Reverse First-mover and Second-mover Advantage in a Vertical Structure

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25 September 2014

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This version: 25 September 2014

Abstract

This paper examines the issue of the first-mover and second-mover advantage in a vertical structure in which each manufacturer trades with a separated retailer via two-part tariffs. Compared to the canonical result in one-tier market, we find that the manufacturers' preference orderings over sequential versus simultaneous play are reversed in a vertical structure. We show that the Stackelberg leader (Stackelberg follower) had the first (second)-mover advantage in the downstream Cournot (Bertrand) competition. The first (second)-mover advantage compels its manufacturer to set the wholesale price higher than that of rival. Finally, we show that the manufacturer in which its retailer moves second (first) in a downstream Stackelberg Cournot (Bertrand) competition earns higher profits than the other in which its retailer moves first (second) in a downstream Stackelberg Cournot (Bertrand) competition.
JEL Classification: D43, L13, L14.
Keywords: First- and Second-mover Advantage, Two-part Tariffs, Vertical Structure.

1 Introduction

There is a large literature on first- and second-mover advantages. Usually, analyzing the effects of the strategic decision on either delay or preemption matter is an important topic. According to a well-known result in oligopoly theory, a sequential-move quantity game yields a higher aggregate-industry output level and a lower market price than do simultaneous-move quantity games. Furthermore, the leader's (follower's) profit under a sequential-move quantity game is higher (lower) than under simultaneous-move quantity games, which implies that firms enjoy a first-mover advantage. In contrast, both leader and follower collect a higher profit under a sequential-move price game than under simultaneous-move price games. However, the firm (i.e., the leader) that sets its price first makes a lower profit than the firm (i.e., the follower) that sets its price second, which implies that firms enjoy a second-mover advantage[1]. Comparing Cournot and Bertrand competition under either sequential or simultaneous decision-making, these works suggest some important implications for the determination of market outcomes.

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[1]For example, see Gal-Or (1985), Amir and Grilo (1999), and Amir and Stepanova (2006).

The existing literature has produced an array of extensions of the Stackelberg model. In one strand of extensions and generalizations of the Stackelberg model, Boyer and Moreaux (1987), Mailath (1993), Albaek (1990), Hamilton and Slutsky (1990), and Amir and Jin (2001), for example, reveal counter-results based on the original framework by allowing for a wider range of cost and demand asymmetries. In another strand of extensions and generalizations of Singh and Vives (1984), Dastidar (1997), Qiu (1997), Lambertini (1997), and Hackner (2000), among others, deal with the choice of strategic variables for prices or quantities and suggest important implications for the determination of market outcomes in a one-tier duopoly. On the other hand, Lopez (2007) examines the Bertrand-Cournot ranking of profits in a duopoly model with union. Lopez (2007) shows that Bertrand profits may exceed Cournot profits when decentralized bargaining over labor cost is introduced. Arya *et al.* (2008) explore the standard conclusions about duopoly competition when the production of a key input is outsourced to a vertically integrated retail competitor with upstream market power. They show that Bertrand competition leads to higher prices, higher industry profits, lower consumer surplus, and lower total surplus than does Cournot competition.

We address the issue of first- and second-mover advantages under both Cournot and Bertrand competition in a vertically related market, in which each upstream firm trades with each downstream firm through a two-part tariff contract. In fact, even though our issue was analyzed in one-tier market of the industrial organization context, the potential impact of vertical structure was not theoretically incorporated when each manufacturer sells its product to its own retailer. The paper that is closely related to the present model of first- and second-mover advantages includes Lee *et al.* (2014) in our companion paper. Lee *et al.* (2014) showed that in which a *monopolistic* upstream firm trades with two competing downstream firms through two-part tariffs. They showed that the profit of the upstream firm and social welfare are equal between Cournot and Bertrand competition regardless of both simultaneous- and sequential-move games. However, when the market structure involves sequential- or simultaneous-moves in a vertically related market, one issue that remains is whether the above results are robust or not when each manufacturer trades with a separated retailer via two-part tariffs. This paper compares such situations with both simultaneous- and sequential-move games in a vertically related market. Notably, our paper is the first study to consider a case in which prices or quantities are set with a simultaneous- or sequential-move game between two downstream firms in a vertically related duopoly.

The main result of our paper is as follows. Contrast to the canonical results in one-tier market, we find that incorporating the issue of first- and second-mover advantages under both Cournot and Bertrand competition into a vertically related market yields completely reversed, borrowing the setting of Lee *et al.* (2014). This is because each upstream firm in each channel controls first- and second-mover advantages by adjusting input prices under either Cournot or Bertrand competition when the market structure involves sequential or simultaneous moves. The intuition behind main results is as follows. Since input prices under Cournot competition are strategic substitutes, each upstream firm sets the input price to be *below* its marginal cost when the market structure involves simultaneous-move. Thus, each downstream firm sets the final-good price to be above its marginal cost, which enhancing each upstream firm's profit. However, when the market structure involves sequential-move, the leader's upstream firm sets the input price to be equal to its marginal cost, while the follower's upstream firm sets the input price to be below its marginal cost. That is, under Cournot competition, such lower input pricing of follower's upstream firm forces the downstream firm of the Stackelberg follower to be aggressive in producing output and yields higher profit of the follower's upstream firm than the leader's upstream firm. On the other hand, since input prices under Bertrand competition are strategic complements, each upstream firm sets the input price to be *above* its marginal cost when the market structure involves simultaneous move. However, when the market structure involves sequential move, the follower's upstream firm sets the input price to be above its marginal cost, while the leader's upstream firm sets the input price to be equal to its marginal cost. Hence, the follower's upstream firm has incentive to remove the second-mover advantage of downstream firm. Thus, we show that even if there exists a first-mover (second-mover) advantage at the downstream competition, the upstream firm resolves the first-mover (second-mover) advantage by providing for differential input prices to the downstream firms. As a result, we show that when the goods are substitutes, the upstream firm in which its retailer moves second (first) in a downstream Stackelberg Cournot (Bertrand) competition earns higher profits than the other in which its retailer moves first (second) in a downstream Stackelberg Cournot (Bertrand) competition, and vice versa when the goods are complements.

Our study differs from the existing literature in at least two important aspects. First, rather than compare simultaneous- and sequential-move games under Bertrand or Cournot competition in a vertical structure, existing studies focus on negotiated input prices. Second, previous studies focus on simultaneous- move games while comparing Bertrand and Cournot profits in one-tier market. In contrast, this paper presents upstream profit and social welfare comparisons between simultaneous- and sequential-move games under both Bertrand and Cournot competition in a vertically related market, in which each upstream firm trades with two downstream firms through a two-part tariff contract. To the best of the authors' knowledge, Mukherjee *et al.* (2012) and Alipranti *et al.* (2014) are the only studies that are closely related to our vertical structure model. Mukherjee *et al.* (2012) compare Cournot with Bertrand competition in a vertical structure where the timing of games is not provided, assuming price discrimination by an upstream firm and homogeneous final goods. Alipranti *et al.* (2014) demonstrated that the results drawn from a comparison between Cournot and Bertrand competition are reversed in a vertically related market with upstream monopoly and trading via two-part tariffs. They only focus on a comparison between Bertrand and Cournot competition with simultaneously negotiated input prices.

The remainder of this paper is organized as follows. In Section 2, we describe the model. In Section 3, we consider the bench mark case of Cournot and Bertrand simultaneous-move games. Section 4 considers the Cournot and Bertrand sequential-move game. The concluding remarks appear in Section 5.

2 The Model

Consider a manufacturing duopoly in which each upstream firm (i.e., manufacture) sells its product to its own downstream firm (i.e., retailer). The inverse and direct demands for downstream firm are:

$$p_i = 1 - q_i - bq_j, \text{ and } q_i = \frac{1 - b - p_i + bp_j}{1 - b^2}; i, j = 1, 2, i \neq j, \tag{1}$$

where q_i and q_j are the outputs, p_i and p_j are the retail prices charged for final product i and j, respectively. The parameter b, with $b \in [0, 1]$, of the demand function measures the degree of horizontal differentiation. As b approaches one, the products become less differentiated, and as b approaches zero, the products become more differentiated. Each product is produced with the marginal cost of c. For simplicity, there are no retailing costs. We also assume that each upstream firm prohibits its downstream from transacting and distributing the product produced by the rival upstream firm, and that only one downstream firm serves a given upstream firm.

We posit a three-stage game. At stage one, each upstream firm offers a contract to its own downstream firm. The contract is composed of two variables; wholes price w_i and franchise fee F_i. At stage two, downstream firm j (leader) sets the outputs q_j (retail price p_j) in Stackelberg Cournot (Bertrand) competition. At stage three, downstream firm i (follower) sets the output q_i (retail price p_i) in Stackelberg Cournot (Bertrand) competition.

3 Benchmark

3.1 Cournot Simultaneous-move Game

We first consider the Cournot competition in which downstream firm simultaneously sets a quantity. At stage two, given the two-part tariffs contract and downstream firm j's quantity, downstream firm i sets the quantity so as to maximize its profit. Downstream firm i's maximization problem is as follows:

$$\max_{q_i} \ \pi_i = (p_i - w_i)q_i - F_i = (1 - bq_j - q_i - w_i)q_i - F_i; \quad i, j = 1, 2, i \neq j.$$

where w_i is the wholesale price and F_i is the franchise fee. Downstream firm i chooses its output as the function of wholesale prices as follows:

$$q_i = \frac{2 - b - 2w_i + bw_j}{4 - b^2}, \quad q_j = \frac{2 - b - 2w_j + bw_i}{4 - b^2},$$

We obtain the equilibrium retail price p_i and profit π_i as follows:

$$p_i = \frac{2 - b + (2 - b^2)w_i + bw_j}{4 - b^2}, \quad \pi_i = \frac{(2 - b - 2w_i + bw_j)^2}{4 - b^2} - F_i.$$

At stage one, upstream firm i's maximization problem is as follows:

$$\max_{w_i, F_i} u_i = (w_i - c)q_i + F_i \quad \text{s.t. } \pi_i = (p_i - w_i)q_i - F_i \geq 0.$$

Note that the above constraint is binding. Therefore, we rewrite the above maximization problem as follows:

$$\max_{w_i} u_i = (p_i - c)q_i = \frac{(2 - b - 2w_i + bw_j)[(2 - b)(1 - w_i) - c(4 - b^2) + bw_j]}{(4 - b^2)^2}.$$

The equilibrium wholesale for upstream firm i is derived as follows:

$$w_i^C = c - \frac{b^2\theta}{4 + 2b - b^2}.$$

Using $1 - c = \theta$, the equilibrium of the first stage for a simultaneous-move game is described in Lemma 1.

Lemma 1: *Under Eq. (1), if each upstream firm offers a two-part tariffs contract to its downstream firm, the equilibrium wholesale prices, retail prices, quantities, and the upstream firms' profits and fixed fees are respectively given by*

$$q_i^C = \frac{2\theta}{4 + 2b - b^2}, \quad w_i^C = c - \frac{b^2\theta}{4 + 2b - b^2}, \quad p_i^C = c + \frac{(2 - b^2)\theta}{4 + 2b - b^2},$$
$$u_i^C = \frac{2(2 - b^2)\theta^2}{(4 + 2b - b^2)^2}, \quad F_i^C = \frac{4\theta^2}{(4 + 2b^2 - b^2)^2}.$$

where the superscript 'C' denotes Cournot simultaneous-move game.

Note that the wholesale prices are strategic substitutes. In other words, if upstream firm j decreases wholesale price w_j, downstream firm j increases quantity q_j. On the other hand, the output function for downstream firm i shifts to downward. Consequently, profit function for upstream firm i shifts down to the right[2]. Each upstream firm sets its wholesale price to be below its marginal cost in order to be beneficial in downstream competition.

[2]The second cross derivative function for upstream firm i's profit function is $\partial^2 u_i/\partial w_i \partial w_j < 0$. Therefore, the

3.2 Bertrand Simultaneous-move Game

We now consider Bertrand competition in which each downstream firm simultaneously sets a retail price.

At stage two, given the two-part tariffs contract and downstream firm j's price, downstream firm i sets the price p_i so as to maximize its profit. Downstream firm i's maximization problem is as follows:

$$\max_{p_i} \ \pi_i = \frac{(p_i - w_i)(1 - b - p_i + bp_j)}{1 - b^2} - F_i; \quad i, j = 1, 2, i \neq j.$$

We obtain the equilibrium prices in terms of wholesale prices, w_i and w_j.

$$p_i = \frac{2 - b - b^2 + 2w_i + bw_j}{4 - b^2}.$$

We obtain the equilibrium quantity and profit as follows:

$$q_i = \frac{2 - b - b^2 - (2 - b^2)w_j + bw_i}{(4 - b^2)(1 - b^2)}, \quad \pi_i = \frac{[2 - b - b^2 - (2 - b^2)w_i + bw_j]^2}{(4 - b^2)^2(1 - b^2)} - F_i.$$

At stage one, the upstream firm i's maximization problem is as follows:

$$\max_{w_i, F_i} u_i = (w_i - c)q_i + F_i \quad \text{s.t. } \pi_i = (p_i - w_i)q_i - F_i \geq 0.$$

Note that the above constraint is binding. Therefore, we rewrite the above maximization problem as follows:

$$\max_{w_i} u_i = (p_i - c)q_i = \frac{[2 - b - b^2 - (2 - b^2)w_i + bw_j][2 - b - b^2 - (4 - b^2)c + 2w_i + bw_j]}{(4 - b^2)^2(1 - b^2)}.$$

From the above maximization problem, we obtain the equilibrium wholesale prices w_i as follows.

$$w_i^B = c + \frac{b^2(1 - b)\theta}{4 - 2b - b^2}.$$

Note that each upstream firm sets the wholesale price to be above its marginal cost as wholesale prices are strategic complements under Bertrand competition[3].

Using $1 - c = \theta$, the equilibrium of the first stage for a simultaneous-move game is described in Lemma 2.

Lemma 2: *Under Eq. (1), if each upstream firm offers a two-part tariffs contract to its own downstream firm, the equilibrium wholesale prices, retail prices, output, and the upstream firm's profit and fixed fee are respectively given by*

$$w_i^B = c + \frac{b^2(1 - b)\theta}{4 - 2b - b^2}, \quad p_i^B = c + \frac{2(1 - b)\theta}{4 - 2b - b^2},$$
$$q_i^B = \frac{\theta(2 - b^2)}{(1 + b)(4 - 2b - b^2)}, \quad u_i^B = \frac{2(1 - b)(2 - b^2)\theta^2}{(1 + b)(4 - 2b - b^2)^2}.$$

wholesale prices are strategic substitutes. Upstream firm i's profit function with two-part tariffs is $(p_i - w_i)q_i$. The second cross derivative function for upstream firm i's profit function is $\partial^2 u_i/\partial w_i \partial w_j = (\partial^2 p_i/\partial w_i \partial w_j)q_i + (\partial p_i/\partial w_i)(\partial q_i/\partial w_j) + (\partial p_i/\partial w_j)(\partial q_i/\partial w_i) + (p_i - c)(\partial^2 qi/\partial w_i \partial w_j)$. Note that $(\partial^2 p_i/\partial w_i \partial w_j) = 0$ and $(\partial^2 q_i/\partial w_i \partial w_j) = 0$ by Eq. (1). We also know that $\partial q_i/\partial w_j = b/(4 - b^2), \partial q_i/\partial w_i = -2/(4 - b^2), \partial p_i/\partial w_i = (2 - b^2)/(4 - b^2)$, and $\partial p_i/\partial w_j = b/(4 - b^2)$. Therefore, it is obvious that the sign of the second cross derivative function for upstream firm i's is negative.

[3]For detail, consult to footnote 2.

4 Sequential-move Game

4.1 Cournot Sequential-move Game

We now turn to the Cournot sequential-move game in which downstream firm j is the Stackelberg leader. At stage three, given the two-part tariff contract and downstream firm j's quantity, downstream firm i (Stackelberg follower) sets the quantity so as to maximize its profit. Downstream firm i's maximization problem is as follows:

$$\max_{q_i} \pi_i = (p_i - w_i)q_i - F_i = (1 - q_i - bq_j - w_i)q_i - F_i,$$

Note that the sales quantity is independent of F_i. Therefore, downstream firm i chooses its sales quantity and final good price as the function of wholesale price w_i and downstream firm j's quantity as follows:

$$q_i = \frac{1 - bq_j - w_i}{2}.$$

Thus, price and downstream firm i's profit at stage three is as follows:

$$p_i = \frac{1 - bq_j + w_i}{2}, \quad \pi_i = \frac{(1 - bq_j - w_i)^2}{4} - F_i.$$

At stage two, downstream firm j (Stackelberg leader) sets the sales quantity q_j so as to maximize it's profit for given wholesale prices. Downstream firm j's maximization problem is as follows:

$$\max_{q_j} \pi_j = (p_j - w_j)q_j - F_j = \frac{[2 - b - (2 - b^2)q_j - 2w_j + bw_i]q_j}{2} - F_j.$$

Downstream firm j chooses its quantity as the function of wholesale prices as follows:

$$q_j = \frac{2 - b - 2w_j + bw_i}{2(2 - b^2)}.$$

Substituting the quantity into its rival's quantity, retail prices and downstream firms' profits, we obtain the rival's quantity, retail prices p_i, and p_j, and downstream firms' profits π_i, and π_j.

$$q_i = \frac{4 - 2b - b^2 - (4 - b^2)w_i + 2bw_j}{4(2 - b^2)}, \quad p_j = \frac{2 - b + 2w_j + bw_i}{4}, \quad p_i = \frac{4 - b - b^2 + 2bw_j + (4 - 3b^2)w_i}{4(2 - b^2)},$$
$$\pi_j = \frac{(2 - b - 2w_j + bw_i)^2}{8(2 - b^2)} - F_j, \quad \pi_i = \frac{[4 - 2b - b^2 + 2bw_j - (4 - b^2)w_i]^2}{16(2 - b^2)^2} - F_i.$$

Finally, we obtain the following results.

Lemma 3: *If both wholesale prices are equal, downstream firm j has the first-mover advantage.*

Proof: Suppose that $w_i = w_j = w$. Then, we obtain $q_j^L - q_i^F = \frac{b^2(1-w)}{4(2-b^2)} > 0$ and $p_i^F - p_j^L = \frac{(1-b)b^2(1-w)}{4(2-b^2)} > 0$. Define $\Delta q \equiv q_j^L - q_i^F$ and $\Delta p \equiv p_i^F - p_j^L$. We have $\Delta q - \Delta p = \frac{b^3(1-w)}{4(2-b^2)} > 0$. Therefore, if $w_i = w_j = w$, downstream firm j has the first-mover advantage in the downstream competition.
Q.E.D.

At stage one, upstream firm i sets the retail price w_i and franchise fee F_i so as to maximize it's profit for given w_j. Upstream firm i's maximization problem is as follows:

$$\max_{w_i, F_i} u_i = (w_i - c)q_i + F_i \quad \text{s.t. } \pi_i \geq 0.$$

Note that the above constraint is binding. Therefore, we rewrite the above maximization problem as follows:

$$\max_{w_i} u_i = (p_i - c)q_i = \frac{[4 - 2b - b^2 + (4 - 3b^2)w_i + 2bw_j - 4(2 - b^2)c][4 - 2b - b^2 - (4 - b^2)w_i + 2bw_j]}{16(2 - b^2)^2}.$$

On the other hand, upstream firm j's maximization problem is as follows:

$$\max_{w_j, F_j} u_j = (w_j - c)q_j + F_j \quad \text{s.t. } \pi_j \geq 0.$$

Note that the above constraint is binding. Therefore, we rewrite the above maximization problem as follows:

$$\max_{w_j} u_j = (p_j - c)q_j = \frac{[2 - b + bw_i - 2w_j][2 - b - 4c + bw_i + 2w_j]}{8(2 - b^2)}.$$

The equilibrium retail prices are derived as follows:

$$w_j^L = c, \quad w_i^F = c - \frac{b^2\theta(4 - 2b - b^2)}{16 - 16b^2 + 3b^4},$$

As $\theta = (1 - c)$, we define a condition that $w_i \geq 0$, i.e., $c \geq [b^2(4 - 2b - b^2)]/[16 - 12b^2 + b^3 - b^4]$ where the superscript 'L' denotes Stackelberg leader and 'F' denotes Stackelberg follower. For the positive value of w_i^F, we assume that $c \geq [b^2(4 - 2b - b^2)]/[16 - 12b^2 + b^3 - b^4]$. Note that the upstream firm j (Stackelberg leader) sets the wholesale price to be equal to its marginal cost, while upstream firm i (Stackelberg follower) sets the wholesale price to be below its marginal cost.

Using w_j^L, w_i^F and noting $1 - c = \theta$, we obtain the quantities, retail prices, and upstream firms' profits as follows:

Lemma 4: *Suppose a sequential-move Cournot competition. Under Eq. (1), if each upstream firm offers two-part tariff contracts to its downstream firms, the equilibrium quantities, retail prices, upstream firms' profits and fixed fees are respectively given by*

$$\begin{aligned}
q_j^L &= \frac{(8 - 4b - 4b^2 + b^3)\theta}{16 - 16b^2 + 3b^4}, \quad q_i^F = \frac{(4 - 2b - b^2)\theta}{8 - 6b^2}, \\
p_j^L &= c + \frac{(16 - 8b - 16b^2 + 6b^3 + 4b^4 - b^5)\theta}{2(16 - 16b^2 + 3b^4)}, \quad p_i^F = c + \frac{(4 - 2b - b^2)\theta}{2(4 - b^2)}, \\
u_j^L &= \frac{(2 - b^2)(8 - 4b - 4b^2 + b^3)^2\theta^2}{2(16 - 16b^2 + 3b^4)^2}, \quad u_i^F = \frac{(4 - 2b - b^2)^2\theta^2}{4(16 - 16b^2 + 3b^4)}, \\
F_j^L &= \frac{(2 - b^2)(8 - 4b - 4b^2 + b^3)^2\theta^2}{2(16 - 16b^2 + 3b^4)^2}, \quad F_i^F = \frac{(4 - 2b - b^2)^2\theta^2}{4(4 - 3b^2)^2}.
\end{aligned}$$

We summarize these findings in Proposition 1.

Proposition 1: *Under Eq. (1), the upstream firm in which its downstream firm moves second sets the wholesale price to be below the marginal cost, while the rival in which its downstream firm moves* *first sets the wholesale price to be equal to the marginal cost.*

Proposition 1 can be explained as follows. Profit for downstream firm i (Stackelberg follower) is given by $\pi_i(q_i, q_j, w_i) = (1 - q_i - bq_j - w_i)q_i - F_i$. So, downstream firm i's best-response function is given by $BR_i(q_j, w_i) = (1 - w_i - bq_j)/2$. Thus, $\pi_j(q_j, BR_i, w_i, w_j) = (1 - q_j - b(1 - w_i - bq_j)/2)q_j - w_j q_j - F_j$. Note that now the upstream firms' payoffs differ from those of their downstream firms. Setting the derivative of $u_j(w_i, w_j)$ with respect to w_j equal to zero and simplifying yields the first-order condition: $(c - w_j)/(2 - b^2) = 0$ for all w_i. Thus, we find it is a dominant strategy for upstream firm j to set wholesale price equal to marginal cost when downstream firm j is a Stackelberg leader in the downstream market[4].

More specifically, the intuition behind this is as follows. Recall that upstream firm j's payoff is given by $u_j(w_i, w_j) = (w_j - c)q_j + \pi_j\{q_j(w_i, w_j), BR_i[q_j(w_i, w_j), w_i, w_j]\}$. This payoff depends on w_i both directly and indirectly through $q_j(w_i, w_j)$. Moreover, downstream firm i plays according to its best response that depends on q_j and w_i, but not direct on w_j. Essentially, upstream firm j can influence downstream i only indirectly through its impact on q_j, which then affects downstream firm i's best response BR_i. If downstream j is a Stackelberg leader, it already considered this impact of q_j on BR_i in the choice of q_j. More formally, by the envelope theorem (since π_j is maximized already by q_j), the optimal w_j solves:

$$\frac{\partial u_j(w_i, w_j)}{\partial w_j} = \frac{\partial \pi_j\{q_j(w_i, w_j), BR_i[q_j(w_i, w_j), w_i, w_j]\}}{\partial w_j} + q_j(w_i, w_j) + (w_j - c)\left[\frac{\partial q_j}{\partial w_j}\right] = 0.$$

Since $\frac{\partial \pi_j\{q_j(w_i,w_j), BR_i[q_j(w_i,w_j),w_i,w_j]\}}{\partial w_j} = -q_j$, this reduces to $\frac{\partial u_j(w_i,w_j)}{\partial w_j} = (w_j - c)\frac{\partial q_j}{\partial w_j} = 0$. Since $\frac{\partial q_j}{\partial w_j} < 0$, it follows that the optimal $w_j = c$ for all w_i. This result simplifies the determination of upstream firm i's optimal wholesale price w_i, since we can substitute $w_j = c$ into upstream firm i's objective function $u_i(w_i, w_j)$ before proceeding. Differentiating $u_i(w_i, c)$ with respect to w_i, we obtain $w_i^F = c - \frac{\theta b^2(4-2b-b^2)}{16-16b^2+3b^4}$. Thus, upstream firm i set the wholesale price to be below its marginal cost.

We now compare outputs and profits. Under the two-part tariffs contract, the Stackelberg leader's output is less than that of the Stackelberg follower. This is the contrast to the case under the linear pricing contract, in which the Stackelberg leader's output is more than that of the Stackelberg follower. We now turn to the upstream firm's profits. It can be easily shown that $u_j^L < u_i^F$; that is, Stackelberg leader is strongly disadvantageous under the two-part tariffs contract. We summarize these results in Proposition 2.

Proposition 2: *Under Eq. (1), (i) $q_i^F > q_j^L$ for all b; and (ii) $u_i^F > u_j^L$ for all b.*

Proof: From equations in Lemma 2, we obtain $q_i^F > q_j^L = b^4\theta/[2(16 - 16b^2 + 3b^4)]$. Therefore, downstream firm i's output is larger than that of downstream firm j. On the other hand, from equations in Lemma 2, we obtain $u_i^F - u_j^L = \frac{b^5(16-16b-4b^2+5b^3)\theta^2}{4(16-16b^2+3b^4)^2}$. Therefore, the upstream firm i's profits are higher than those of the downstream firm j. Q.E.D.

Proposition 2 suggests that under Eq. (1), the upstream firm in which its downstream firm moves second in a downstream competition earns higher profits than the other in which its downstream firm moves first in a downstream competition.

[4]As in Lemma 2, if $w_i = w_j$ in stage three, the downstream firm j has the first-mover advantage in the sense of comparing outputs and retail prices. Hence, the follower's upstream firm i has incentive to remove the first-mover advantage of downstream firm j. That is, the upstream firm i wants to set its wholesale price to be below its marginal cost in order to obtain an advantage in downstream competition.

The intuition behind Proposition 2 is as follows. At the downstream competition, the Stackelberg leader has the first-mover advantage ($q_j > q_i$). However, The follower's upstream firm has an incentive to set a lower wholesale price than that of the leader's upstream firm at stage one. The above two effects play important roles in competition. The effect of wholesale price on competition is larger the effect of the first-mover advantage. In the end, we show that the standard conclusions regarding the sequential Cournot competition can be reversed in a vertical market.

To understand the relationship between a simultaneous-move game and a sequential-move game, straightforward computation yields as follows:

$$\begin{aligned} u_i^C - u_i^F &= \frac{-b^8\theta^2}{4(4+2b-b^2)^2(16-16b^2+3b^4)}, \\ u_i^C - u_i^L &= \frac{b^5(2-b^2)(64-64b^2+12b^4-b^5)\theta^2}{2(4+2b-b^2)^2(16-16b^2+3b^4)^2}. \end{aligned}$$

Thus, we summarize these results in Proposition 3.

Proposition 3: *Under Eq. (1), we have the following results that* $u_i^F > u_i^C > u_i^L$.

The intuition behind Proposition 3 is as follows. In a simultaneous-move Cournot game, downstream firm i perceives the output produced by downstream firm j as given. However, in a sequential-move Cournot game, downstream firm j knows downstream firm i's best-response function. Therefore, downstream firm j has an incentive to increase its output. On the other hand, the downstream firm i will reduce its output level in response to downstream firm i's output level. However, anticipating such downstream firms' strategies, the follower's upstream firm has the incentive to set the wholesale price to be below its marginal cost. Hence, when the wholesale price w_i^F is lower than the wholesale price w_i^C. Therefore, we have the Proposition 3.

4.2 Bertrand Sequential-move Game

Now consider the sequential-move game in which firm j is arbitrarily designated the Stackelberg leader under Bertrand competition. At stage three, the downstream firm i's maximization problem is

$$\max_{p_i} \pi_i = (p_i - w_i)q_i - F_i = \frac{(p_i - w_i)(1-b+bp_j-p_i)}{1-b^2} - F_i; i,j = 1,2, i \neq j.$$

Note that the input price is independent of F_i. Therefore, downstream firm i chooses its sales price as the function of wholesale price w_i and downstream firm i's sales price p_i as follows:

$$p_i = \frac{1-b+bp_j+w_i}{2}.$$

Substituting retail price p_i into downstream firm i's output and profit, we obtain the output and profit.

$$q_i = \frac{1-b+bp_j-w_i}{2(1-b^2)}, \quad \pi_i = \frac{(1-b+bp_j-w_i)^2}{4(1-b^2)} - F_i.$$

At stage two, downstream firm j sets the final good price p_j so as to maximize it's profit for given wholesale prices. Downstream firm j's maximization problem is as follows:

$$\max_{p_j} \pi_j = \frac{(p_j - w_j)[2-b-b^2-(2-b^2)p_j+bw_i]}{2(1-b^2)} - F_j.$$

Downstream firm j chooses its retail price as the function of wholesale prices as follows:

$$p_j = \frac{2 - b - b^2 + (2 - b^2)w_j + bw_i}{2(2 - b^2)}.$$

Thus, it is straightforward that the equilibrium quantities q_i, q_j, rival's retail price p_i, and pay-offs π_i, and π_j are derived at stage two:

$$\begin{aligned}
q_j &= \frac{2 - b - b^2 - (2 - b^2)w_j + bw_i}{4(1 - b^2)},\\
q_i &= \frac{4 - 2b - 3b^2 + b^3 + (2 - b^2)bw_j - (4 - 3b^2)w_i}{4(2 - 3b^2 + b^4)},\\
p_i &= \frac{4 - 2b - 3b^2 + b^3 + b(2 - b^2)w_j + (4 - b^2)w_i}{4(2 - b^2)},\\
\pi_j &= \frac{[2 - b - b^2 - (2 - b^2)w_j + bw_i]^2}{8(2 - 3b^2 + b^4)} - F_j,\\
\pi_i &= \frac{[4 - 2b - 3b^2 + b^3 + (2 - b^2)bw_i - (4 - 3b^2)w_j]^2}{16(1 - b^2)(2 - b^2)^2} - F_i.
\end{aligned}$$

Finally, we obtain the following results.

Lemma 5: *If both wholesale prices are equal, downstream firm i has the second-mover advantage.*

Proof: We assume that $w_i = w_j = w$. Then, we obtain $q_j - q_i = \frac{b^2(1-w)}{4(2-b^2)} > 0$ and $p_i - p_j = \frac{(1-b)b^2(1-w)}{4(2-b^2)} > 0$. Define $\Delta q \equiv q_j - q_i$ and$\Delta p \equiv p_i - p_j$. We have $\Delta q - \Delta p = \frac{b^3(1-w)}{4(2-b2)} > 0$. Therefore, downstream firm i has the second-mover advantage in the downstream competition. Q.E.D.

At stage one, the upstream firm i sets the input price w_i and the franchise fee F_i so as to maximize it's profit for given w_j. Upstream firm i's maximization problem is as follows:

$$\max_{w_i, F_i} u_i = (w_i - c)q_i + F_i \quad \text{s.t. } \pi_i \geq 0.$$

Note that the above constraint is binding. Therefore, we rewrite the above maximization problem as follows:

$$\max_{w_i} u_i = (p_i - c)q_i = \frac{[4 - 2b - 3b^2 + b^3 - (4 - 3b^2)w_i + 2bw_j(1 - b^2)][K]}{16(2 - b^2)^2(1 - b^2)},$$
$$\text{where} \quad K = 4 - 2b - 3b^2 + b^3 + (4 - b^2)w_i + 2bw_j(1 - b^2) - 4c(2 - b^2).$$

On the other hand, the upstream firm j's maximization problem

$$\max_{w_j, F_j} u_j = (w_j - c)q_j + F_j \quad \text{s.t. } \pi_j \geq 0.$$

Noting that the above constraint is binding, we also rewrite the maximization problem as with the upstream firm j of Stackelberg leader:

$$\max_{w_j} u_j = (p_j - c)q_j = \frac{[2 - b - b^2 + (2 - b^2)w_j + bw_i][2 - b - b^2 - 2c(2 - b^2) + (2 - b^2)w_j + bw_i]}{8(2 - 3b^2 + b^4)}.$$

From the equilibrium values and input prices, we obtain response functions, w_i and w_j under the Bertrand sequential-moves competition as follows:

$$w_j^l = c, \quad w_i^f = c + \frac{b^2(4-2b-3b^2+b^3)\theta}{16-16b^2+3b^4},$$

where the superscript 'l' denotes Stackelberg leader and 'f' denotes Stackelberg follower.

Note that upstream firm j (Stackelberg leader) sets the wholesale price to be equal to its marginal cost, while upstream firm i (Stackelberg follower) sets the wholesale price to be above its marginal cost. Using w_j^l, w_i^f, and θ, we obtain the following results.

Lemma 6: *Suppose a sequential-move Bertrand competition. Under Eq. (1), if each upstream firm offers two-part tariffs contract to each downstream firm, the equilibrium quantities, retail prices, upstream firms' profits and fixed fees are respectively given by*

$$q_j^l = \frac{\theta(2-b^2)(8+4b-4b^2-b^3)}{2(2-b)(1+b)(2+b)(4-3b^2)}, \quad q_i^f = \frac{\theta(4+2b-b^2)}{2(4+4b-b^2-b^3)},$$
$$p_j^l = \frac{8-4b-8b^2+3b^3+b^4-b^5+c(8+4b-8b^2-3b^3+2b^4)}{16-16b^2+3b^4},$$
$$p_i^f = \frac{4-2b-3b^2+b^3+c(4+2b-3b^2-b^3)}{8-6b^2},$$
$$u_j^l = \frac{\theta^2(1-b)(2-b^2)(8+4b-4b^2-b^3)^2}{2(1+b)(16-16b^2+3b^4)^2}, \quad u_i^f = \frac{\theta^2(1-b)(4+2b-b^2)^2}{4(1+b)(16-16b^2+3b^4)}.$$

We summarize these findings in Proposition 4.

Proposition 4: *Under Eq. (1)* $q_j^l > q_i^f$ *for* $0 < b \leq 1$; *and* $u_j^l > u_i^f$ *for* $0 < b \leq 1$

Proof: From equations in Lemma 6, we obtain $q_j^l - q_i^f > 0$. Therefore, downstream firm j's sales volume is larger than that of downstream firm i. In addition, from equations in Lemma 6, we obtain $u_j^l - u_i^f = \frac{b^5(16-20b^2-b^3+5b^4)\theta^2}{4(1-b)(16-16b^2+3b^4)^2}$. Therefore, the upstream firm in which its downstream firm moves first in a downstream Stackelberg Bertrand competition earns higher profits than the other in which its downstream firm moves second in a downstream Stackelberg Bertrand competition. Q.E.D.

We now turn to the relationship between a simultaneous-move game and sequential-move game, straightforward computation yields as follows:

$$u_i^B - u_i^f = \frac{-b^8(1-b)\theta^2}{4(1+b)(16-16b^2+3b^4)(4-2b-b^2)^2} \quad \text{regardless of nature of goods,}$$
$$u_i^B - u_i^l = \frac{-b^5(1-b)\theta^2(2-b^2)(64-64b^2+12b^4+b^5)}{2(1+b)(16-16b^2+3b^4)^2(4-2b-b^2)^2} < (>) 0,$$

when the goods are subsitutes (complements).

Thus, we summarize these results in Proposition 5.

Proposition 5: *Under Eq. (1), we have the following results that* $u_i^l > u_i^f > u_i^B$ *for* $b \in (0,1)$.

The intuition behind Proposition 5 is as follows. In a simultaneous-move Cournot game, downstream firm i perceives the output produced by downstream firm j as given. However, in a sequential-move Cournot game, downstream firm j knows downstream firm i's best-response function. Therefore, downstream firm j has an incentive to increase its retail price. On the other hand, the downstream firm i will decrease its retail price in response to downstream firm i's retail price. However, anticipating such downstream firms' strategies, the follower's upstream firm has the incentive to set the wholesale price to be above its marginal cost. Hence, the wholesale price w_i^f is lower than the wholesale price w_i^B. Therefore, we have the Proposition 5.

5 Concluding Remarks

In the present study, we investigated the issue of the first- and the second-mover advantages in a vertical structure in which each upstream firm trades with a separated retailer via two-part tariffs. We have shown that under Cournot (Bertrand) competition, the follower's upstream firm has the incentive to set the input price to be below (above) its marginal cost, while leader's upstream firm has the incentive to set the input price equal to marginal cost. This implies that the upstream firm resolves the first- or second-mover advantage by providing for differential input prices to the downstream firms. Hence, when the goods are substitutes, the upstream firm in which its downstream firm moves first under Courtnot (Bertrand) competition earns lower (higher) profits than the other in which its downstream firm moves second in a downstream Courtnot (Bertrand) competition, and vice versa when the goods are complements. This result is in stark contrast to the result under one-tier market, which already has explained as in Introduction. Hence, unlike the literature of one-tier without the vertical structure context, we have analyzed that the upstream firms' preference orderings over sequential versus simultaneous play are reversed in a vertical structure under either Cournot or Bertrand competitions when each upstream firm trades with a separated retailer via two-part tariffs.

We conclude by discussing the limitations and extensions of our paper. We have used a simplified model without negotiation or asymmetric information between upstream and downstream firms. We do not consider asymmetric costs between downstream firms, either. Moreover, we need to examine intermediate goods markets where an upstream firm negotiates sequentially with two downstream firms and to consider nonlinear demand structures with negotiation between simultaneous and sequential moves. The extensions of our model in these directions are left for future research. Moreover, we expect the basic results of our paper to hold in these extended settings as well.

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