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Passive Backward Acquisitions and Downstream Collusion*

Shiva Shekhar [†] Tim Paul Thomes[‡]

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Abstract

We investigate the effects of passive backward acquisitions in their efficient upstream supplier on downstream firms' ability to collude in a dynamic game of price competition with homogeneous goods. We find that passive backward acquisitions impede downstream collusion. The main driver of our finding is that a passive backward acquisition secures an acquirer from zero continuation profits after a breakdown of collusion. This anti-collusive effect cannot be outweighed by a lower collusive price that is set by the cartel to increase the acquirer's profit from its claim on the upstream margin.

JEL Classification: D43, L13, L40, L81.

Keywords: Tacit collusion, passive backward acquisitions, Bertrand competition.

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1 Introduction

There is a longstanding debate by scholars and antitrust authorities on the collusive effects of horizontal non-controlling acquisitions in competitors.[1] Similarly, collusive effects of vertical (controlling) mergers have attracted wide attention.[2] Yet little is known about the collusive effects of vertical non-controlling minority acquisitions. This is surprising given that such ownership profiles are very common.[3]

This paper provides a first step towards the understanding of the collusive effects of passive vertical acquisitions. We set up a model of a vertically related market, where firm interactions are infinitely repeated. Downstream firms offer a homogeneous product to consumers that they can procure from an upstream firm or a less efficient competitive fringe.[4] The upstream and the downstream firms charge linear prices. The industry may encompass a passive acquisition held by a downstream firm in the efficient upstream firm. Downstream firms may collude on the consumer price and collusion is sustained by Nash reversion trigger strategies. In this setting, we find that a passive backward acquisition makes downstream collusion harder to sustain.

The competitive effects of passive backward integration are ambiguous in static settings. It is well known that a passive backward acquisition works like a partial rebate of the upstream margin. Upstream firms optimally respond to this by increasing their wholesale tariffs in such a manner that strategic choices in the downstream market may remain invariant (Flath (1989); Greenlee and Raskovich (2006)). However, if downstream firms are sufficiently differentiated, a passive acquisition may exacerbate double marginalization since an acquirer profitably internalizes an increase in its competitors' demand resulting from an increase in the own consumer price (Hunold and Stahl (2016)).

In contrast — and to the best of our knowledge — our model is the first that analyzes effects of passive vertical acquisitions in a dynamic perspective. The paper closest to ours is Biancini and Ettinger (2017). They use the same model setup but investigate effects of a full vertical merger on downstream collusion. Full integration provides the acquirer with a cost advantage as goods are traded at marginal cost within the integrated entity, which, one may suppose, impedes

[1]See, e.g., O'Brien and Salop (1999), Gilo et al. (2006) or de Haas and Paha (2020).

[2]For example, the European Commission's guidelines on the assessment of non-horizontal mergers state that „a vertical merger may make it easier for the firms in the upstream or downstream market to reach a common understanding on the terms of coordination.“

[3]Examples include the electricity supply industry (Gans and Wolak (2012)), stock exchanges and clearing houses (Hunold (2020)) or broadcasters and cable TV companies (Brito et al. (2016)).

[4]This setup of asymmetric upstream competition traces back to Chen (2001).

collusion.[5] Biancini and Ettinger (2017) find the opposite by showing that two pro-collusive effects can be elicited. First, they allow the upstream division of the integrated firm to offer wholesale pricing schemes contingent on output quotas under collusion that mitigate double marginalization and dampen the unintegrated firms' deviation incentives. Second, they let the unintegrated firms coordinate on penal codes that are different from standard Nash reversion and that involve prices below input cost, thereby diluting the integrated firm's deviation incentives. However, our setting of passive vertical integration is different in that the acquirer and the target remain independent entities. This implies, first, that the acquirer is not able to affect the strategic choices of the target. Second, a passive backward acquisition does not result in a cost advantage, but, on the contrary, we show that the target raises the acquirer's input tariff in equilibrium.

Our analysis identifies new effects on collusion incentives arising exclusively from passive backward acquisitions. We first confirm that an upstream firm increases the nominal wholesale price for a downstream acquirer in such a way that its rebate on own input purchases is neutralized. After collusion broke down, an acquirer therefore optimally abstains from entering perfect Bertrand competition downstream, which allows it to secure the largest possible profit obtained through its claim on the efficient upstream firm's profit from selling to its rivals. This makes a grim trigger punishment less harsh, therefore spurring incentives to deviate from collusion.

However, there are opposing pro-collusive effects. Firms collude on a consumer price below the level that maximizes downstream flow profits. By doing so, the cartel takes into account that a downstream acquirer profitably internalizes larger sales of the efficient upstream firm to its cartel partners. This strengthens an acquirer's incentives to collude. Moreover, the lowered collusive price decreases profits obtained in a deviation period, where an acquirer does not benefit from its passive acquisition, since it supplies the consumer demand alone at an input price that is effectively the same as the one charged to its unintegrated rivals. This further weakens an acquirer's deviation incentives.

The net result of gauging these effects is that downstream collusion becomes harder to sustain in an industry encompassing a passive backward acquisition. This result suggests that such ownership profiles are not held for anticompetitive purposes in games of repeated interaction.[6] In lieu thereof, an acquirer's backward integration incentive is rather based on its ability to profitably internalize trades of the upstream target with its rivals, which is particularly

[5]See, e.g., Bae (1987) and Harrington (1991) who analyze optimal collusive outcomes between cost-asymmetric firms in infinitely repeated (normal-form) homogeneous-good Bertrand games.

[6]This is in line with Greenlee and Raskovich (2006), who show for a broad class of static settings that passive backward acquisitions have no anticompetitive effects.

intuitive in our setting where downstream margins are erased under competition.

2 Model

Consider $n > 2$ downstream firms denoted by R_i ($i = 1, 2, \dots n$), which purchase a homogeneous input produced by two upstream suppliers U and M. We assume that U's marginal cost is normalized to 0, while that of M equals $c > 0$ (we abstain from fixed production costs). For the sake of tractability, M is a competitive fringe that offers the good always at marginal cost.[7] Denote U's wholesale price charged to a representative downstream firm R_i by w_i^K, with $K \in \{C, P\}$ indicating whether downstream firms collude (C) or compete (P).[8] Each downstream firm requires one unit of the input to produce one unit of the final product. Downstream firms sell their products to consumers who perceive them as homogeneous. The final demand function $D(p)$ is finite at $p = 0$ and there exists a choke price $\overline{p} > 0$, such that $D(p) = 0$ for any $p \geq \overline{p}$ and $D(p) > 0$ for any $p < \overline{p}$. $D(p)$ is strictly downward-sloping and twice continuously differentiable. For all $i \in \{1, \dots n\}$, $(p - \iota_i)D(p)$ is strictly concave on $[\iota_i, \overline{p}]$, where $\iota_i \in \{w_i^K, c\}$. This ensures existence of a unique monopoly price $p^M(\iota_i)$ that maximizes downstream flow profits. Finally, the cost asymmetry between U and M is supposed to be non-drastic, so that $p^M(0) > c$.

We first analyze the scenario in which upstream and the downstream firms are fully separated. We then compare it with the scenario in which R_1 holds a passive acquisition in U, while the other downstream firms remain separated. Denote R_1's acquisition in U by $s_1 \in [0, \overline{s}]$, with $\overline{s} \in (0, 1)$. The acquisition is a pure claim on U's profit from selling to the downstream industry without conveying any control over her strategic decisions.

The original game encompasses an infinitely repeated number of periods. In each period, the following extensive-form stage game is played:

1. *Upstream Stage.* U sets its public wholesale prices w_i^K and downstream firms individually decide whether to buy from U or M.

2. *Downstream Stage.* Downstream firms simultaneously set consumer prices and order the quantities demanded by consumers from the upstream firm they decided to purchase the input from at the relevant wholesale prices.

All actions are observable. The solution concept is subgame perfection.

[7] See, e.g., Hunold and Stahl (2016).

[8] We condition wholesale prices on downstream strategies for expositional reasons. In what follows, we show that wholesale prices are invariant to downstream strategies in equilibrium.

Assume that downstream firms set the collusive consumer price p^C to maximize their joint profits, consisting of the flow profits plus R_1's profits from its acquisition in U. Collusion is sustained by Nash reversion: a deviation is followed by the infinite repetition of the subgame perfect non-cooperative equilibrium of the extensive-form stage game. We abstain from side payments and focus on equilibria along the collusion path in which symmetric firms obtain symmetric market shares. If R_1 holds an acquisition in U, the collusive market sharing rule is defined by the share $\alpha \in [0, 1]$ of the consumer demand allocated to R_1 (while each unintegrated cartel member supplies $D(p^C)(1-\alpha)/(n-1)$).

Our focus is on the effects of passive backward acquisitions on downstream collusion. Therefore, we assume that U discounts future profits at an infinite rate and maximizes only spot profits. We solve for the downstream firms' critical discount factor $\underline{\delta}^* \in (0, 1)$ under vertical separation. We say that a scenario in which R_1 holds a passive acquisition in U makes it easier (more difficult) to sustain downstream collusion when the minimum discount factor for the joint profit maximum is below (above) $\underline{\delta}^*$.

3 Equilibrium Analysis

3.1 Vertical Separation

Under vertical separation, the critical discount factor resembles the standard one of an infinitely repeated normal-form Bertrand game of n symmetric firms that collude on the price for a homogeneous good.

Lemma 1. *Under vertical separation, downstream collusion can be sustained for any discount factor above*

$$\underline{\delta}^* = (n-1)/n. \tag{1}$$

This finding coincides with *Result 1* in Biancini and Ettinger (2017), which can be summarized as follows. Given that $\iota_i = \min\{w_i^C, c\}$ constitutes the decision rule from which upstream firm to buy, U sets a uniform w^* slightly below c and the entire downstream industry always buys from her. Downstream firms collude on $p^C = p^M(c)$, which is the solution to the following first-order condition to the cartel's maximization problem:

$$0 = (p-c)\ \partial D(p)/\partial p + D(p). \tag{2}$$

A deviant slightly undercuts p^C, which triggers an infinite reversion the non-cooperative equilibrium from the next period onward, which involves $p^P = c$. The standard non-deviation incentive constraint is given by $\Pi^M/n \geq (1-\delta)\Pi^M$, with $\Pi^M = (p^M(c) - c)D(p^M(c))$. Solving for δ yields (1).

3.2 Passive Backward Acquisition

Consider now that R_1 holds a passive acquisition in U. We first characterize the outcomes of the downstream and upstream stage under collusion and competition and the deviation strategies. We then define the subgame perfect equilibrium of the original infinite horizon game.

3.2.1 Downstream Stage

Collusion. In the upstream stage, U charges $\breve{w}_1^C$ to R_1 and $\breve{w}_j^C$ to each (symmetric) unintegrated R_j ($j \neq 1$). Suppose for the sake of simplicity that $(\breve{w}_1^C, \breve{w}_j^C)$ are set in such a manner that each cartel member prefers to purchase from U, so that we can focus on the outcomes of the downstream stage.

Downstream firms collude on the consumer price that maximizes their joint profits. Hence, the cartel's maximization program is given by

$$\arg\max_p D(p)\left[p - (1-s_1)\left(\alpha \breve{w}_1^C + (1-\alpha)\breve{w}_j^C\right)\right]. \tag{3}$$

Denote the solution to (3) by $\breve{p}^C$. The individual collusion profit of each unintegrated firm is given by

$$\breve{\pi}_j^C = (1-\alpha)D(\breve{p}^C)\left(\breve{p}^C - \breve{w}_j^C\right)/(n-1), \tag{4}$$

while R_1 earns

$$\breve{\pi}_1^C = \alpha D(\breve{p}^C)\left(\breve{p}^C - (1-s_1)\breve{w}_1^C\right) + s_1(1-\alpha)D(\breve{p}^C)\breve{w}_j^C. \tag{5}$$

The first expression on the right-hand side of (5) represents R_1's profit from its own downstream activity. It can be seen that R_1's effective per-unit input cost decreases below $\breve{w}_1^C$ by the rebate $s_1\breve{w}_1^C$. The reason is that its acquisition enables R_1 to recoup part of its input expenses. The second expression on the right-hand side of (5) is R_1's claim on U's profit from selling to its unintegrated cartel partners. This implies that R_1 may benefit from a reduction of $\breve{p}^C$ as it can profitably internalize the resulting increase in U's sales, which aligns R_1's incentives with those of U to mitigate double marginalization.

Deviation. As under vertical separation, a cartel member optimally deviates its price by slightly undercutting $\breve{p}^C$ at given wholesale prices $(\breve{w}_1^C, \breve{w}_j^C)$. Each unintegrated firm's deviation profit is given by

$$\breve{\pi}_j^D = D(\breve{p}^C)\left(\breve{p}^C - \breve{w}_j^C\right), \tag{6}$$

while the one of R_1 becomes

$$\breve{\pi}_1^D = D(\breve{p}^C)\left(\breve{p}^C - (1-s_1)\breve{w}_1^C\right). \tag{7}$$

In a deviation period, R_1 supplies the consumer market alone. Thus, R_1 has a claim on profits of U arising exclusively from sales to itself.

Punishment. A deviation becomes public knowledge after prices have been set in the downstream stage. In the upstream stage of the subsequent stage game, U charges $\breve{w}_1^P$ to R_1 and $\breve{w}_j^P$ to each unintegrated R_j ($j \neq 1$), which are again supposed to satisfy each firm's participation constraint on own input purchases.

Consider first the unintegrated firms. With Nash reversion, each of them sets the competitive price, given by $\breve{p}_j^P = \breve{w}_j^P$, in the continuation following a deviation. From $n > 2$, it immediately follows that their punishment profit becomes $\breve{\pi}_j^P = 0$, irrespective of R_1's consumer price.

Consider next R_1. The pricing strategy of R_1 depends on whether $\breve{w}_1^P$ being above, equal or below $\breve{w}_j^P$. Suppose first that $\breve{w}_1^P < \breve{w}_j^P$. The dominant strategy of R_1 is then to set its price arbitrarily below $\breve{p}_j^P$ to supply $D(\breve{p}_j^P)$ alone. Suppose second that $\breve{w}_1^P = \breve{w}_j^P$. In this case, R_1 is indifferent between setting $\breve{p}_j^P$, therefore equally splitting $D(\breve{p}_j^P)$ with its competitors, and raising its price above $\breve{p}_j^P$, therefore not realizing own sales and obtaining profits only from its acquisition.[9] Suppose third that $\breve{w}_1^P > \breve{w}_j^P$. Following the logic outlined before, R_1's dominant strategy is to set its price above $\breve{p}_j^P$. Hence, no own sales are executed and R_1's profit consists exclusively of its claim on U's profits from selling to its competitors. Summarizing, R_1's punishment profits are given by

$$\breve{\pi}_1^P = \begin{cases} D\left(\breve{p}_j^P\right)\left(\breve{p}_j^P - (1-s_1)\breve{w}_1^P\right) & \text{if } \breve{w}_1^P < \breve{w}_j^P \\ s_1 D\left(\breve{p}_j^P\right)\breve{w}_j^P & \text{if } \breve{w}_1^P \geq \breve{w}_j^P. \end{cases} \tag{8}$$

Thus, with grim trigger strategies, R_1 obtains strictly positive punishment profits, while its unintegrated rivals end up with zero profits. Although perfect Bertrand competition squeezes all downstream margins to zero if $\breve{w}_1^P \geq \breve{w}_j^P$, R_1 is secured from suffering a zero-profit retaliation due to its acquisition.

3.2.2 Upstream Stage

As under vertical separation, U optimally charges $\breve{w}_j^*$ ($j \neq 1$) marginally below c to each unintegrated downstream firm to satisfy their participation constraints on own input purchases. This holds irrespective of whether they collude or compete in the downstream stage.

In contrast, if U charged R_1 a wholesale price equal to c, R_1 would effectively pay only $(1-s_1)c$ for each unit sold to consumers. When downstream firms collude on the consumer price, this is taken into account by U who optimally raises R_1's nominal wholesale price to $\breve{w}_1^C = c/(1-s_1)$. This neutralizes R_1's rebate on own input purchases. It follows that R_1 pays effectively the same price as its competitors and cannot improve by buying from M.

[9] Setting $\breve{p}_1^P < \breve{w}_j^P$ is never profitable as downstream flow profits become negative.

However, in the punishment phase, where the unintegrated firms set the competitive price, R_1's downstream margin will be zero for any $\check{w}_1^P \geq c$ provided that $\check{w}_j^* = c$. From the preceding discussion on R_1's pricing strategies in the downstream stage, we know that R_1 is indifferent between entering competition and obtaining profits only through its acquisition by setting $p_1^P > c$ if $\check{w}_1^P = c$. Abstaining from making own sales is strictly preferred by R_1 for any $\check{w}_1^P > c$. In this case, R_1 obtains profits exclusively through its claim on U's profits from selling to its rivals, which are given by the second line of (8) with $\check{w}_j^P$ replaced by c. This implies that each wholesale price combination from the set $\{\check{w}_1^P \in [c, \infty), \check{w}_j^* = c\}$ constitutes a payoff equivalent equilibrium of the upstream stage.[10] It follows that the stage game of each period in the punishment phase has multiple subgame perfect Nash equilibria. We select the most plausible equilibrium, which is the one where R_1's incentive constraint on own input purchases is satisfied. Precisely, when R_1 offers a positive quantity and sets the non-cooperative price $\check{p}_1^P = c$ in the downstream stage, it would be just indifferent between purchasing the input from U and M at $\check{w}_1^P = c/(1-s_1)$.[11] This implies that U's strategies are invariant to the strategies of the downstream firms.

Lemma 2. *The set of U's equilibrium wholesale prices is given by* $\check{w}_1^* = c/(1-s_1)$ *and* $\check{w}_j^* = c$, *which is subgame perfect irrespective of whether downstream firms collude or compete.*

3.2.3 Stage Game Outcomes

We can now define the outcomes of the (extensive-form) stage games played in each infinitely repeated period in the collusion and the punishment phase as well as in a deviation period. Consider first collusion. Given $(\check{w}_1^*, \check{w}_j^*)$, the collusive consumer price $\check{p}^C$ is a solution to the following first-order condition to the maximization problem defined by (3):

$$0 = [p - c(1 - s_1(1-\alpha))] \;\; \partial D(p)/\partial p + D(p). \tag{9}$$

[10] Setting $\check{w}_1^P < c$ would never be optimal for U.

[11] The multiplicity of equilibria in the upstream stage of the non-cooperative game is due to perfect Bertrand competition downstream and vanishes in settings where the non-cooperative consumer price is set above input cost. In this case, a downstream firm with a passive acquisition would be strictly better off from supplying consumers. Hunold and Stahl (2016)—in a setting similar to ours, but with differentiated price competition downstream—and Greenlee and Raskovich (2006)—in a setting with a uniform input price set by an unconstrained upstream monopolist and symmetric ownership profiles and Cournot and differentiated price competition downstream—show, then, that there exists a unique subgame perfect stage game equilibrium in which the upstream firm raises the acquirer's input price in a way that the rebate on input purchases is exactly offset.

Comparing (9) with the cartel's first-order condition under vertical separation, given by (2), immediately yields that $\check{p}^C < p^M(c)$ holds, whenever $s_1 > 0$ and $\alpha \in [0, 1)$. The reason is that firms collude on the joint profit maximum. That is, the cartel takes into account that R_1 profitably internalizes the sales of U to its cartel partners. This implies that R_1's incentives become aligned with those of U to mitigate double marginalization. Plugging $(\check{w}_1^*, \check{w}_j^*)$ into (4) and (5) yields the profits that downstream firms obtain in a collusive equilibrium, which are given by

$$\check{\pi}_j^C = (1-\alpha)D(\check{p}^C)(\check{p}^C - c)/(n-1) \tag{10}$$

and

$$\check{\pi}_1^C = \alpha D(\check{p}^C)(\check{p}^C - c) + s_1(1-\alpha)cD(\check{p}^C). \tag{11}$$

Inserting $(\check{w}_1^*, \check{w}_j^*)$ into (6) and (7) yields that each firm gets an identical deviation profit given by

$$\check{\pi}^D = D(\check{p}^C)(\check{p}^C - c). \tag{12}$$

The deviation profit (12) equals the total downstream flow profit at price $\check{p}^C$ and input cost c. Deviating from collusion implies that a deviant supplies the full consumer demand. The resulting deviation profit is the same for R_1 and the unintegrated firms, since $\check{w}_1^*$ neutralizes the rebate that R_1 obtains on own input purchases through its acquisition. As a consequence, R_1 cannot take advantage of its acquisition in the deviation period.

Using grim trigger strategies, each unintegrated firm sets $\check{p}^P = c$ and obtains $\check{\pi}_j^P = 0$ in the punishment phase. In contrast, R_1 optimally raises its consumer price above c. Hence, R_1 does not execute own sales, but secures strictly positive profits due to its acquisition in U, which are given by

$$\check{\pi}_1^P = s_1 cD(c). \tag{13}$$

3.3 Sustainability of Collusion

The collusive outcome can be established as subgame perfect equilibrium of the original infinite horizon game if and only if all individual non-deviation incentive constraints hold. R_1 is willing to stick to collusion if $\check{\pi}_1^C \geq (1-\delta)\check{\pi}_1^D + \delta\check{\pi}_1^P$ is satisfied. Using (11), (12) and (13) and solving for δ yields

$$\underline{\check{\delta}}_1 = \frac{(1-\alpha)\left[D(\check{p}^C)(\check{p}^C - c) - s_1 cD(\check{p}^C)\right]}{D(\check{p}^C)(\check{p}^C - c) - s_1 cD(c)}. \tag{14}$$

Similarly, the non-deviation incentive constraint of each unintegrated firm is $\check{\pi}_j^C \geq (1-\delta)\check{\pi}_j^D$. Inserting (10) and (12) and solving for δ gives

$$\underline{\check{\delta}}_j = [n - 2 + \alpha]/(n-1). \tag{15}$$

Notice that $\underline{\check{\delta}}_1$, given by (14), depends on the collusive consumer price $\check{p}^C$, the market sharing arrangement α and the acquisition s_1, while $\underline{\check{\delta}}_j$, given by (15), only depends on α. The reason is that R_1 obtains a part of U's profits from selling to its unintegrated rivals due to its acquisition under collusion that is lost in the deviation period. In contrast, for a given α, each unintegrated firm's incentives not to deviate from a collusive agreement with R_1 are the same for any $\check{p}^C \in (c, p^M(c)]$. Thus, although our assumption of joint profit maximization implies that the unintegrated firms are worse off under collusion compared to vertical separation whenever $\alpha \geq 1/n$, a collusive outcome with $\check{p}^C \in (c, p^M(c)]$ and $\alpha \geq 1/n$ is supportable as equilibrium provided the individual non-deviation incentive constraints, characterized by (14) and (15), are satisfied. Comparing (14) and (15) with the joint critical discount factor under vertical separation, given by (1), yields the following result:

Proposition 1. *A passive backward acquisition of R_1 in U makes downstream collusion harder to sustain.*

Proof. See Appendix.

Downstream firms optimally collude on a consumer price below the level that maximizes downstream flow profits. This strengthens R_1's incentives to stick to collusion. A first reason is that the lowered collusive price increases R_1's profit from its acquisition due to a reduction of double marginalization and thus larger sales of U to its cartel partners. This pro-collusive effect is further reinforced by R_1's inability to take advantage of its acquisition in a defection period, since U raises R_1's nominal wholesale price in such a way that any rebate on own input purchases (due to its acquisition) is fully neutralized. In fact, R_1—as well as each other firm—obtains a deviation profit equal to downstream flow profits at the lowered collusive consumer price.

However, R_1 realizes strictly positive profits through its acquisition in the punishment phase. This spurs R_1's incentives to cheat on the cartel as R_1 is prevented from suffering a harsh punishment when its rivals reverse to the non-cooperative equilibrium following a deviation. This punishment profit, given by (13), is largest when R_1 abstains from entering downstream competition. The reason is that each unit sold by R_1 yields it exactly zero profit due to the increased wholesale price that U charges it, while U cannot offset R_1's profit from its claim on her markup obtained from selling to R_1's unintegrated rivals.

Proposition 1 states that this latter anti-collusive effect of a positive punishment profit dominates, implying that collusion becomes harder to sustain if R_1 has a passive acquisition in U. As demonstrated in the Appendix, this can be seen by the collusive market sharing arrangement. In particular, any market sharing arrangement $\alpha > 1/n$ implies that each unintegrated firm's discount factor increases above the minimum joint discount factor $\underline{\delta}^*$ at which collusion can be supported under vertical separation. Similarly, any $\alpha \leq 1/n$ implies that R_1's critical discount factor is raised above $\underline{\delta}^*$. Hence, there exists no market sharing arrangement $\alpha \in [0, 1]$ at which the critical discount factors of all firms mutually fall below the (joint) one under vertical separation.

Appendix

Proof of Proposition 1. Consider first the unintegrated firms. From (15), we have that $\partial\check{\underline{\delta}}_j/\partial\alpha = 1/(n-1) > 0$. Furthermore, evaluating $\check{\underline{\delta}}_j$ at $\alpha = 1/n$, which entails a market share of $(1-\alpha)/(n-1)$ for each R_j $(j \neq 1)$, yields that $\check{\underline{\delta}}_j(\alpha = 1/n) \equiv \underline{\delta}^* = (n-1)/n$. Thus, $\check{\underline{\delta}}_j > \underline{\delta}^*$ holds whenever $\alpha > 1/n$.

Let us second rewrite R_1's critical discount factor, given by (14), to be $\check{\underline{\delta}}_1 = (1-\alpha)X/\Lambda$, where $\Lambda = D(\check{p}^C)(\check{p}^C - c) - s_1 c D(c)$ and $X = D(\check{p}^C)(\check{p}^C - c) - s_1 c D(\check{p}^C)$. Since collusion involves that $\check{p}^C > c$, it follows that $D(\check{p}^C) < D(c)$, which implies that $X > \Lambda$. Evaluating $\check{\underline{\delta}}_1$ at $\alpha = 1/n$ yields that $\check{\underline{\delta}}_1(\alpha = 1/n) \equiv \underline{\delta}^* X/\Lambda > \underline{\delta}^*$. Since $(1-\alpha)$ increases with a decreasing α, and since $X > \Lambda$ is true irrespective of α, it follows that $\check{\underline{\delta}}_1 > \underline{\delta}^*$ holds whenever $\alpha \leq 1/n$. Hence, there exists no market sharing arrangement $\alpha \in [0,1]$ at which $\check{\underline{\delta}}_1(\alpha) < \underline{\delta}^*$ and $\check{\underline{\delta}}_j(\alpha) < \underline{\delta}^*$ hold at the same time. $\square$

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