the same best response function:

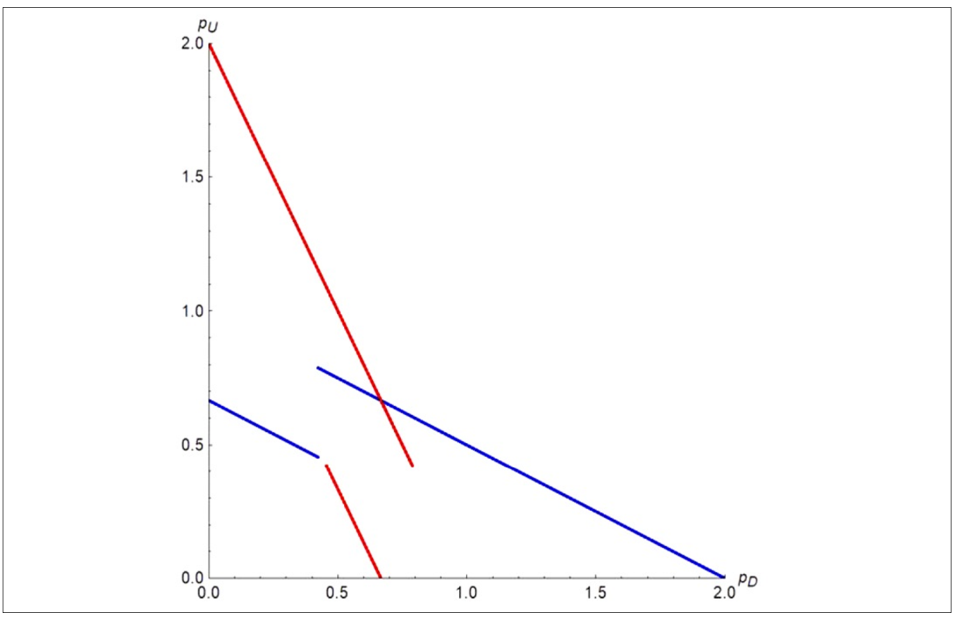
$$p_i^r(p_j) = \begin{cases} \frac{a}{a+1} - \frac{p_j}{2} & \text{for } p_j \le 1 - \frac{a-1}{\sqrt{a+1}} \text{ (both serving)} \\ \frac{a}{2} - \frac{p_j}{2} & \text{for } p_j > 1 - \frac{a-1}{\sqrt{a+1}} \text{ (single serving)} \end{cases}, \quad i = U, D, j \ne i. \tag{15}$$

The symmetric equilibrium prices are

$$p^s = \begin{cases} \frac{2a}{3(a+1)} & \text{for } 1 < a \le 1.961 \text{ (both serving)} \\ \frac{a}{3} & \text{for } a > 1.708 \text{ (single serving)} \end{cases}. \tag{16}$$

Multiple equilibria occur for $1.708 < a \le 1.961$ due to the kinks of the reaction functions of the two firms. Figure 11 depicts the case of a unique single-serving equilibrium for $a = 2$. The lower parts of the reaction functions will intersect along with the upper parts for smaller values of a.

[Figure 11] Single-serving equilibrium under simultaneous pricing ($a = b = 2$)

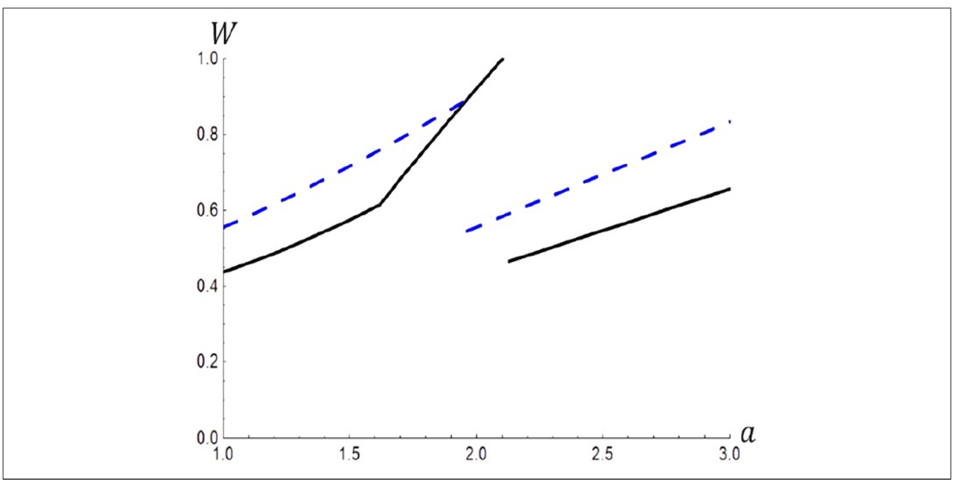


V. Simultaneous Pricing versus Sequential Pricing

The order of moves in the pricing game affects not only equilibrium prices but also the decision on single or both serving. In the sequential-move game, the leader facing the follower's deviation threat reduces its price for $\frac{1+\sqrt{5}}{2} < a < 2.127$. Even though the follower increases its price in response, its size is smaller than that of the leader's price cut. In addition, the exclusion of the weak market is more likely under simultaneous pricing compared with sequential pricing. Exclusion occurs for $a > 2.127$ under sequential pricing, whereas it occurs for $a > \underline{a}$ $(1.708 < \underline{a} \leq 1.961)$ under simultaneous pricing. In terms of social welfare, sequential pricing is better than simultaneous pricing due to the two factors, and their effects can be sufficiently large to reverse the traditional result of the welfare superiority of simultaneous moves in bilateral pricing games.

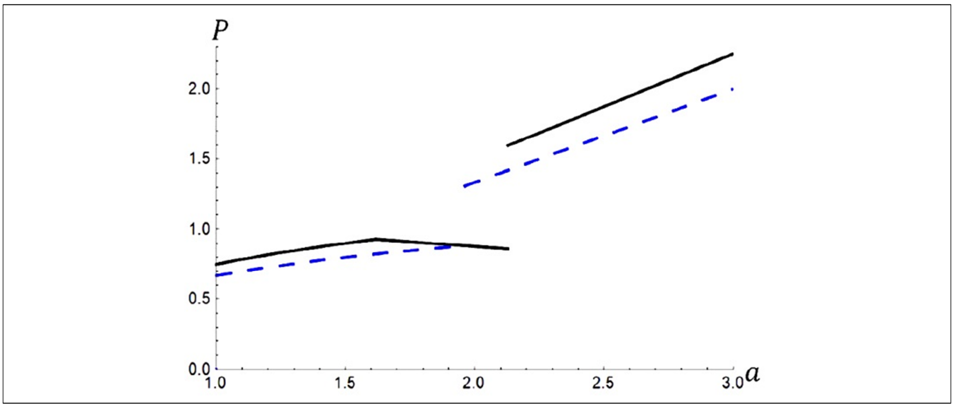
The total price is higher under sequential pricing as long as both markets are served under simultaneous pricing. However, the total price is lower under sequential pricing for $a \in (1.961, 2.127)$, where the weak market is excluded under simultaneous pricing while being served under sequential pricing. Moreover, for $a \in (1.708, 1.961)$, the weak market may be excluded due to coordination failure between the two firms, resulting in a lower total price realized under sequential pricing.

[Figure 12] Total prices under sequential (solid) and simultaneous (dashed) pricing



If such a price reversal occurs, then social welfare is higher under sequential pricing than simultaneous pricing. As shown in Figure 13, sequential pricing is welfare superior if the weak market is excluded under simultaneous pricing while being served under sequential pricing (i.e., $1.708 < a < 2.127$). When both pricing regimes serve both markets or only the strong one, the standard outcome occurs, resulting in a lower price and increased welfare under simultaneous pricing.

[Figure 13] Social welfares under sequential (solid) and simultaneous (dashed) pricing



The main driver of the welfare reversal is the demand expansion effect of sequential pricing. The weak market is more likely to be excluded under simultaneous pricing because neither firm considers negative price externalities caused by complementarity. Conversely, in sequential pricing, the leader partially internalizes the external effects by lowering its price to induce the follower to serve both markets. Given that the market structure analyzed in this paper is commonly observed in reality, policymakers should be cautious when intervening in complementary goods markets.

VI. Conclusion and Discussion

This paper examined bilateral vertical monopolies pricing, which involves two consumer groups with different demands for a complementarity product. We showed that a second-mover advantage might appear, and sequential pricing can be more efficient than simultaneous pricing, in contrast to traditional theories. Given the follower's threat of shutting down the smaller market, the standard first-mover advantage is eroded in the bilateral pricing game. We also found that the follower may wish to commit to uniform pricing to take advantage of its strategic position. According to our findings, the relative merit of the two pricing regimes depends on the structure of the market demand, which calls for caution in implementing relevant policies.

The above conclusion has been reached under several simplifying assumptions. Particularly, our analysis is based on a linear demand model with two groups of consumers and zero marginal cost for the firms. Thus, the robustness of the main result in other situations should be checked. The same result may not be obtained for nonlinear demands and increasing and/or asymmetric marginal costs. For instance, if firms have different marginal costs (but still constant) both serving equilibria are less likely to occur; thus, the possibility of the second-mover advantage with margin and profit reversal will be smaller. Specifically, suppose the upstream and downstream firms' constant marginal costs be c_U and c_D, respectively. Let the total perceived input cost of firm D be $w = p_U + c_D$. The downstream firm has to incur an additional marginal cost of c_D. Then, to compensate for this additional marginal cost, the upstream firm has to lower the threshold price to $\hat{p}_U = 1 - \frac{a-1}{\sqrt{b+1}} - c_D$, resulting in the decrease in the downstream firm indifferent between both serving and single serving. Unfortunately, the analysis with nonlinear demands and costs seems considerably more complicated because determining the point of kink in the follower's marginal revenue is difficult. Here, we contend with finding the possibility of second-mover advantage and the superiority of sequential pricing due to the follower's threat of shutting down the smaller market in vertical bilateral monopolies. Finding sufficient conditions that guarantee the result or the situations where the result does not hold is a worthwhile endeavor, and we intend to address this in our future work.

VII. Appendix : The Follower's Incentive to Commit to Uniform Pricing

Here, we discuss a related problem where firm D can set different prices in the two markets, namely, third-degree price discrimination. Given that the margin and profit reversal result comes from the follower's ability to exclude the weak market under linear pricing, a question of interest is whether firm D will give up price discrimination by committing to uniform pricing across the markets.

To compare the two pricing regimes, suppose that firm D can price discriminate between the two markets and can commit to uniform pricing through a public announcement.[3] Assume that firm U cannot price discriminate because of the inability to distinguish two groups of consumers. For instance, firm U is an upstream producer, and firm D is a downstream retailer in a vertical market which is only the retailer who possesses information about consumer identity. The timing of the game is as follows:

1. Firm D announces whether it will commit to uniform pricing;
2. Firm U sets its uniform price p_U;
3. Firm D sets a uniform or discriminative pricing depending on the announcement that it made.

[3] This problem can also be viewed as determining whether the government should allow firm D to price discriminate.

Given that the margin and profit reversal result comes from the follower's ability to exclude the weak market under linear pricing, a question of interest is whether firm D will give up price discrimination by committing to uniform pricing across the markets.

Let p_D^k be the price firm D sets in market $k=1,2$. Firm D's best response is $p_D^1=\frac{1}{2}-\frac{p_U}{2}$ for $p_U\le 1$ and $p_D^2=\frac{a}{2}-\frac{p_U}{2}$ for $p_U\le a$. Then, firm U's profit is

$$\pi_U(p_U)=\begin{cases} p_U(1-\frac{a+1}{2a}p_U) & \text{for } p_U\le 1 \text{ (both serving)} \\ p_U(\frac{1}{2}-\frac{p_U}{2a}) & \text{for } p_U>1 \text{ (single serving)} \end{cases}. \tag{17}$$

Firm U has two options that induce firm D to choose either: i) selling in both markets by setting $p_U=\frac{a}{a+1}$ for any given a or ii) selling only in the strong market by setting $p_U=\frac{a}{2}$ for $a\ge 2$ (interior solution) and $p_U=1$ for $a<2$ (corner solution). We compare the two options, and the optimal price turns out to be

$$p_U^d=\begin{cases} \frac{a}{a+1} & \text{for } 1\le a\le 3 \text{ (both serving)} \\ \frac{a}{2} & \text{for } a>3 \text{ (single serving)} \end{cases}. \tag{18}$$

Then, the equilibrium profits of the two firms are

$$\pi_U^d=\begin{cases} \frac{a}{2(a+1)} & \text{for } 1\le a\le 3 \text{ (both serving)} \\ \frac{a}{8} & \text{for } a>3 \text{ (single serving)} \end{cases}, \tag{19}$$

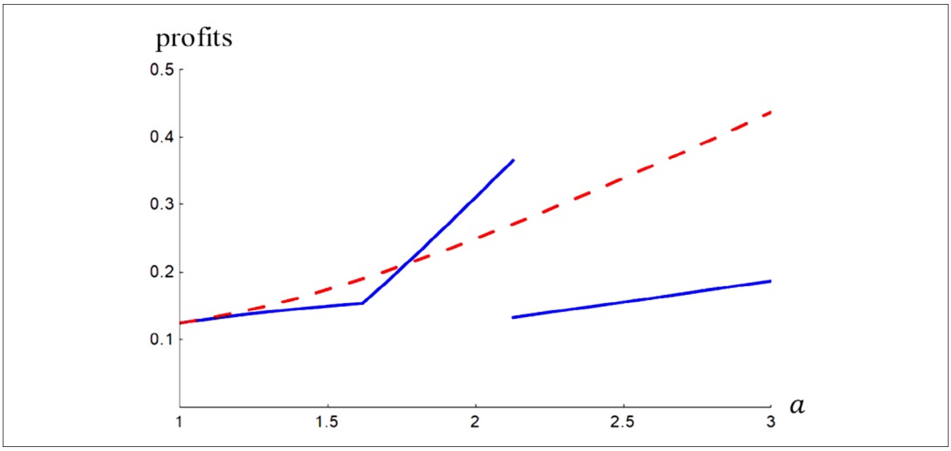
and

$$\pi_U^d=\begin{cases} \frac{1-a+a^2}{4(a+1)} & \text{for } 1\le a\le 3 \text{ (both serving)} \\ \frac{a}{16} & \text{for } a>3 \text{ (single serving)} \end{cases}, \tag{20}$$

which are depicted in Figure 14. The superscript d denotes the case of price discrimination by firm D.

When a belongs to Both-serving Region I ($1\le a<\frac{1+\sqrt{5}}{2}$), firm D's threat of excluding the smaller market is invalid even if it commits to uniform pricing. Thus, choosing price discrimination over uniform pricing is profitable for firm D, as shown in Figure 14. Similar logic holds when a belongs to Single-serving Region ($a>2.127$). Conversely, when a belongs to Both-serving Region II ($\frac{1+\sqrt{5}}{2}\le a\le 2.127$), firm D can pose a valid threat of deviating to single serving when it commits to uniform pricing. Firm D may increase its profits by sacrificing this advantage, but it will also have to pay a larger upstream price when it chooses to price discriminate. As a result, firm D commits to uniform pricing when $1.765 < a \leq 2.127$, which is a larger part of Both-serving Region II (Figure 14). Here, the gain from the price increase under uniform pricing outweighs the benefit of price discrimination for firm D.

[Figure 14] Follower's profits under uniform pricing (solid) and price discrimination (dashed)



References

Adachi, T. and T. Ebina (2014), "Double Marginalization and Cost Pass-through: Weyl-Fabinger and Cowan meet Spengler and Bresnahan-Reiss," *Economics Letters*, 122(2), 170–175.

Amir, R. (1995), "Endogenous Timing in Two-player Games: A Counterexample," *Games and Economic Behavior*, 9(2), 234–237.

Amir, R. and A. Gama (2019), "On Cournot's Theory of Oligopoly with Perfect Complements," Working paper.

Amir, R. and I. Grilo (1999), "Stackelberg Versus Cournot Equilibrium," *Games and Economic Behavior*, 26(1), 1–21.

Amir, R. and A. Stepanova (2006), "Second-Mover Advantage and Price Leadership in Bertrand Duopoly," *Games and Economic Behavior*, 55(1), 1–20.

Berbel, J., M. A. Mesa-Jurado, and J. M. Piston (2011), "Value of Irrigation Water in Guadalquivir Basin (Spain) by Residual Value Method," *Water Resources Management*, 25(6), 1565–1579.

Bontemps, C. and S. Couture (2002), "Irrigation Water Demand for the Decision Maker," *Environment and Development Economics*, 7(4), 643-657.

Bresnahan, T. F. and P. C. Reiss (1985), "Dealer and Manufacturer Margins," *RAND Journal of Economics*, 16(2), 253–268.

Dowrick, S. (1986), "von Stackelberg and Cournot Duopoly: Choosing Roles," *RAND Journal of Economics*, 17(2), 251–260.

Formby, J. P., S. Layson, and W. J. Smith (1982), "The Law of Demand, Positive Sloping Marginal Revenue, and Multiple Profit Equilibria," *Economic Inquiry*, 20(2), 303–311.

Gal-Or, E. (1985), "First Mover and Second Mover Advantages," *International Economic Review*, 26(3), 649-653.

Gal-Or, E. (1987), "First Mover Disadvantages with Private Information," *Review of Economic Studies*, 54(2), 279–292.

Greenhut, M. L. and H. Ohta (1972), "Monopoly Output Under Alternative Spatial Pricing Techniques," *American Economic Review*, 62(4), 705–713.

Hamilton, J. H. and S. M. Slutsky (1990), "Endogenous Timing in Duopoly Games: Stackelberg or Cournot Equilibria," *Games and Economic Behavior*, 2(1), 29–46.

Hazlett, T., S. Oh, and B. Skorup (2018), "Mobile Phone Regulation: The Effects of Prohibiting Handset Bundling in Finland," *Journal of Competition Law & Economics*, 14(1), 65–90.

Hirata, D. and T. Matsumura (2011), "Price Leadership in a Homogeneous Product Market," *Journal of Economics*, 104(3), 199–217.

Hirose, K., S. H. Lee, and T. Matsumura, (2017), "Environmental Corporate Social Responsibility: A Note on the First-mover Advantage under Price Competition," *Economics Bulletin*, 37(1), 214–221.

Hoel, M. (1984), "Extraction of a Resource with a Substitute for Some of its Uses," *Canadian Journal of Economics / Revue Canadienne d'Economique*, 17(3), 593–602.

Johnson, J. P. and D. P. Myatt (2003), "Multiproduct Quality Competition: Fighting Brands and Product Line Pruning," *American Economic Review*, 93(3), 748–774.

Ono, Y. (1978), "The Equilibrium of Duopoly in a Market of Homogeneous Goods," *Economica*, 45, 287–295.

Rasmusen, E. and Y. R. Yoon (2012), "First versus Second Mover Advantage with Information Asymmetry about the Profitability of New Markets," *Journal of Industrial Economics*, 60, 374–405.

van Damme, E. and S. Hurkens (2004), "Endogenous Price Leadership," *Games and Economic Behavior*, 47(2), 404–420.

Walters, A. A. (1980), "A Note on Monopoly Equilibrium," *Economic Journal*, 90(357), 161–162.

수요가 상이한 구매자 그룹에 대한 수직 쌍방독점의 순차 가격 설정

한 종 희* · 이 영 준**

초 록 본 논문은 두 개의 완전보완재로 구성된 최종 제품에 대해 서로 다른 수요를 지닌 두 구매자 그룹에 각 재화를 판매하는 두 쌍방독점 기업의 가격 설정 문제를 고려한다. 이 경우 전통적 이론과 달리 후발자 혜택이 나타날 수 있고, 동시가격설정보다 순차가격설정에서 사회후생이 더 높아질 수 있는데, 그 이유는 순차가격설정에서 후발자가 수요가 낮은 그룹에 대한 판매를 거부할 위협을 가하여 선발자의 가격 인하를 유도할 수 있기 때문이다. 같은 이유로 후발자는 가격차별보다 균등가격에서 더 높은 이윤을 얻을 수 있다.

핵심 주제어: 쌍방독점, 수직연계시장, 후발자 혜택, 꾸르노 보완재
경제학문헌목록 주제분류: L11, L13

투고 일자: 2022. 2. 14. 심사 및 수정 일자: 2022. 10. 28. 게재 확정 일자: 2022. 12. 16.

* 교신저자, 연세대학교 경제학부 교수, e-mail: hahnjh@yonsei.ac.kr
** 제1저자, 로체스터대 싸이몬 경영대학원 박사과정, e-mail: ylee141@simon.rochester.edu