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Strategic upfront marketing channel integration as an entry barrier

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Abstract

This paper investigates an organizational design problem concerning whether duopolistic firms competing in a product market should vertically integrate or separate their marketing channels in a dynamic noncooperative game setting. Previous operational research models have shown that the separation of the marketing channel with the adoption of a two-part tariff contract is the dominant strategy compared with integration for each firm if the two firms face retail price competition, and thereby constitutes the subgame perfect Nash equilibrium (SPNE). Contrary to this previous insight, this paper demonstrates that if exogenous parameters that characterize fixed costs, product substitutability, and a demand function fall into a specific region, marketing channel integration dominates the separation strategy when one of the two firms is the incumbent firm while the other is a potential entrant. In other words, the well-known result in the price-setting game can be reversed when we take entry threats into consideration. Specifically, we show that upfront vertical integration of the marketing channel enables the incumbent to deter the entry of the potential competitor and to monopolize the market in the SPNE. This result has operational implications for a firm confronting the threat of potential rivals entering the market, in that the firm can use this apparently inferior strategy as a commitment device, which creates a virtual entry barrier.

Keywords: Marketing, Channels of distribution, Vertical integration, Entry barrier, Game theory

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1. Introduction

Vertical organization design in relation to the choice between marketing channel integration and separation under various economic environments has commanded significant attention in the operational research and management science (OR/MS) literature. Traditionally, previous game-theoretic OR models have defined marketing channel separation as the delegation of decision making to an economic agent other than the central management of the firm (e.g., Jeuland and Shugan, 1983; McGuire and Staelin, 1983; Moorthy, 1988). Given the substantial number of previous works within this research strand, this paper investigates the organizational design problem concerning whether duopolistic firms competing in a product market should vertically integrate or separate their marketing channels in a dynamic noncooperative game setting. Previous OR models have shown that the separation of the marketing channel, combined with the adoption of a two-part tariff contract on a downstream retailer, is the dominant strategy compared with integration for both firms if two firms compete in terms of retail prices, and that this strategy thereby constitutes the subgame perfect Nash equilibrium (SPNE).¹ Contrary to this previous insight, this paper demonstrates that if exogenous parameters that characterize fixed costs, product substitutability, and a demand function fall into a specific region, marketing channel integration dominates the separation strategy when one of the two firms is an incumbent firm while the other is a potential entrant. In other words, the well-known result in the price-setting game can be reversed when we take entry threats into consideration. Specifically, we show that upfront vertical integration of the marketing channel enables the incumbent to deter entry of the potential competitor and to monopolize the market in the SPNE. This result has operational implications for a firm confronting an entry threat by a potential rival in that the firm can use this apparently inferior strategy as a commitment device, which creates a virtual entry barrier.

The logic behind this outcome is as follows. If one of the two firms (the "leader") undertakes marketing channel separation in advance as a Stackelberg leader, the other firm (the "follower") subsequently enters the market with the vertical separation form as its optimal response because the follower can earn sufficient positive revenue that cancels out the entry costs associated with the business. Eventually, the leader has to share the market with the follower. By contrast, if the leader undertakes vertical integration of the marketing channel as its strategy, the follower cannot earn sufficient revenue to offset its entry costs,

¹ Because this paper aims to construct a noncooperative game model, we repeatedly use technical terms of game theory throughout this paper. Here, "dominant strategy" means that the strategy brings the player the maximum payoff no matter what strategy other players take. "Nash equilibrium" means that the strategy taken by each player in the equilibrium is the best response for him/her, and is most frequently used to identify the equilibrium in a static (i.e., one-shot) noncooperative game. "SPNE" means that each state in all subgames included in a dynamic game is a Nash equilibrium. The SPNE is the concept that is generally used to identify an equilibrium in a noncooperative dynamic game when information is complete among all players. For more detailed definitions of the game-theoretic concepts and strategies, see Gibbons (1992).

irrespective of its organizational choice when entering the market. Consequently, the follower gives up on entering the market. In summary, upfront vertical integration enables the leader to monopolize the market and increase its profits in the SPNE, which is the central implication of this paper.

To date, there has been a large body of OR/MS literature that investigates the issue of strategic delegation through marketing channel separation by using the game-theoretic approach. The study of the strategic effects of vertical separation dates back at least to McGuire and Staelin (1983), who developed a deterministic model of two manufacturers selling their competing brands through retail outlets. Based on the assumption that price competition between the manufacturers takes place, they showed that the vertical separation (i.e., decentralization) is a Nash equilibrium strategy for a firm compared with integration (i.e., centralization) if the firm imposes a two-part tariff contract on a retailer who deals exclusively with the product. The rationale behind their finding is that strategic delegation of the pricing decision to an external retailer through vertical separation softens the reaction of other competitors when the control variable for firms is a strategic complement (e.g., the retail price).² Moorthy (1988) showed that a necessary condition for the result of McGuire and Staelin (1983) to hold is that the firms' prices are strategic complements.³ His analytical results showed that what is important for decentralization to occur in the Nash equilibrium is not how substitutable the two manufacturers' products are, but rather the nature of the relationship between demand dependence and strategic dependence for competing firms. These two papers are classic studies on the choice between marketing channel integration and separation. The current study is closely linked to these two papers because we reverse the conventional result from them, that is, the strategic dominance of channel separation. Parlar and Weng (2006) studied the effects of coordinating pricing and production decisions on the improvement of a firm's position in a duopolistic price-competitive environment. Specifically, their model not only considered the pricing decision made by the marketing department and the production quantity decision made by the production department separately but also allowed the two departments to coordinate their decisions to compete against another firm with a similar organizational structure in a random demand environment. With this setting, they employed a game-theoretic approach to analyze two scenarios, comprising (i) no coordination and (ii) coordination in both firms. They showed that by coordinating their pricing and production decisions, competing firms can increase their profitability especially

² The positive effect on price is confirmed also in a number of empirical studies (discussed in Lafontaine and Slade, 1997).

³ The reason why prices under Bertrand-type price competition are referred to as "strategic complements" is that the slope of the reaction function for each player is positive, as shown in Figure 4; that is, a firm raises its selling price in response to its rival raising its price. By contrast, if the firms are engaged in a Cournot-type quantity competition, the quantities of the product, which are the strategic variable in this case, are referred to as "strategic substitutes". This is because the slope of the reaction function is negative; that is, a firm reduces the selling quantity when the other rival increases its quantity. For more detail on such competition mechanisms, see Tirole (1988).

under unfavorable conditions, such as when market sizes diminish, unit costs increase, or when unit revenues become lower. Furthermore, their model provided a concrete means for formalizing and quantifying the differences between the two policies, which is a practical contribution. Anderson and Bao (2010) investigated price competition and compared two organizational forms, i.e., vertical integration and separation. Their unique assumption that reflects real market environments is the incorporation of switching customers, who definitely buy one of the competing products, and marginal customers, who buy one of the competing products only if the price is below a certain level, into a linear demand function. Based on the assumption that a fixed portion of demand is allotted to each oligopolistic firm as its underlying market share, they demonstrated that the coefficient of variation of the share determines whether decentralized channels can outperform integrated channels with an appropriate level of competition. Furthermore, they demonstrated that the results on which the previous research had mainly focused, i.e., the results from a case with two competitors, can be generalized to the multiple supply chain case. Atkins and Liang (2010) generalized the outcome of McGuire and Staelin (1983) by taking into account supply economies of scale, as well as competitive intensity, because economies (or diseconomies) of scale in production are highly prevalent in practice. Their unique contribution was to find that equilibrium channel structures are primarily determined by competitive intensity, even in the presence of economies of scale in the industry.⁴ These previous studies provide common assumptions that we should use to address the channel design problem in the present research. For example, McGuire and Staelin (1983), Anderson and Bao (2010), and Atkins and Liang (2010) basically used a linear demand function to yield clear-cut results. Parlar and Weng (2006) employed a duopolistic price competition setting between supply chains. Accordingly, our model borrows the settings provided by these previous works.

In addition to the OR/MS literature, we should not overlook the substantial number of economic studies that have addressed the issue on the vertical boundary of organization. Similarly to the OR/MS studies, previous industrial economic studies that are referred to as discussing strategic incentive theory, where agents make decisions about price (Bertrand competition) or quantity (Cournot competition), also showed that vertical separation is the dominant strategy for oligopolistic firms (e.g., Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987). Moreover, apart from this stream of research on managerial incentive systems, an industrial economic study by Dixit (1979) was the first to point out that an incumbent firm in a business can deter the entry of another rival by marketing a larger quantity of products than the level that would be optimal under a duopoly. Our model is closely related to Dixit (1979) because we incorporate entry threats into the strategic delegation model.

Despite the significant number of works that have investigated whether marketing channels should be integrated, the above overview suggests that research incorporating the possibility of entry deterrence into the strategic delegation model appears neither in the

⁴ Furthermore, there are significant OR studies that investigate the optimal level of promotional efforts in oligopolistic firms with two-echelon marketing channels (e.g., Xia and Gilbert, 2007; Xie and Wei, 2009; SeyedEsfahani et al., 2011).

OR/MS literature nor in the economic literature. Hence, no previous study has pointed out that upfront integration of the marketing channel for a firm confronting potential rivalry can be used as an entry barrier. This paper is the first to derive this outcome based on a rigorous game-theoretic framework, thereby providing useful operational research insights for business practitioners.⁵

The remainder of the paper is structured as follows. Section 2 delineates the basic settings of our noncooperative game model. Then, we initially assume that both firms are incumbents operating in a business, and, thus, that they compete on retail price immediately from the beginning of the game, identifying the SPNE as the benchmark. Subsequently, Section 3 alters the scenario of the model by assuming that one of the two firms is an incumbent firm while the other is a potential entrant. We demonstrate that entry deterrence and the development of a monopoly position by the incumbent firm through strategic marketing channel integration occur as the SPNE under certain economic environments, contrary to the results in the benchmark scenario. Section 4 discusses some limitations of our model and explore possible extensions. The final section provides concluding remarks.

2. Game by two incumbent firms

Initially, we present the settings that underpin our noncooperative game model. The variables used in the models are listed as follows.

p	retail price
q	quantity
r	marginal wholesale price
F	fixed payments from a downstream retailer to an upstream firm (franchise fee)
c	marginal cost
a	positive constant greater than c
b	positive constant
f	fixed cost
θ	substitutability of products supplied by the two firms ($0 < \theta < 1$) ($1-\theta$ is the degree of product differentiation.)
n	number of entrants
m	number of incumbents
i	subscript that indexes the firm

⁵ Empirical industry studies provide significant evidence that oligopolists tend to centralize organizational structures. Coca-Cola and Pepsi both steadily integrated with bottling suppliers (Saltzman et al., 1999), grocers and retailers established their own distribution centers (Martinez, 2002), and television networks increasingly produce their own TV shows (Einstein, 2004). These empirical examples are related to our result because these manufacturers supplying well-established brands or services might undertake the centralization strategy so as to deter entry of other potential rivals into each market, which is the implication from this paper.

j	subscript that indexes the firm that is different from firm i
Π	profit for a firm that integrates its marketing channel
π^M	profit for an upstream firm operating as a manufacturer that vertically separates its marketing channel
π^R	profit for a downstream retailer employed by a firm that vertically separates its marketing channel
C	strategy of marketing channel integration (i.e., centralization of organization)
D	strategy of marketing channel separation (i.e., decentralization of organization)
NE	strategy of not entering the market
I	subscript that denotes an incumbent
E	subscript that denotes a potential entrant

Suppose that each of the two existing firms can produce differentiated products and sell them to consumers. Each firm can manufacture the product at a variable cost of c per unit, with fixed costs of f . Note that these assumptions are common under both the benchmark scenario in the current section and the extended scenario in the next section.

In this section, we initially assume that both the firms are incumbent firms, operating in the business from the beginning of the game, and we construct an analytical model based on this assumption, although the major purpose of the present research is to show that marketing channel integration can be the dominant strategy when there is a potential entrant who is not an incumbent. On the basis of the basic results of the benchmark scenario, in the following section, we will alter the scenario and highlight our unique implications by contrasting the results from the benchmark scenario and the extended scenario.

Figure 1 illustrates the timeline of events that occur in this benchmark scenario. Initially, each of the two firms simultaneously chooses whether to integrate or separate its marketing channel vertically at Date 1. Let "strategy C" (centralization of organization) denote vertical integration of the channel, whereas "strategy D" (decentralization of organization) denotes vertical separation. Figure 2 describes the structures of each organizational form. If a firm chooses integration, the firm not only manufactures the product but also retails it, i.e., it directly determines the retail price. By contrast, if a firm decides to separate the marketing channel, the firm is vertically divided, as it employs an external retailer. Specifically, the firm chooses a single retailer from a sufficient number of potential retailers, which then exclusively deals with the product manufactured by the firm. The firm proposes a two-part tariff contract, which includes the marginal price per unit of the product and the fixed payments, to the retailer.⁶ Following the literature (McGuire and Staelin, 1983;

⁶ A two-part tariff contract design can also be interpreted as a transfer pricing problem between two-echelon intrafirm divisions. Employment of an external retailer with the imposition of the two-part tariff contract yields the same equilibrium outcomes as in the case where an intrafirm department is used as the retailing division and a transfer price controlled by the central management is imposed. This is because the upstream firm extracts all of the retailer's profits when employing an external retailer, whereas the firm's headquarters glean subordinate divisional profits when using an internal retailing division. That is, the firm

Bonanno and Vickers, 1988), we refer to the fixed payments as a "franchise fee". Using the contract, the firm delegates the retail pricing decision to the downstream retailer, who signs the contract.⁷ Instead of the retail price, the firm designs the contract: it sets the marginal wholesale price of the product and the fixed franchise fee. Then, the firm becomes the only producer of the good, which it sells to the retailer, and the retailer subsequently resells the product with no retailing cost.

A firm that vertically separated the channel at Date 1 sets the marginal wholesale price and the franchise fee included in the contract between the upstream firm and the downstream retailer at Date 2. Finally, price competition arises at Date 3; the retail price is chosen either by the firm, if it chose vertical integration, or by the retailer, if the firm chose the separation strategy.

[Figure 1]

[Figure 2]

At Date 3, Firm i faces the following inverse demand function of product i :

$$p_i = a - b(q_i + \theta q_j) \quad (i, j) = (1, 2) \text{ or } (2, 1), \quad (1)$$

where p_i and q_i are the retail price and the quantity of Firm i 's ($i = 1, 2$) product, respectively.⁸ Hereafter, (i, j) signifies either $(1, 2)$ or $(2, 1)$. $\theta \in (0, 1)$ represents the degree of substitution among products, and a ($> c$) and b are positive constants. The products become differentiated as θ approaches zero, whereas they become similar as θ approaches one. Jointly solving $p_1 = a - b(q_1 + \theta q_2)$ and $p_2 = a - b(q_2 + \theta q_1)$ represented by Equation (1) yields each demand

maximizes the overall profits for the whole marketing channel in both cases. See Alles and Datar (1998), Göx (2000), Narayanan and Smith (2000), Göx and Schiller (2007), Fjell and Foros (2008), and Matsui (2011a, 2011b) on the similarity between strategic transfer pricing and two-part tariff contract design.

⁷ As long as the retailer obtains some minimal profits through the contract, usually approximated as zero in the literature, the retailer accepts the contract because it otherwise earns no profit due to perfect competition at the retail level. Because the technology to manufacture the product is owned not by a downstream retailer but by an upstream firm, the latter can design the contract and propose it to the former as a "take it or leave it" opportunity. This is the rationale behind the assumption that each decentralized firm imposes the two-part tariff contract on a retailer and appropriates all of the retailer's profits. For a more detailed explanation, see, for example, Tirole (1988, pp. 170–171), McGuire and Staelin (1983), and Bonanno and Vickers (1988).

⁸ Previous studies of strategic delegation have usually employed the linear demand schedule (e.g., McGuire and Staelin, 1983; Atkins and Liang, 2010). Moreover, Dixit (1979) used the linear demand function to examine the issue of entry barriers. Because these works form the foundation for our model, we also use the linear demand schedule represented by Equation (1). Note that the inverse demand function of Equation (1) can be derived based on optimizing behavior by consumers with a budget constraint if the objective maximization function for a representative consumer is formulated as $a(q_1 + q_2) - (b(q_1^2 + q_2^2) + 2b\theta q_1 q_2)/2$. For a more detailed derivation process, see Singh and Vives (1984).

quantity as a function of the prices charged by the two firms:

$$q_i = ((1 - \theta)a - p_i + \theta p_j) / ((1 - \theta)(1 + \theta)b) \quad (i, j) = (1, 2) \text{ or } (2, 1). \quad (2)$$

Using the above settings, we may derive payoffs for each firm according to the combination of strategies as summarized in the following proposition. (All proofs are provided in the Appendix.)

Proposition 1. *Payoffs for each firm by strategy in the benchmark scenario are described in Table 1. The former argument in each parentheses represents the payoff for Firm 1, whereas the latter is that for Firm 2.*

[Table 1]

The next two corollaries immediately follow from Proposition 1.

Corollary 1. *Strategy D strictly dominates strategy C for each firm at Date 1 in the benchmark scenario.*

Corollary 2. *The combination of strategies (D, D) constitutes the SPNE in the benchmark scenario.*

The above proposition and corollaries are well-known results from the previous literature (e.g., see McGuire and Staelin, 1983; Fershtman and Judd, 1987; Bonanno and Vickers, 1988).⁹ Taking the benchmark outcomes into account, we proceed to construct another dynamic game where the timing regarding the choice of organizational form differs between the two firms.

3. Game by one incumbent firm and one potential entrant

This section addresses the original purpose of this study by changing the benchmark scenario discussed earlier. Specifically, we alter the model settings so that one of the two firms is the incumbent firm operating in the business, whereas the other is a potential entrant. Let Firm 1 be the incumbent and let Firm 2 be the entrant. Similarly to the benchmark

⁹ Although we concentrate on competition through price, it has been shown that (D, D) constitutes the Nash equilibrium not only when the strategic variable is the price but also when it is the quantity (e.g., Fershtman and Judd, 1987). However, the equilibrium for the latter case is not a mutually desirable one, as payoffs for both the firms can be improved if they both change to strategy C. In this sense, the Nash equilibrium in quantity competition is an example of the so-called "prisoners' dilemma". Recently, Shor and Chen (2009) proved that this dilemma can be resolved in a repeated game setting because (C, C) becomes an SPNE in that case.

scenario, we employ the SPNE as the equilibrium concept of the game.

Figure 3 illustrates the timeline of events. One of the primary differences in the events between the present and the previous scenarios is that Date 0 is added; at Date 0, Firm 1, as the Stackelberg leader, chooses, before Firm 2 does, whether to integrate its marketing channel or to separate it vertically. This choice of organizational form is assumed to be irreversible at subsequent dates. In this sense, organizational design operates as a commitment device, credibly binding the firm to more or less aggressive behavior.¹⁰ At Date 1, Firm 2 determines whether to enter the market, which would involve incurring fixed costs to start the business, f , and, if it does decide to enter, it also chooses whether to integrate or separate its marketing channel. Therefore, in this altered scenario, f represents not only fixed costs but also an entry fee for Firm 2, whereas for Firm 1 it represents fixed costs only because Firm 1 has already paid its business start-up costs. Stated differently, Firm 1 regards f as sunk costs. Accordingly, there arises another alternative strategy for Firm 2: not to enter the market, which we denote by "strategy NE".

[Figure 3]

If Firm 2 enters the market, the events after Date 2 are exactly the same as those of the benchmark scenario. Indeed, one may confirm from Figures 1 and 3 that the events at Dates 2 and 3 are identical. Because price competition takes place in this case, the demand function that Firm i faces is represented by Equation (2).

By contrast, if Firm 2 does not enter the market, Firm 1 monopolizes the market, choosing prices at the monopoly level with the aim of overall profit maximization at Dates 2 and 3. In this case, Firm 1 encounters the following inverse demand function:

$$p_1 = a - bq_1,$$

or the following demand function:

$$q_1 = (a - p_1)/b. \quad (3)$$

Based on the above settings, we calculate payoffs according to the strategy chosen.

Proposition 2. *Payoffs for each firm based on the combinations of strategies in the altered scenario are described in Table 2. The first term in each set of parentheses represents the payoffs to Firm 1, whereas the second term represents the payoffs to Firm 2.*

¹⁰ Göx (2000) suggested that an appropriate practical example of the credible signaling of such an organizational form is commitment to a particular cost accounting system. For example, decentralization of the organization is signaled by full-cost transfer pricing, whereas centralization is related to marginal-cost transfer pricing (Alles and Datar, 1998). Choosing an accounting system is typically a long-term commitment because its introduction requires substantial investments associated with the installation of the system.

[Table 2]

The following corollary comes from Proposition 2.

Corollary 3. *Suppose that the fixed cost, f , takes a value satisfying the following inequality:*

$$\frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} < f < \frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2}. \quad (C1)$$

Then, if Firm 1 chooses strategy C, Firm 2 does not enter the market in the SPNE, whereas if Firm 1 chooses strategy D, then Firm 2 enters the market. The adoption of these strategies in the equilibrium signifies that Firm 1 deters the entry of Firm 2 and monopolizes the market.

Corollary 3 is the most notable finding of this paper and thus deserves attention. Even though strategy D strictly dominated strategy C in the benchmark scenario (Corollary 1), and the result has also been confirmed in the literature on strategic delegation, strategy C can dominate strategy D for Firm 1 in the present altered scenario as long as the exogenous parameters satisfy Inequality (C1). That is, the result that we obtain is the opposite of that found in the existing literature.

Notice that the above result indicates that channel integration plays the role of a commitment device, in that Firm 1 takes the apparently disadvantageous strategy in advance. At first glance, vertical integration (strategy C) is less desirable for Firm 1 because, in the benchmark scenario shown in Section 2, it is dominated by vertical separation (strategy D). However, this is no longer the case in the altered scenario where the threat of entry is present. If Firm 1 selects strategy D at Date 0, which seems advantageous for the firm according to the benchmark scenario, then Firm 2 enters the market with a vertically separated form (strategy D) as the optimal response at Date 1. Eventually, Firm 1 has to share the market with Firm 2, leading to lower profits. To avoid this inferior equilibrium, instead, Firm 1 should take strategy C at Date 0, even though it is seemingly disadvantageous because it lowers the firm's own profits as compared with strategy D if duopolistic price competition takes place. Actually, however, upfront vertical integration by Firm 1 prevents Firm 2 from earning sufficient revenue to cancel out Firm 2's entry costs, f , irrespective of Firm 2's organizational choice when it enters the market. Consequently, Firm 2 gives up on entering the market. In summary, upfront vertical integration enables Firm 1 to monopolize the market, boosting its profits in the SPNE.

Next, we briefly summarize the SPNE if exogenous parameters do not satisfy Inequality (C1). If $f > 2(a-c)^2(1-\theta)(2-\theta^2)/(b(1+\theta)(4-2\theta-\theta^2)^2)$, then Firm 2 does not enter the market regardless of whether Firm 1 selects strategy C or strategy D, because Firm 2 cannot earn positive profits under either strategy, owing to the significant entry costs. Hence, Firm 1 is indifferent to the two strategies, indicating that Firm 1 "blockades" the entry of Firm 2 and monopolizes the market in the SPNE. Therefore, both strategies (C, NE) and (D, NE) correspond to the SPNE that provides Firm 1 with monopoly profits in this case. At

the other extreme, if $f < (a-c)^2(1-\theta)(2+\theta)^2 / (8b(1+\theta)(2-\theta^2))$, then Firm 2 enters the market regardless of whether Firm 1 selects strategy C or strategy D, because Firm 2 can obtain positive profits in either case thanks to the low entry fees. Hence, strategy D remains the dominant strategy for the incumbent, and (D, D) in Table 2 constitutes the SPNE, which is identical to the one in the benchmark scenario (Corollary 2). In this case, Firm 1 "accommodates" the entry of Firm 2 into the market.¹¹ Overall, note that Firm 1, as the Stackelberg leader, has the initiative to choose either (C, NE) or (D, D) for the equilibrium only when

$(a-c)^2(1-\theta)(2+\theta)^2 / (8b(1+\theta)(2-\theta^2)) < f < 2(a-c)^2(1-\theta)(2-\theta^2) / (b(1+\theta)(4-2\theta-\theta^2)^2)$ is met.

Finally, we analyze how the domain of f in Corollary 3 depends on exogenous parameters in order to yield additional managerial implications. Product substitutability affects the dominance of strategy C in the following way.

Corollary 4. *The domain of f that satisfies Inequality (C1) is inversely related to the substitutability of the products, θ .*

As θ decreases, the products supplied by the two firms become more differentiated, which drives up revenue for each firm under duopoly. Hence, the threshold for entry costs that counterbalance this increased revenue and eliminate profit for Firm 2 also increases. Consequently, as θ becomes lower, the values of fixed costs that engender the possibility that strategy C dominates strategy D for Firm 1 tend to be higher, as shown in Corollary 4, and vice versa.

Exogenous parameters other than θ and f in Inequality (C1) include a , b , and c . Notice here that $(a-c)^2/b$ is multiplicatively separable from both the upper limit and the lower limit of Inequality (C1). Moreover, we may regard $(a-c)^2/b$ as approximating the market size, because the equilibrium quantity that would be transacted in the case of perfect substitutability of the products (i.e., $\theta = 1$) is $(a-c)/b$.¹² This measure of the market size affects the dominance of strategic marketing channel integration as follows.

¹¹ Tirole (1988, p. 306) summarized the definitions of the terms "accommodate", "blockade", and "deter". Suppose there is a case in which an incumbent firm maximizes its monopoly profit and, consequently, entry does not arise even when the incumbent ignores the existence of the potential entrant. Then, we refer to the entry as "blockaded". On the other hand, if entry does not arise because an incumbent intentionally prevents the entry of another firm, we refer to this case as entry being "deterred". If an incumbent firm allows another firm to enter the industry and entry actually arises, the entry is "accommodated".

¹² The supply curve ($p_i = c$) and the demand curve ($p_i = a - b(q_i + \theta q_j)$) intersect at $q_i + q_j = (a-c)/b$ when $\theta = 1$, indicating that the total transaction quantity under perfect substitutability of the products would be $(a-c)/b$.

Corollary 5. *The domain of f that satisfies Inequality (C1) is positively related to the measure of market size $((a-c)^2/b)$.*

As the relative market size $((a-c)^2/b)$ increases, revenue for each firm under duopoly grows. Hence, the threshold of fixed costs that counterbalance this increased revenue and eliminate profit for Firm 2 is also raised. Consequently, when $(a-c)^2/b$ takes a relatively high value, the values of fixed costs that engender the possibility that strategy C dominates strategy D for Firm 1 tend to be higher, as shown in Corollary 5. Corollaries 4 and 5 yield practical implications, which are summarized in the following remark.

Remark 1. *There is a possibility that upfront marketing channel integration enables an incumbent firm in a business to deter the entry of rivals and monopolize the market when the fixed costs associated with the business have a relatively high value, assuming circumstances where (1) products are more differentiated in the market or (2) market size is large. In addition, such a possibility also arises when the fixed costs take a relatively low value in the cases where (1) products are less differentiated or (2) market size is small.*

4. Extension and discussion

Thus far, we have constructed a basic model with concise assumptions of a linear demand function and a one-on-one relationship between an incumbent and an entrant. While simple settings yield explicit solutions and clear-cut implications, at the same time they represent limitations of our basic model, which thus admits improvement in several directions. Indeed, if a series of the previous results holds by using more general settings, our model will have a broader range of applications in real business practices. Therefore, we explore possible extensions of our model and demonstrate that our results hold under more general circumstances in this section.

4.1. Demand function

We first consider a general demand function form rather than a linear one. Similarly to our model under the benchmark scenario in Section 2, Bonanno and Vickers (1988) demonstrate that channel separation (strategy D) by both firms becomes the SPNE even if two firms face a more general, say, nonlinear demand function. Specifically, they present a sufficient condition for each firm to choose channel separation as the dominant strategy. The sufficient condition is that we should assume the following four properties in the model: (i) the demand function is decreasing and concave in the price, (ii) products supplied by firms are substitutes, (iii) the demand functional form satisfies the stability of the SPNE,¹³ and (iv) prices set by firms are strategic complements. If assumptions satisfy these four properties, our results in the benchmark scenario of Section 2 (Corollaries 1 and 2) also hold under a general demand function.

¹³ For more detail on this property, see Assumption 3 in Bonanno and Vickers (1988, p. 259).

Moreover, by applying their insight to our altered scenario in Section 3, we may demonstrate that entry deterrence through upfront channel integration (strategy C) takes place as the SPNE under a general demand function when exogenous parameters fall into a specific region; in other words, Corollary 3 also holds under a general function. Following Figure 1 in Bonanno and Vickers (1988, p. 261), we may draw Figure 4, which illustrates the rationale behind such an implication. Although Bonanno and Vickers (1988) used this figure to describe the competition between two firms that simultaneously compete with each other, we may adapt it to explain the competition between an incumbent and an entrant as long as the above four properties are assumed. In Figure 4, the steeper of the two continuous lines represents the reaction curve of the vertically separated Firm 1 (which has chosen strategy D), while the other continuous line represents the reaction curve of the vertically separated Firm 2. The dashed line represents the reaction curve of Firm 1 when it chooses vertical integration (strategy C). If Firm 1 chooses strategy D and accommodates the entry of Firm 2, the Nash equilibrium price set is given by $p^{(D, D)}$. On the other hand, if Firm 1 chose strategy C and Firm 2 enters the market, the Nash equilibrium price set will be along retailer 2's reaction curve at a point where both final prices have fallen to $p^{(C, D)}$. Observe that not only Firm 1's price but also Firm 2's price falls when the reaction curve of Firm 1 shifts from strategy D (continuous line) to strategy C (dashed line), reducing margins for both firms. Eventually, if the entry fee, f , is less than the revenue for Firm 2 at the price set of $p^{(D, D)}$ but is greater than the revenue at the price set of $p^{(C, D)}$, Firm 2 becomes unable to earn sufficient revenue to recoup the entry fee and gives up entering the market. This condition corresponds to Inequality (C1) if the demand function takes the linear form represented by Equation (1). As can be seen from Figure 4, the assumption (assumption (iv) above) that prices are strategic complements is crucially important for both firms' prices to decrease.

[Figure 4]

Note that a major benefit of employing a linear demand function is that one can derive explicit payoffs as presented in Table 2, and show how they depend on exogenous parameters (i.e., θ , a , b , and c) as summarized in Corollaries 4 and 5 and Remark 1. Therefore, we have focused our analysis on the linear demand function. Overall, however, the above discussion suggests that our basic results hold under a general demand functional form as long as several properties are assumed in advance, as stated earlier.

4.2. Multiple firms

4.2.1. Multiple entrants

Another possible extension is the existence of multiple firms instead of one-on-one competition between an incumbent and an entrant. The previous literature (e.g., Matsui, 2011b) demonstrates that even if n (> 2) multiple firms simultaneously compete in price as in the benchmark scenario in Section 2, all firms vertically separate the channel as the dominant strategy, i.e., Corollary 1 still holds under competition among n firms. Moreover, even if we consider an entry threat such as presented in the scenario in Section 3, we can prove that Inequality (C1) is a sufficient condition for the incumbent preventing entry of not only one firm but also more than two multiple firms, as follows.

Suppose that n symmetric firms simultaneously enter the market because each of them can earn positive profits by doing so. Then, Corollary 1 suggests that the dominant strategy for each entrant is channel separation (strategy D) and the payoff for each entrant is calculated as follows:¹⁴

$$\pi_E^{M(C,D)} = \frac{(a-c)^2(1-\theta)(1+(n-1)\theta)(8+4(2n-1)\theta-2\theta^2-\theta^3+2(n-1)n\theta^4+(n-1)^2\theta^5)(16+8(2n-1)\theta-12\theta^2-6(2n-1)\theta^3+2\theta^4+n\theta^5)}{8b(n\theta+1)(2+(n-2)\theta)^2(2+(2n-1)\theta)^2(2-\theta^2)^2} - f, \quad (4)$$

where superscript (C, D) signifies that the incumbent takes strategy C whereas all n entrants take strategy D. Henceforth, subscript E attached to profit represents an entrant, whereas subscript I represents an incumbent. Equation (4) is less than or equal to $(a-c)^2(1-\theta)(2+\theta)^2/(8b(1+\theta)(2-\theta^2))-f$, which is the difference between the lower limit of Inequality (C1) and the entry fee.¹⁵ Therefore, profit for an entrant represented by Equation (4) is negative if Inequality (C1) is met, which in turn means that if the incumbent deters the entry of one potential entrant then it automatically deters entry of multiple potential entrants. To conclude, we need not consider the existence of multiple entrants and it suffices to consider the situation where only one entrant exists. Based on this notion, we have considered only a single entrant in the above sections.

4.2.2. Multiple incumbents

Next, we consider the situation where multiple incumbents exist. Let m denote the number of incumbents. When all incumbents take strategy C and the potential entrant enters the market by taking the dominant strategy D, the number of competitors is $m+1$ and profit for the entrant is stated as follows:¹⁶

$$\pi_E^{M(C,D)} = \frac{(a-c)^2(1-\theta)(2+(2m-1)\theta)^2}{4b(2+(m-1)\theta)(1+m\theta)(2+3(m-1)\theta+(m^2-3m+1)\theta^2)} - f, \quad (5)$$

¹⁴ Although we do not present the detailed calculation process for Equation (4) due to space limitation, one may derive it by extending "Case (2) strategy (C, D)" of the proof of Proposition 1 in the Appendix to encompass the existence of one firm (the incumbent) with strategy C and n firms (entrants) with strategy D. Matsui (2011b) detailed how to derive the SPNE when multiple competitors exist in a price-setting game.

¹⁵ One may confirm this relationship by showing that Equation (4) is maximized and equals $(a-c)^2(1-\theta)(2+\theta)^2/(8b(1+\theta)(2-\theta^2))-f$ if and only if $n = 1$ and decreases in n based on mathematical induction.

¹⁶ Equation (5) is derived by extending "Case (2) strategy (C, D)" of the proof of Proposition 1 in the Appendix to encompass the existence of m firms with strategy C and one firm with strategy D. Equation (6) is derived by developing "Case (1) strategy (C, C)" of the same proof to encompass m firms taking strategy C. Finally, Equation (7) is derived by extending "Case (4) strategy (D, D)" of the proof to consider $m+1$ firms taking strategy D. Propositions 1 and 2 in Matsui (2011b, pp. 528–529) detail the calculation process.

where superscript (C, D) represents that all incumbents take strategy C and the potential entrant enters the market with strategy D. Meanwhile, if the incumbents deter entry by taking strategy C, the number of competitors is m and the payoff for an incumbent is:

$$\Pi_I^{(C,NE)} = \frac{(a-c)^2(1-\theta)(1+(m-2)\theta)}{b(2+(m-3)\theta)^2(1+(m-1)\theta)} - f, \quad (6)$$

where superscript (C, NE) signifies that all incumbents take strategy C and the potential entrant does not enter the market. Moreover, when all incumbents take strategy D and consequently accommodate entry, the number of competitors is $m+1$ and the payoff for each incumbent or entrant is:

$$\pi^{M(D,D)} = \frac{(a-c)^2(1-\theta)(2+(m-1)\theta)(2+3(m-1)\theta+(m^2-3m+1)\theta^2)}{b(1+m\theta)(4+2(2m-3)\theta+(m^2-4m+2)\theta^2)^2} - f, \quad (7)$$

where superscript (D, D) signifies that all the incumbents and the entrant take strategy D. Because one can prove that Equation (6) is greater than Equation (7) after some calculations, the incumbents collectively have an incentive to deter entry through channel integration. In addition, there exists the domain of f where $\pi_E^{M(C,D)} < 0 < \pi^{M(D,D)}$ holds because we can confirm that Equation (7) is greater than Equation (5) through calculations. If f takes a value that satisfies this inequality, the potential entrant will not enter the market if all the incumbents take strategy C in equilibrium.

However, there remains a concern that this equilibrium might be unstable because we are dealing with a noncooperative game; that is, an incumbent might have an incentive to deviate from the equilibrium by altering its strategy from C to D, because D is the dominant strategy for him/her if the number of competitors is fixed (Corollary 1). To resolve this concern, we use insights from Gilbert and Vives (1986), who incorporate the existence of multiple incumbents into an entry deterrence model with quantity competition. Gilbert and Vives (1986) pointed out that each incumbent has an incentive to "free-ride" on the entry-preventing activities of its competitors, with the consequence that there would be too small a supply of entry deterrence activities. Recall that a firm wishes to supply less through channel separation than through integration in our model, because the former is the dominant strategy under a fixed number of competitors (Corollary 1), meaning that an incumbent free-rides on the entry deterrence activity of others. Nonetheless, Gilbert and Vives (1986) demonstrated that entry deterrence arises in equilibrium as long as the minimum supply quantity required for the deterrence is relatively small. Namely, they prove that multiple incumbents cooperatively deter entry even in a noncooperative entry deterrence game under specific circumstances. Their result also holds in our model.

To obtain a clearer picture of the implications of Gilbert and Vives (1986) in the

context of our model, let us consider the existence of two incumbents and one entrant. Let the three symbols within the parentheses denote the strategies taken by the first incumbent, the second incumbent, and the entrant, respectively. For example, (C, D, NE) signifies that incumbent 1 integrates the channel, incumbent 2 separates the channel, and the potential entrant does not enter the market. Moreover, subscript I1 denotes incumbent 1, I2 denotes incumbent 2, Ii denotes either incumbent, and E represents the entrant. Overall profits for an incumbent and the entrant under several combinations of strategies are calculated as follows:¹⁷

$$\pi_E^{M(C,C,D)} = \frac{(a-c)^2(1-\theta)(2+3\theta)^2}{4b(2+\theta)(1+2\theta)(2+3\theta-\theta^2)} - f,$$

$$\pi_E^{M(C,D,D)} = \frac{(a-c)^2(2+3\theta)^2(2+3\theta-\theta^2)(2-\theta-\theta^2)}{4b(1+2\theta)(4+8\theta+\theta^2-2\theta^3)^2} - f,$$

$$\Pi_{Ii}^{(C,C,NE)} = \frac{(a-c)^2(1-\theta)}{b(2-\theta)^2(1+\theta)} - f,$$

$$\pi_{Ii}^{M(D,D,D)} = \frac{(a-c)^2(1-\theta)(2+\theta)(2+3\theta-\theta^2)}{b(1+2\theta)(4+2\theta-2\theta^2)^2} - f,$$

$$\pi_{I2}^{M(C,D,D)} = \frac{(a-c)^2(2+3\theta)^2(2+3\theta-\theta^2)(2-\theta-\theta^2)}{4b(1+2\theta)(4+8\theta+\theta^2-2\theta^3)^2} - f.$$

Given the above equations, one may prove that exogenous parameters that satisfy the following inequalities exist:

$$\pi_E^{M(C,C,D)} < 0, \tag{8}$$

$$\pi_E^{M(C,D,D)} > 0, \tag{9}$$

$$\Pi_{I2}^{(C,C,NE)} > \pi_{I2}^{M(C,D,D)}, \tag{10}$$

$$\Pi_{Ii}^{(C,C,NE)} > \pi_{Ii}^{M(D,D,D)}. \tag{11}$$

Inequalities (8) and (9) suggest that:

$$\frac{(a-c)^2(1-\theta)(2+3\theta)^2}{4b(2+\theta)(1+2\theta)(2+3\theta-\theta^2)} < f < \frac{(a-c)^2(2+3\theta)^2(2+3\theta-\theta^2)(2-\theta-\theta^2)}{4b(1+2\theta)(4+8\theta+\theta^2-2\theta^3)^2}. \tag{12}$$

¹⁷ If entry is deterred, i.e., the entrant takes strategy NE, profit calculated here is equal to that in Proposition 1, which represents the two-firm case. If entry is accommodated, one may derive these overall profits by extending the calculation process in the proof of Proposition 1

Inequalities (10) and (11) are satisfied due to the following relationships:

$$\Pi_{12}^{(C,C,NE)} - \pi_{12}^{M(C,D,D)} = \frac{(a-c)^2(1-\theta)\theta(64 + 304\theta + 480\theta^2 + 216\theta^3 - 124\theta^4 - 105\theta^5 + 8\theta^6 + 9\theta^7)}{4b(2-\theta)^2(1+\theta)(1+2\theta)(4+8\theta+\theta^2-2\theta^3)^2} > 0,$$

$$\Pi_{li}^{(C,C,NE)} - \pi_{li}^{M(D,D,D)} = \frac{(a-c)^2(1-\theta)\theta(4+7\theta+\theta^2)}{4b(2-\theta)^2(1+\theta)^2(1+2\theta)} > 0.$$

These inequalities mean that if Inequality (12) is met, the entrant does not enter the market when both the incumbents take strategy C (Inequality (8)). However, if one of the incumbents alters its strategy from C to D, the entrant enters the market (Inequality (9)), which always reduces profit for the incumbent (Inequality (10)). Finally, profit for each incumbent with strategy C and entry deterrence exceeds that with strategy D and entry accommodation (Inequality (11)). Therefore, neither incumbent is willing to deviate from strategy C. As a consequence, Inequality (12) is a sufficient condition to ensure that the state where both the incumbents integrate marketing channels and the entrant does not enter the market (i.e., (C, C, NE)) is sustained as the SPNE. This example suggests that multiple incumbents can collectively deter entry in a noncooperative game if exogenous parameters fall into a specific region.

To summarize this section, even in the presence of multiple entrants and incumbents, there arise exogenous circumstances such as Inequality (C1), where entry deterrence takes place through channel integration.

5. Conclusions

This paper investigates the organizational design problem of whether duopolistic firms engaged in interfirm rivalry should vertically integrate or separate their marketing channels. Overall, the previous significant OR/MS studies have concluded that the dominant strategy involves vertical separation of the marketing channel combined with the use of a two-part tariff contract (e.g., McGuire and Staelin, 1983; Moorthy, 1988; Atkins and Liang, 2010). Contrary to this, our paper demonstrates that if exogenous parameters that characterize fixed costs, product substitutability, and a demand function fall into a specific region, a marketing channel integration strategy dominates the separation strategy when one of the two firms is the incumbent firm and the other is a potential entrant. That is, the familiar result from the decision delegation model is reversed when we take entry threats into consideration. Specifically, we show that the incumbent can deter entry of the potential competitor and can thus monopolize the market by vertically integrating the channel in the SPNE.

The primary managerial implication of the present study is that vertical separation of

to the three-firm case.

the marketing channel is not necessarily an advantageous strategy for a firm facing price competition, even though the conventional wisdom from previous studies is that the separation strategy dominates the integration strategy. Therefore, managers should note that this apparently advantageous strategy, i.e., vertical separation, may actually be disadvantageous because it may allow another competitor to enter the market, which reduces the firm's profits in the long run. Moreover, Remark 1 suggests that the external environment, in relation to the market size and the degree of product differentiation, can affect the dominance of the integration strategy. This additional result indicates that the central management of a firm should carefully examine the exogenous economic circumstances surrounding the market before designing the marketing channel, because the form of the channel could very well act as an entry barrier that helps the firm to monopolize the market.

Appendix

Proof of Proposition 1. We derive the Nash equilibrium under each of the four combinations of strategies taken by the two firms. The first letter contained in the parentheses below represents the strategy taken by Firm 1, whereas the latter represents that taken by Firm 2.

Case (1): strategy (C, C)

From Equation (2), Firm i 's overall profit under centralization at Date 3 is stated as follows:

$$\begin{aligned}\Pi_i &= (p_i - c)q_i - f \\ &= (p_i - c)((1 - \theta)a - p_i + \theta p_j)/((1 - \theta)(1 + \theta)b) - f\end{aligned}\quad (\text{A1})$$

Simultaneously solving the first-order conditions for Firms 1 and 2 ($\partial\Pi_1/\partial p_1 = 0$ and $\partial\Pi_2/\partial p_2 = 0$) yields the following equilibrium price:

$$p_1 = p_2 = ((1 - \theta)a + c)/(2 - \theta). \quad (\text{A2})$$

One may easily confirm that the second-order derivative of each firm's profit in this equilibrium is negative, i.e., $\partial^2\Pi_1/\partial p_1^2 < 0$ and $\partial^2\Pi_2/\partial p_2^2 < 0$. Evaluating Equation (A1) at the equilibrium price given by Equation (A2) yields the equilibrium profit for each firm.

Case (2): strategy (C, D)

Because Firm 1 centralizes its marketing decision, its overall profit is:

$$\begin{aligned}\Pi_1 &= (p_1 - c)q_1 - f \\ &= (p_1 - c)((1 - \theta)a - p_1 + \theta p_2)/((1 - \theta)(1 + \theta)b) - f\end{aligned}\quad (\text{A3})$$

Meanwhile, profit for the retailer employed by Firm 2 is:

$$\begin{aligned}\pi_2^R &= (p_2 - r_2)q_2 - F_2 \\ &= (p_2 - r_2)((1 - \theta)a - p_2 + \theta p_1)/((1 - \theta)(1 + \theta)b) - F_2,\end{aligned}\quad (\text{A4})$$

where r_2 represents the marginal wholesale price and F_2 represents the fixed franchise fee paid by the retailer to Firm 2. Solving $\partial\Pi_1/\partial p_1 = 0$ and $\partial\pi_2^R/\partial p_2 = 0$ at Date 3 yields the following prices.

$$p_1 = \frac{a(1-\theta)(2+\theta) + 2c + \theta r_2}{(2-\theta)(2+\theta)}, \quad p_2 = \frac{a(1-\theta)(2+\theta) + 2r_2 + \theta c}{(2-\theta)(2+\theta)}. \quad (A5)$$

Because Firm 2 extracts all profits from the retailer (i.e., $\pi_2^R = 0$), we substitute Equation (A5) into Equation (A4) and solve $\pi_2^R = 0$ for F_2 . Then:

$$F_2 = (c\theta - (2 - \theta^2)r_2 + a(1-\theta)(2+\theta))^2 / (b(2-\theta)^2(2+\theta)^2(1-\theta)(1+\theta)). \quad (A6)$$

Profit for Firm 2 as the manufacturer is:

$$\begin{aligned} \pi_2^M &= (r_2 - c)q_2 + F_2 - f \\ &= (r_2 - c)((1-\theta)a - p_2 + \theta p_1) / ((1-\theta)(1+\theta)b) + F_2 - f. \end{aligned} \quad (A7)$$

Substituting Equations (A5) and (A6) into Equation (A7) and maximizing with respect to r_2 by solving $\partial \pi_2^M / \partial r_2 = 0$ at Date 2 yields:

$$r_2 = \frac{a\theta^2(1-\theta)(2+\theta) + c(8 - 6\theta^2 + \theta^3 + \theta^4)}{4(2 - \theta^2)}. \quad (A8)$$

Reevaluating Equations (A3) and (A7) by using Equations (A5), (A6), and (A8) gives equilibrium profits in this case.

Case (3): strategy (D, C)

Because this case is the symmetric opposite to that of Case (2) (C, D) with respect to the firms' strategies, equilibrium profits for Case (3) are given simply by interchanging the profits between Firm 1 and Firm 2 from that for Case (2).

Case (4): strategy (D, D)

When both firms decentralize their organizational forms, profits for the retailers employed by each firm at Date 3 are as follows:

$$\begin{aligned} \pi_1^R &= (p_1 - r_1)q_1 - F_1 \\ &= (p_1 - r_1)((1-\theta)a - p_1 + \theta p_2) / ((1-\theta)(1+\theta)b) - F_1, \end{aligned} \quad (A9)$$

$$\begin{aligned} \pi_2^R &= (p_2 - r_2)q_2 - F_2 \\ &= (p_2 - r_2)((1-\theta)a - p_2 + \theta p_1) / ((1-\theta)(1+\theta)b) - F_2, \end{aligned} \quad (A10)$$

where r_i represents the marginal wholesale price and F_i represents the fixed franchise fee paid by each retailer to Firm i . Solving $\partial \pi_1^R / \partial p_1 = 0$ and $\partial \pi_2^R / \partial p_2 = 0$ yields the following prices:

$$p_1 = \frac{a(1-\theta)(2+\theta) + 2r_1 + \theta r_2}{(2-\theta)(2+\theta)}, \quad p_2 = \frac{a(1-\theta)(2+\theta) + 2r_2 + \theta r_1}{(2-\theta)(2+\theta)}. \quad (A11)$$

Because each upstream firm appropriates all profits from the downstream retailer, we substitute Equation (A11) into Equations (A9) and (A10) and solve $\pi_1^R = 0$ and $\pi_2^R = 0$ for F_1 and F_2 . Then:

$$\begin{aligned} F_1 &= (r_2\theta - (2 - \theta^2)r_1 + a(1-\theta)(2+\theta))^2 / (b(2-\theta)^2(2+\theta)^2(1-\theta)(1+\theta)) \\ F_2 &= (r_1\theta - (2 - \theta^2)r_2 + a(1-\theta)(2+\theta))^2 / (b(2-\theta)^2(2+\theta)^2(1-\theta)(1+\theta)). \end{aligned} \quad (A12)$$

Profits for the two firms operating as manufacturers are:

$$\begin{aligned}\pi_1^M &= (r_1 - c)q_1 + F_1 - f \\ &= (r_1 - c)((1 - \theta)a - p_1 + \theta p_2)/((1 - \theta)(1 + \theta)b) + F_1 - f,\end{aligned}\quad (\text{A13})$$

$$\begin{aligned}\pi_2^M &= (r_2 - c)q_2 + F_2 - f \\ &= (r_2 - c)((1 - \theta)a - p_2 + \theta p_1)/((1 - \theta)(1 + \theta)b) + F_2 - f.\end{aligned}\quad (\text{A14})$$

Substituting Equations (A11) and (A12) into Equations (A13) and (A14) and maximizing with respect to each wholesale price by solving $\partial \pi_1^M / \partial r_1 = 0$ and $\partial \pi_2^M / \partial r_2 = 0$ at Date 2 yields:

$$r_1 = r_2 = \frac{\theta^2(1 - \theta)a + (2 - \theta)(2 - \theta^2)c}{4 - 2\theta - \theta^2}.\quad (\text{A15})$$

Reevaluating Equations (A13) and (A14) by using Equations (A11), (A12), and (A15) yields equilibrium profits in this case. \square

Proof of Corollary 1. We compare profits for Firm 1 arising from its chosen strategy assuming Firm 2 takes a fixed strategy. First, suppose that Firm 2 selects strategy C. Then, Table 1 suggests that profit for Firm 1 when it chooses strategy C is:

$$\Pi_1 = \frac{(a - c)^2(1 - \theta)}{b(2 - \theta)^2(1 + \theta)} - f,$$

whereas its profit under strategy D is:

$$\pi_1^M = \frac{(a - c)^2(1 - \theta)(2 + \theta)^2}{8b(1 + \theta)(2 - \theta^2)} - f.$$

Because the following inequality is met, strategy D dominates strategy C for Firm 1 when Firm 2 selects strategy C:

$$\pi_1^M - \Pi_1 = \left(\frac{(a - c)^2(1 - \theta)(2 + \theta)^2}{8b(1 + \theta)(2 - \theta^2)} - f \right) - \left(\frac{(a - c)^2(1 - \theta)}{b(2 - \theta)^2(1 + \theta)} - f \right) = \frac{(a - c)^2(1 - \theta)\theta^4}{8b(2 - \theta)^2(1 + \theta)(2 - \theta^2)} > 0.$$

Second, suppose that Firm 2 selects strategy D. Then, if Firm 1 chooses strategy C, its profit is:

$$\Pi_1 = \frac{(a - c)^2(1 - \theta)(4 + 2\theta - \theta^2)^2}{16b(1 + \theta)(2 - \theta^2)^2} - f,$$

whereas its profit under strategy D is:

$$\pi_1^M = \frac{2(a - c)^2(1 - \theta)(2 - \theta^2)}{b(1 + \theta)(4 - 2\theta - \theta^2)^2} - f.$$

Because the following inequality is satisfied, strategy D dominates strategy C for Firm 1 when Firm 2 selects strategy D:

$$\begin{aligned}\pi_1^M - \Pi_1 &= \left(\frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} - f \right) - \left(\frac{(a-c)^2(1-\theta)(4+2\theta-\theta^2)^2}{16b(1+\theta)(2-\theta^2)^2} - f \right) \\ &= \frac{(a-c)^2(1-\theta)\theta^4(16-8\theta^2-\theta^4)}{16b(1+\theta)(2-\theta^2)^2(4-2\theta-\theta^2)^2} > 0\end{aligned}$$

Finally, note that payoffs are symmetric between the two firms with respect to their strategies as shown in Table 1. Consequently, this corollary holds. \square

Proof of Corollary 2. Because Corollary 1 suggests that strategy D is the unique dominant strategy for both firms, the combination (D, D) constitutes the SPNE in this dynamic game.

\square

Proof of Proposition 2. We solve the game by backwards induction along the timeline shown in Figure 3. We note that in relation to channel formation and the price strategies played by the two firms, the game is similar to that of the model in Section 2 if and only if Firm 2 enters the market. That is, the events at Dates 2 and 3 are equivalent in Figures 1 and 3. Hence, payoffs under strategies (C, C), (C, D), (D, C), and (D, D) are identical to those shown in Table 1. Therefore, in this proof, we focus only on the case where Firm 2 does not enter the market (strategy NE). Obviously, the payoffs for Firm 2 are zero, irrespective of the strategy taken by Firm 1.

Case (1): strategy (C, NE)

If Firm 1 selects strategy C at Date 0, its profit at Date 3 is:

$$\Pi_1 = (p_1 - c)q_1 - f = (p_1 - c)(a - p_1)/b - f. \quad (\text{A16})$$

Solving the first-order condition of Equation (A16) with respect to p_1 (i.e., $\partial\Pi_1/\partial p_1 = 0$) yields $p_1 = (a+c)/2$. Substituting this into Equation (A16) gives the equilibrium profit of

$\Pi_1 = (a-c)^2/(4b) - f$, as shown in Table 2.

Case (2): strategy (D, NE)

If Firm 1 selects strategy D at Date 0, the retailer's profit at Date 3 is:

$$\pi_1^R = (p_1 - r_1)q_1 - F_1 = (p_1 - r_1)(a - p_1)/b - F_1. \quad (\text{A17})$$

Solving the first-order condition of Equation (A17) with respect to p_1 (i.e., $\partial\pi_1^R/\partial p_1 = 0$) gives $p_1 = (a+r_1)/2$. Replacing p_1 in Equation (A17) with this yields:

$$\pi_1^R = (a - r_1)^2/(4b) - F_1.$$

Because the upstream firm extracts all profits from the retailer (i.e., $\pi_1^R = 0$),

$F_1 = (a - r_1)^2/(4b)$. Profit for the upstream firm operating as the manufacturer is:

$$\begin{aligned}\pi_1^M &= (r_1 - c)q_1 + F_1 - f \\ &= (r_1 - c)(a - p_1)/b + F_1 - f.\end{aligned} \quad (\text{A18})$$

Substituting $p_1 = (a+r_1)/2$ and $F_1 = (a-r_1)^2/(4b)$ into Equation (A18) and maximizing it on r_1 (i.e., $\partial \pi_1^M / \partial r_1 = 0$) gives:

$$r_1 = c. \quad (\text{A19})$$

Putting $F_1 = (a-r_1)^2/(4b)$ and Equation (A19) into Equation (A18) gives equilibrium profit as: $\pi_1^M = (a-c)^2/(4b) - f$, which is identical to the case (C, NE) as shown above. \square

Proof of Corollary 3. Initially, suppose that Firm 1 selects strategy C at Date 0. Recall that if Firm 1 selects strategy C, strategy D dominates strategy C for Firm 2 in the benchmark scenario according to Corollary 1. When Firm 2 selects strategy D at Date 1 and enters the market, Proposition 2 suggests that its profit is as follows:

$$\pi_2^M = \frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} - f. \quad (\text{A20})$$

If Equation (A20) is negative, that is, $f > (a-c)^2(1-\theta)(2+\theta)^2/(8b(1+\theta)(2-\theta^2))$, Firm 2 will not enter the market in the equilibrium because of the negative profit achieved under duopoly.

Second, suppose that Firm 1 selects strategy D at Date 0. Corollary 1 suggests that strategy D also dominates strategy C for Firm 2 in the benchmark scenario if Firm 1 selects strategy D. If Firm 2 selects strategy D at Date 1 and enters the market, its profit is as follows:

$$\pi_2^M = \frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} - f. \quad (\text{A21})$$

Note that Firm 2 will enter the market in this case as long as Equation (A21) is positive, that is, $f < 2(a-c)^2(1-\theta)(2-\theta^2)/(b(1+\theta)(4-2\theta-\theta^2)^2)$. As a consequence, if Inequality (C1) holds, Firm 2 enters the market if Firm 1 selects strategy D, but it does not enter if Firm 1 selects strategy C.

Next, the monopoly profits achieved by Firm 1 through strategy C at Date 0 $((a-c)^2/(4b) - f)$ are greater than the duopoly profits

$(2(a-c)^2(1-\theta)(2-\theta^2)/(b(1+\theta)(4-2\theta-\theta^2)^2) - f)$ achieved through strategy D, as follows:

$$\begin{aligned} & ((a-c)^2/(4b) - f) - (2(a-c)^2(1-\theta)(2-\theta^2)/(b(1+\theta)(4-2\theta-\theta^2)^2) - f) \\ &= (a-c)^2 \theta (16 - 12\theta - 8\theta^2 + 5\theta^3 + \theta^4) / (4b(1+\theta)(4-2\theta-\theta^2)^2) > 0 \end{aligned}$$

This inequality holds because $2 < 16 - 12\theta - 8\theta^2 + 5\theta^3 + \theta^4 < 16$ given that $0 < \theta < 1$. As a consequence, (C, NE) is the unique SPNE if Inequality (C1) holds.

Finally, the next inequality holds because $0 < \theta < 1$:

$$\frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} - \frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} = \frac{(a-c)^2\theta^3(1-\theta)(16-8\theta^2-\theta^3)}{8b(1+\theta)(2-\theta^2)(4-2\theta+\theta^2)^2} > 0. \quad (\text{A22})$$

Inequality (A22) shows that the upper limit of Inequality (C1) is greater than the lower limit, which guarantees that the domain of f satisfying the inequality actually exists. \square

Proof of Corollary 4. The first-order derivative of the upper limit of f shown by Inequality (C1) on θ is:

$$\frac{\partial}{\partial \theta} \left(\frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} \right) = -\frac{4(a-c)^2(4-4\theta-2\theta^2+3\theta^3+\theta^4-\theta^5)}{b(1+\theta)^2(4-2\theta-\theta^2)^3} < 0,$$

indicating that the upper limit decreases according to θ . This inequality holds because $1 < 4-4\theta-2\theta^2+3\theta^3+\theta^4-\theta^5 < 4$ and $1 < 4-2\theta-\theta^2 < 4$, given that $0 < \theta < 1$. Meanwhile, the first-order derivative of the lower limit of f on θ is:

$$\frac{\partial}{\partial \theta} \left(\frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} \right) = -\frac{(a-c)^2(2+\theta)(2+\theta^3)}{4b(1+\theta)^2(2-\theta^2)^2} < 0. \quad (\text{A23})$$

Inequality (A23) suggests that the lower limit also decreases according to θ . Consequently, this corollary holds. \square

Proof of Corollary 5. Looking at the functional forms, we may confirm that both the upper limit $\left(\frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} \right)$ and the lower limit $\left(\frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} \right)$ of f in Inequality (C1) increase with $(a-c)^2/b$ because $0 < \theta < 1$. Therefore, this corollary holds. \square

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Table 1. Payoff matrix of the game by two incumbents

		Firm 2	
Strategy		C	D
Firm 1	C	$\left(\frac{(a-c)^2(1-\theta)}{b(2-\theta)^2(1+\theta)} - f, \frac{(a-c)^2(1-\theta)}{b(2-\theta)^2(1+\theta)} - f \right)$	$\left(\frac{(a-c)^2(1-\theta)(4+2\theta-\theta^2)^2}{16b(1+\theta)(2-\theta^2)^2} - f, \frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} - f \right)$
	D	$\left(\frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} - f, \frac{(a-c)^2(1-\theta)(4+2\theta-\theta^2)^2}{16b(1+\theta)(2-\theta^2)^2} - f \right)$	$\left(\frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} - f, \frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} - f \right)$

Table 2. Payoff matrix of the game by one incumbent and one entrant

		Firm 2		
Strategy		C	D	NE
Firm 1	C	$\left(\frac{(a-c)^2(1-\theta)}{b(2-\theta)^2(1+\theta)} - f, \frac{(a-c)^2(1-\theta)}{b(2-\theta)^2(1+\theta)} - f \right)$	$\left(\frac{(a-c)^2(1-\theta)(4+2\theta-\theta^2)^2}{16b(1+\theta)(2-\theta^2)^2} - f, \frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} - f \right)$	$\left(\frac{(a-c)^2}{4b} - f, 0 \right)$
	D	$\left(\frac{(a-c)^2(1-\theta)(2+\theta)^2}{8b(1+\theta)(2-\theta^2)} - f, \frac{(a-c)^2(1-\theta)(4+2\theta-\theta^2)^2}{16b(1+\theta)(2-\theta^2)^2} - f \right)$	$\left(\frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} - f, \frac{2(a-c)^2(1-\theta)(2-\theta^2)}{b(1+\theta)(4-2\theta-\theta^2)^2} - f \right)$	$\left(\frac{(a-c)^2}{4b} - f, 0 \right)$

Fig. 1. Timeline of events in the game by two incumbents

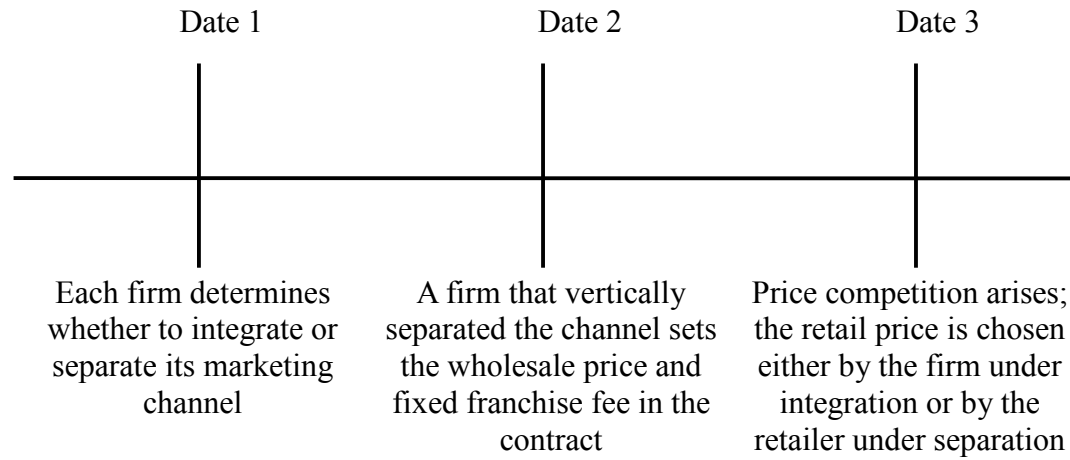
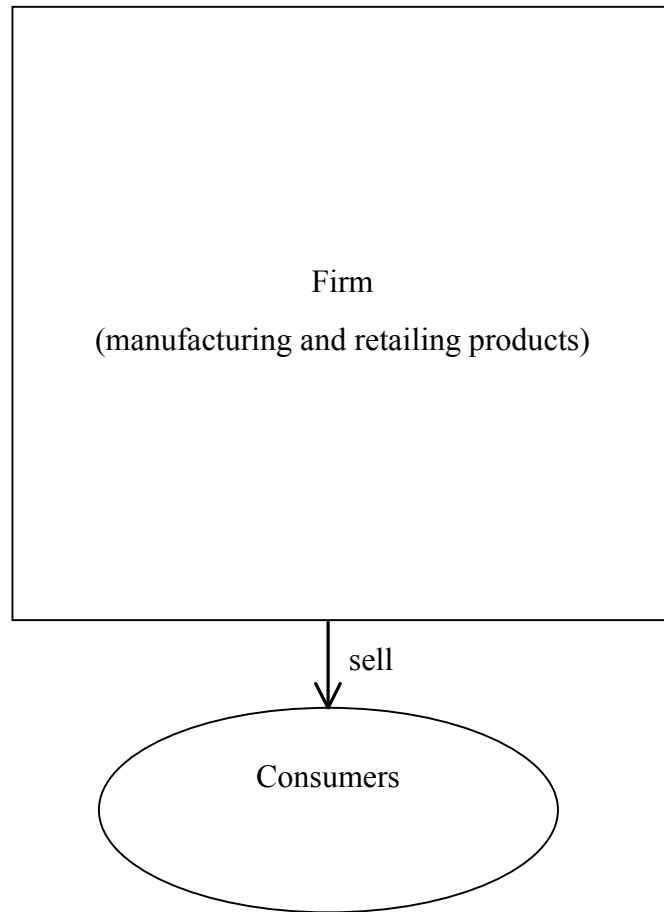


Fig. 2. Organizational structures

Strategy C (marketing channel integration)



Strategy D (marketing channel separation)

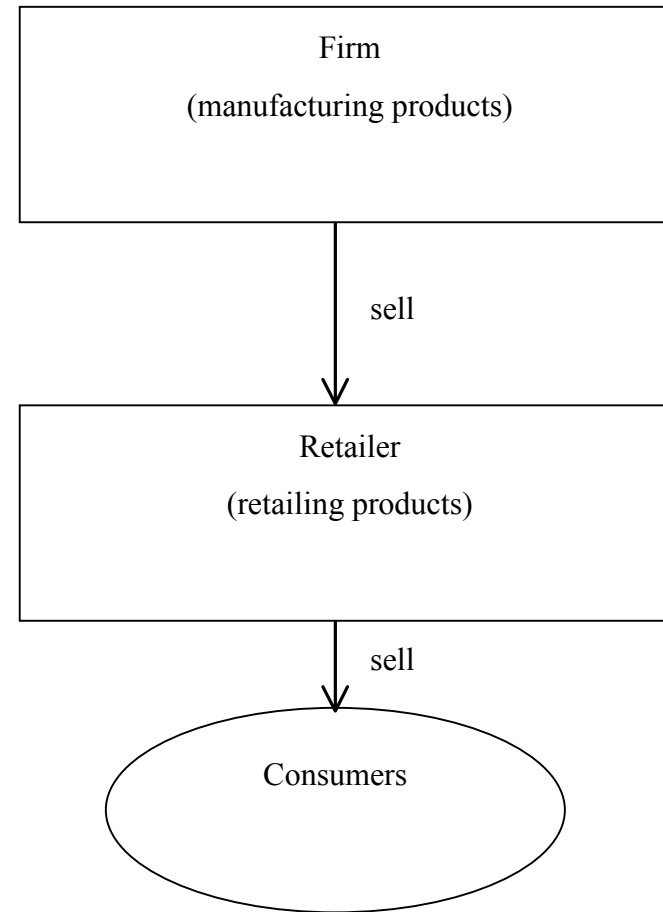


Fig. 3. Timeline of events in the game by one incumbent and one entrant

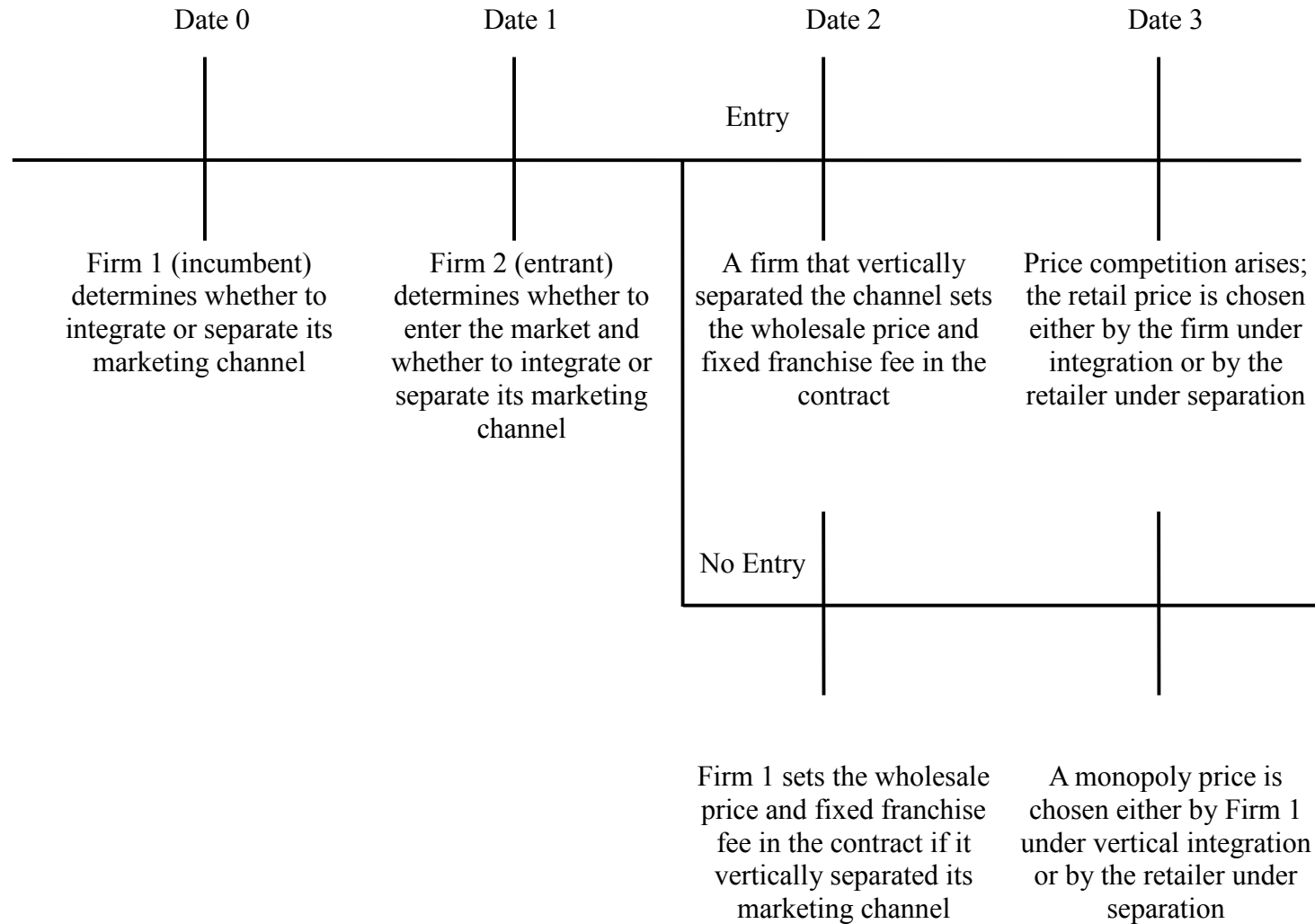


Fig. 4. Reaction functions of firms under general demand functions

