Vertical Collusion

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Abstract: We characterize the features of collusion involving retailers and their supplier, who engage in secret vertical contracts and all equally care about future profits ("vertical collusion"). We show such collusion is easier to sustain than collusion among retailers. The supplier pays retailers slotting allowances as a prize for adhering to the collusive scheme. In the presence of competing suppliers, vertical collusion can be sustained using short – term exclusive dealing in every period with the same supplier, if the supplier can inform a retailer that the other retailer did not offer the supplier exclusivity.

Keywords: vertical relations, tacit collusion, exclusive dealing, opportunism, slotting allowances.

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1. Introduction

This paper asks what are the features of ongoing collusion involving not only retailers, but also their joint supplier (all of whom are strategic players caring about future profits), and whether such collusion is more sustainable than collusion among retailers that does not involve a forward-looking supplier. Retailers (or other intermediaries) would prefer to collude at the expense of consumers, but competition among them is often too intense to support such collusion. Retailers typically buy from a joint supplier, where all firms interact repeatedly. The supplier is typically a strategic player too, who, like retailers, cares about future profits. This raises the question: can including the supplier in the collusive scheme improve the prospects of collusion, and if so, how? What is the role that such a supplier plays in facilitating collusion? How can antitrust authorities prevent practices that facilitate such collusion?

Intuitively, when competing retailers do not place a high value on future profits, they may benefit from including a more patient supplier in their collusive scheme. It seems counterintuitive, however, that including a supplier that is as impatient as retailers are in the collusive scheme can help sustain it. After all, a short-sighted supplier, which can gain from deviating from the collusive scheme, may at first blush seem to be more of a burden to the collusive scheme than an asset.

Also, how can such a collusive scheme survive when the contract between the supplier and each retailer is not observable to the other retailer? Had each retailer been able to observe the other retailer's contract with the supplier, retailers could have made a credible commitment to each other to charge a high retail price, by paying the supplier an observable high wholesale price. But normally, vertical contracts between suppliers and retailers are not publicly observable, so one retailer does not know whether the supplier granted a secret discount to a competing retailer. Importantly, exchange of information among retailers competing in a downstream market regarding the terms of their contracts with a supplier is likely to be an antitrust violation.[1] Since discounts given by the supplier to a retailer are

[1] See Department of Justice/Federal Trade Commission (2000) (stressing that the exchange of current or future, firm specific, information about costs is most likely to raise competitive concerns); European Commission (2011) ("the exchange of commercially sensitive information such as purchase prices and volumes … may facilitate coordination with regard to sales prices and output and thus lead to a collusive outcome on the selling markets"); Federal Trade Commission (2011) ("If the information exchanged is competitively sensitive—that is, if it is information that a company would not normally share with its competitors in a competitive marketplace, such as … supplier or cost information … or other similar information—companies should establish appropriate firewalls or other safeguards to ensure that the companies remain appropriately competitive throughout their cooperation."); OECD (2010) (discussing an antitrust case brought by the South African Competition Commission condemning information exchanges among competing buyers of raw milk regarding the prices paid to suppliers as a violation of the section forbidding illegal agreements); New Zealand Commerce Commission (2014) (warning that information exchanges such as "… discussing supplier interactions with a competitor create an environment in which anti-competitive agreements or conduct can easily

secret, they encourage the retailer to charge a low retail price. Also, when the supplier is tempted to make such secret price cuts in favor of one retailer at the expense of the other retailer, even the supplier of a strong brand finds it difficult to commit to charging a high wholesale price. Hence, in a competitive equilibrium, the wholesale price is often relatively low.

We consider an infinitely repeated game involving competing retailers and a joint supplier. In every period, retailers offer secrete, one-period two-part tariff contracts to the supplier, and then play a game of incomplete information by setting retail prices without observing the contract offer their rival made to the supplier. All three firms have the same discount factor, so that retailers cannot rely on a more patient supplier to assist them in colluding. Since vertical contracts are secret, retailers cannot use vertical contracts as a commitment device in order to raise the retail price.

We find that the retailers and the supplier can engage in a collusive scheme involving all of them. We refer to such a scheme as “vertical collusion”. Each of the three firms has a short-run incentive to deviate from collusion and increase its own current-period profit at the expense of the other two, yet they collude because they all gain a share of future collusive profits, should they adhere to the collusive scheme in the current period. The three firms manage to do so even when retailers are too short-sighted to maintain standard horizontal collusion between themselves. Hence vertical collusion is easier to sustain than horizontal collusion.

The mechanism that enables the supplier to participate in collusion even though the supplier is as short-sighted as retailers are, and even though contracts are secret, works as follows. In every period, each retailer asks the supplier to pay the retailer a fixed fee. The fixed fee implicitly rewards the retailer for adhering to the collusive price in the previous period. This "prize" motivates retailers to collude when they care about their future profit but are too short-sighted to collude by themselves: Retailers expect that the supplier will continue rewarding them in the future only if they maintain the collusive scheme. The supplier, for his part, has a short-run incentive to deviate from the collusive scheme by not paying the fixed fee to both retailers. To incentivize the supplier to participate in the collusive scheme and continue to pay both retailers fixed fees in the future, each retailer offers to pay the supplier a high wholesale price that ensures the supplier a higher profit than his profit in the competitive equilibrium. Accordingly, vertical contracts are constructed so as to deter all of the participants from deviating from the collusive scheme. When a retailer attempts to deviate from the collusive price by offering the supplier a different vertical contract, the supplier, who

emerge. This creates significant risk for the parties involved, including employees. Such exchanges and discussions should be avoided."

also benefits from maintaining the collusive scheme, rejects the retailer's offer. Having to compensate the supplier to avoid such rejection renders the retailer's deviation unprofitable.

Since vertical collusion involves both the upstream and the downstream firms, we examine how they divide the benefits from collusion. We find that when the three firms are short-sighted (i.e., have a low discount factor), the supplier earns most of the collusive profit. The more the supplier and retailers care about the future, retailers can maintain a higher share of collusive profits. The collusive wholesale price decreases the more the three firms care about the future. The level of fixed fee, however, is non-monotonic in the firms' discount factor: the more firms care about future profits, the fixed fee first increases and then decreases.

We then extend the analysis to the case of multiple suppliers competing over selling a homogenous product. We show that there is a vertical collusion equilibrium in which retailers endogenously offer, in every period, to buy exclusively from the same supplier. Hence the equilibrium is sustained with single-period exclusive dealing commitments. We assume a retailer can renegotiate the contract when the supplier informed him, in the form of cheap talk, that the competing retailer did not offer to buy exclusively from the supplier. We show that the supplier is induced to reveal the truth.

Our results have several policy implications, which we discuss in detail in section 6. In particular, we identify several practices that may have the potential, in appropriate market circumstances, to be harmful to competition. Our results can be used as a factor that can shed new light on the antitrust treatment of these practices under the rule of reason, and that can be balanced against the possible virtues of such practices.

First, the paper sheds a new light on exclusive dealing arrangements, where a retailer promises to buy from a single supplier. We show that exclusive dealing agreements between buyers and one of the suppliers may have the anticompetitive effect of facilitating vertical collusion. Interestingly, we show such exclusive dealing facilitates collusion even when the promise to deal exclusively with the supplier is for only a short term. This result stands in stark contrast to current antitrust rulings. Antitrust courts and agencies hold that exclusive dealing contracts that bind a buyer to a supplier for only a short term are automatically legal, and such soft antitrust treatment is also advocated by the antitrust literature.[2] We show that with repeated interaction between a supplier and his customers, exclusive dealing may become a self-enforcing practice. At each period, each of the retailers binds himself to the same supplier for only this period. It is the collusive equilibrium, however, that induces all retailers to offer to buy only from this supplier in subsequent periods as well.

[2] See, e.g., Areeda and Hovenkamp (2011a).

Second, our results imply that antitrust courts and agencies should, in appropriate cases, be stricter toward a supplier that shares information with a retailer on whether a competing retailer offered him exclusivity. Antitrust law generally allows a supplier to tell one retailer about a competing retailer's offer to him.[3] While at first blush such exchange of information between a supplier and his customer seems legitimate and natural, had it been subject to antitrust intervention in the appropriate circumstances, the vertical collusive scheme would be likely to break down in the presence of competition among suppliers.

Third, our paper shows that slotting allowances (fixed fees often paid by suppliers to retailers in exchange for shelf space, promotional activities, and the like) may be more anticompetitive than currently believed. In our framework, slotting allowances facilitate the vertical collusion scheme even though vertical contracts are secret. Current literature implies that such practices can facilitate downstream collusion only when vertical contracts are observable. This implies that slotting allowances with a supplier selling a strong brand, or with a supplier with whom retailers deal exclusively, deserve stricter antitrust treatment, under the rule of reason, than currently believed.[4]

The fourth policy implication is with regard to the antitrust treatment of a supplier's refusal to deal with a retailer. Our analysis shows that the supplier's ability to unilaterally refuse a deviating retailer's contract offer plays a key role in the sustainability of the vertical collusion scheme. By contrast, US case law takes a soft approach toward a supplier's refusal to deal with retailers that do not adhere to the supplier's policy regarding prevention of price competition among retailers over the supplier's brand.

Our paper is related to several strands of the economic literature. The first strand involves vertical relations in a repeated infinite horizon game. Asker and Bar-Isaac (2014) show that an incumbent supplier can exclude the entry of a forward-looking entrant by offering forward-looking retailers, on an ongoing basis, part of the incumbent's monopoly profits, via vertical practices such as resale price maintenance, slotting fees, and exclusive territories. Because retailers in their model care about future profits, they may prefer to keep a new supplier out of the market, so as to continue receiving a portion of the incumbent supplier's profits. While their paper focuses on the importance of retailers being forward looking so that they can help a monopolistic supplier entrench his monopoly position and

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[3] See, e.g., *Ahlström Osakeyhtiö and others v Commission (Wood Pulp II)* Joined Cases C-89, 104, 114, 116, 117, 125-129/85, Court of Justice, [1993] ECR I-1307, [1993] 4 CMLR 407 (where the EU Court of Justice held that suppliers sharing information with their customers regarding the future prices they intend to charge all customers is not an antitrust violation.) The information exchange we refer to in the text would *a fortiori* be exempt under such a rule. A lenient approach toward such practices is also advocated by the antitrust literature. See, e.g., McCabe (2012); Areeda and Hovenkamp (2011b).

[4] At the same time, Chu (1992), Lariviere and Padmanabhan (1997), Desai (2000) and Yehezkel (2014) show that slotting allowances may also have the welfare enhancing effect of enabling suppliers to convey information to retailers concerning demand. See also Federal Trade Commission (2001, 2003), and European Commission (2012) discussing some of the pro's and con's of slotting allowances.

monopoly profits, our paper focuses on the importance of the supplier being forward looking so as to enable a tacitly collusive retail price. Another part of this literature examines collusion among retailers, where suppliers are myopic. In particular, Normann (2009) and Nocke and White (2010) find that vertical integration can facilitate downstream collusion between a vertically integrated retailer and independent retailers. Piccolo and Miklós-Thal (2012) show that retailers with bargaining power can collude by offering myopic and perfectly competitive suppliers a high wholesale price and negative fixed fees. Doyle and Han (2012) consider retailers that can sustain downstream collusion by forming a buyer group that jointly offers contracts to myopic suppliers. The rest of this literature studies collusion among suppliers, where retailers are myopic: Jullien and Rey (2007) consider an infinite horizon model with competing suppliers where each supplier sells to a different retailer and offers it a secret contract. Their paper studies how suppliers can use resale price maintenance to facilitate collusion among the suppliers, in the presence of stochastic demand shocks. Nocke and White (2007) consider collusion among upstream firms and the effect vertical integration has on such collusion. Reisinger and Thomes (2015) analyze a repeated game between two competing and long-lived manufacturers that have secret contracts with myopic retailers. They find that colluding through independent, competing retailers is easier to sustain and more profitable to the manufacturers than colluding through a joint retailer. Schinkel, Tuinstra and Rüggeberg (2007) consider collusion among suppliers in which suppliers can forward some of the collusive profits to downstream firms in order to avoid private damages claims. Piccolo and Reisinger (2011) find that exclusive territories agreements between suppliers and retailers can facilitate collusion among suppliers. The main difference between our paper and this literature is that we examine collusion involving the whole vertical chain: supplier and retailers alike, who are all forward looking, and all have a short run incentive to deviate from collusion which is balanced against a long run incentive to maintain the collusive equilibrium.

The second strand of the literature concerns static games in which vertical contracts serve as a devise for reducing price competition between retailers. Bonanno and Vickers (1988) consider vertical contracts when suppliers have the bargaining power. They find that suppliers use two-part tariffs that include a wholesale price above marginal cost in order to relax downstream competition, and a positive fixed fee, to collect the retailers' profits. Shaffer (1991) and (2005), Innes and Hamilton (2006), Rey, Miklós-Thal and Vergé (2011) and Rey and Whinston (2012) consider the case where retailers have buyer power. In such a case, retailers pay wholesale prices above marginal cost in order to relax downstream competition and suppliers pay fixed fees to retailers.

The difference between our paper and this strand of the literature is that we study a repeated game rather than a static game. This enables us to introduce the concept of vertical collusion, where the supplier, as well as retailers, care about future profits. Also, in this literature, vertical contracts are observable to retailers. We consider the prevalent case where vertical contracts are unobservable.

The third strand of literature involves static vertical relations in which a supplier behaves opportunistically by granting price concessions to one retailer at the expense of the other. Hart and Tirole (1990), O'Brien and Shaffer (1992), McAfee and Schwartz (1994) and Rey and Verg´e (2004) consider suppliers that make secret contract offers to retailers. They find that a supplier may behave opportunistically (depending on the retailers' beliefs regarding the supplier's offer to the competing retailers) and offer secret discounts to retailers. Anticipating this, retailers do not agree to pay high wholesale prices and the supplier cannot implement the monopoly outcome. The vertical collusive scheme we identify resolves an opportunism problem similar to the one exposed in the above literature and restores the supplier's power to charge high wholesale prices. If a supplier and one of the retailers in our model behave opportunistically in a certain period, vertical collusion breaks down in the next periods. Since the two retailers and the supplier all care about future profits, this serves as a punishment against opportunistic behavior.

2. The model

Consider two downstream retailers, R_1 and R_2 that compete in prices. We focus on the extreme case where retailers are homogeneous. Doing so enables us to deliver our main results in a clear and tractable manner.[5]

Retailers can obtain a homogeneous product from an upstream supplier. Production and retail costs are zero. Consumers' demand for the product is $Q(p)$, where p is the final price and $pQ(p)$ is concave in p. Let p^* and Q^* denote the monopoly price and quantity, where p^* maximizes $pQ(p)$ and $Q^*=Q(p^*)$. The monopoly profit is p^*Q^*.

The two retailers and the supplier interact for an infinite number of periods and have a discount factor, δ, where $0 \leq \delta \leq 1$. The timing of each period is as follows:

- *Stage 1*: Retailers offer a take-it-or-leave-it contract to the supplier (simultaneously and non-cooperatively). Each R_i offers a contract (w_i, T_i), where w_i is the wholesale price and T_i is a fixed payment from R_i to the supplier that can be positive or negative. In the latter case the supplier pays slotting allowances to R_i. The supplier observes the offers and decides whether to accept one, both or none. All of the features of the bilateral contracting between R_i and the supplier are unobservable to R_j ($j \neq i$) throughout the game. Moreover, R_i cannot know whether R_j signed a contract with the supplier until the

[5] In an online Appendix, we examine an example extending our model to the case where retailers are horizontally differentiated, and show that the main results carry over to the case of differentiated retailers. See: http://www.tau.ac.il/~yehezkel/gilo%20yehezkel%20vertical%20collusion%20Appendix%20on%20diff-28.2.17.pdf

end of the period, when retail prices are observable. The contract offer is valid for the current period only.[6]

- *Stage 2*: The two retailers set their retail prices for the current period, p_1 and p_2, simultaneously and non-cooperatively. Consumers buy from the cheapest retailer. In case $p_1 = p_2$, each retailer gains half of the demand. At the end of the stage, retail prices become common knowledge (but again retailers cannot observe the contract offers). If in stage 1 the supplier and R_j didn't sign a contract, R_i only learns about it at the end of the period, when R_i observes that R_j didn't set a retail price for the supplier's product (or equivalently charged $p_j = \infty$). Still, R_i cannot know why R_j and the supplier didn't sign a contract (that is, R_i doesn't know whether the supplier, R_j, or both, deviated from the equilibrium strategy).

We consider pure-strategy, perfect Bayesian-Nash equilibria. We focus on symmetric equilibria, in which along the equilibrium path both retailers choose the same strategy, equally share the market and earn identical profits. We allow an individual retailer to deviate unilaterally outside the equilibrium path and a mixed-strategy equilibrium following a deviation.

When there is no upstream supplier and the product is available to retailers at marginal cost, retailers only play the second stage in every period, in which they decide on retail prices, and therefore the game becomes a standard infinitely-repeated Bertrand game with two identical firms. Then, a standard result is that horizontal collusion over the monopoly price is possible if:

$$\frac{p^*Q^*\frac{1}{2}}{1-\delta} > p^*Q^* \quad \Leftrightarrow \quad \delta > \tfrac{1}{2},$$

where the left hand side is the retailer's sum of infinite discounted profit from colluding on the monopoly price and gaining half of the demand and the right hand side is the retailer's profit from slightly undercutting the monopoly price and gaining all the demand in the current period, followed by a perfectly competitive Bertrand game with zero profits in all future periods. Given this benchmark value of δ = ½, we ask whether the prospects of vertical collusion, involving retailers and the supplier as well, are higher than horizontal collusion between the retailers. This analysis will take account of the fact that one retailer's two-part-

[6] See Piercy (2009), claiming that large supermarket chains in the UK often change contractual terms, including the wholesale price and slotting allowances, on a regular basis, e.g., via e-mail correspondence; Lindgreen, Hingley and Vanhamme (2009), discussing evidence from suppliers according to which large supermarket chains deal with them without written contracts and with changing price terms; See also "How Suppliers Get the Sharp End of Supermarkets' Hard Sell, The Guardian, http://www.theguardian.com/business/2007/aug/25/supermarkets.

tariffs are unobservable to the competing retailer throughout the game and both retailers and the supplier equally care about future profits.

3. Competitive static equilibrium benchmark

Before analyzing the features of the repeated game, let us first derive a competitive equilibrium benchmark in which the three firms have $\delta = 0$. This can also be an equilibrium when $\delta > 0$ and the three firms expect that their strategies in the current period will not affect the future. In the next section we will assume that an observable deviation from vertical collusion will result in playing the competitive equilibrium in all future periods. The main result of this section is that in the static game price competition dissipates all of the retailers' profits. Moreover, since contracts are secret and the supplier has an incentive to act opportunistically, there are equilibria in which the supplier earns below the monopoly profits.

Consider a symmetric equilibrium with the following features. In stage 1, both retailers offer the contract (T^C, w^C) that the supplier accepts. Then, in stage 2, both retailers set p^C and equally split the market. Each retailer earns $(p^C - w^C)Q(p^C)/2 - T^C$ and the supplier earns $w^C Q(p^C) + 2T^C$. Since vertical contracts are secret, there are multiple equilibria, depending on firms' beliefs regarding off-equilibrium strategies. In what follows, we characterize the qualitative features of these equilibria.

First, notice that in any such equilibrium $p^C = w^C$, because in the second stage retailers play the Bertrand equilibrium given w^C. Therefore, there is no competitive equilibrium with $T^C > 0$, because retailers will not agree to pay a positive fixed fee in stage 1, given that they don't expect to earn positive profits in stage 2. There is also no competitive equilibrium with $T^C < 0$. To see why, notice that the supplier can profitably deviate from such an equilibrium by accepting only one of the contracts, say, the contract of R_i. R_i expects that in equilibrium both of the retailers' offers are accepted by the supplier. R_i cannot observe the supplier's deviation of not accepting R_j's contract. Accordingly, in stage 2 R_i sets the equilibrium price p^C. The supplier's profit is $w^C Q(w^C) + T^C$ -- higher than the profit from accepting both offers, $w^C Q(w^C) + 2T^C$ whenever $T^C < 0$. Therefore, in all competitive equilibria, $T^C = 0$.

Next, consider the equilibrium wholesale price in the competitive equilibrium, w^C. The multiplicity of equilibria emerges because the equilibrium value of w^C depends on the beliefs regarding out-of-equilibrium strategies and hence there can be multiple equilibrium values of w^C. In particular, suppose that R_i deviated by offering the supplier a contract with $w_i \neq w^C$ and the supplier accepted the deviation. R_i's profitability from offering this deviation depends on R_i's beliefs on whether the supplier accepted R_j's contract as well, which R_i can only observe at the end of the period. At the same time, given that the supplier accepted R_i's deviating contract, the supplier's decision on whether to accept R_j's contract depends on the supplier's beliefs regarding the price that R_i will charge end consumers (which in turn depends on R_i's beliefs concerning the supplier's decision to accept the R_j's contract). Suppose that the three firms share the following belief: When R_i's offer to the supplier deviates from the equilibrium contract, making it worthwhile for the supplier to reject R_j's offer, the supplier indeed rejects R_j's offer. These beliefs are close in nature to the "*wary beliefs*" discussed in McAfee and Schwartz (1994) and in what follows we adopt the same terminology.[7] They imply that firms have rational expectations concerning the behavior of other firms when they observe out-of-equilibrium contract offers.

The following lemma characterizes the set of competitive static equilibria under *wary beliefs*. It shows that in the competitive benchmark case, retailers make zero profits, while the supplier makes a positive profit:

Lemma 1: *Suppose that* $\delta = 0$. *Then, under wary beliefs, there are multiple equilibria with the contracts* $(T^C, w^C) = (0, w^C)$, $w^C \in [w_L, p^*]$, *where* w_L *is the lowest solution to*

$$\max_{w_i}\{w_i Q(p(w_i))\} < w^C Q(w^C) \quad where \quad p(w_i) \in \arg\max_p\{(p - w_i)Q(p)\}, \tag{1}$$

and $0 < w_L \leq p^*$. *In equilibrium, retailers set* p^C *and earn 0 and the supplier earns* $\pi^C \equiv w^C Q(w^C)$, $\pi^C \in [w_L Q(w_L), p^*Q^*]$.

Proof: see the Appendix.

The intuition for Lemma 1 is as follows. In order to benefit from offering a deviating contract, R_i needs to make the supplier an offer that convinces him to reject R_j's equilibrium contract offer. Given that R_i offered such a deviating contract that the supplier accepted, wary beliefs imply that R_i will charge the monopoly price given w_i, $p(w_i)$. However, if $w^C Q(w^C) > w_i Q(p(w_i))$, the supplier will then behave opportunistically and accept R_j's contract, who in turn will charge $p_j = w^C$ and monopolize the market. Condition (1) ensures that R_i cannot deviate to any w_i that prevents the supplier from behaving opportunistically and accepting R_j's contract.

Notice that there is a competitive static equilibrium in which the supplier earns the monopoly profit, p^*Q^*. Intuitively, this equilibrium holds because the supplier can implement the monopoly outcome by dealing with only one of the retailers. Given that R_j offers $w_j = p^*$ and expects that R_i does the same, R_i cannot profitably deviate to any contract other than $w_i = p^*$, because the supplier can earn p^*Q^* by accepting only R_j's contract. In what follows, we

[7] In McAfee and Schwartz (1994), under "wary beliefs" a retailer believes that if the supplier offered him a contract that deviates from the equilibrium contract, the supplier offers the competing retailer a contract that maximizes the joint profit of the supplier and competing retailer.

rule out the equilibrium with $\pi^C = p^*Q^*$ for two reasons. First, this equilibrium is an artifact of our simplifying assumption that retailers are homogeneous. The equilibrium does not hold when retailers are even slightly differentiated, because in such a case the supplier needs to deal with both retailers in order to implement the monopoly outcome. The second reason is that as shown in the next section, retailers' profits in the collusive equilibrium are decreasing with π^C. Consequently, retailers have an incentive to coordinate on a punishment strategy in which following a deviation from collusion they play the competitive equilibrium that provides the supplier with the lowest possible profit.

As we will show in the next section, other than our assumption that $\pi^C < p^*Q^*$, the qualitative features of the collusive equilibrium do not depend on the value of π^C.[8]

4. Vertical collusive equilibrium with infinitely repeated interaction

4.1. The condition for sustainability of the collusive equilibrium

The result that retailers cannot earn positive profits in any competitive equilibrium suggests that in an infinitely repeated game, retailers have an incentive to engage in tacit collusion. They cannot sustain horizontal collusion, however, for $\delta < ½$. The supplier, for its part, has an incentive to participate in a collusive equilibrium when it expects that otherwise retailers will play a competitive equilibrium involving $\pi^C < p^*Q^*$. In this section, we solve for the collusive equilibrium in an infinitely repeated game when $1 \geq \delta > 0$. In this equilibrium, in the first stage of every period, both retailers offer the same equilibrium contract, (w^*,T^*) that the supplier accepts. Then, in stage 2, both retailers set the monopoly price, p^*, and equally split the monopoly quantity, Q^*. Given an equilibrium contract, (w^*,T^*), in every period each retailer earns $\pi_R(w^*,T^*) = (p^* - w^*)Q^*/2 - T^*$ and the supplier earns $\pi_S(w^*,T^*) = w^*Q^* + 2T^*$.

In order to support the collusive scheme, the contract (w^*,T^*) must prevent deviations from this scheme. At the end of every period, R_i can observe whether R_j deviated from the monopoly retail price p^*, thereby dominating the downstream market. R_i cannot observe, however, whether this deviation is a result of R_j offering the supplier a different contract than (w^*,T^*), which motivates R_i to deviate from the monopoly price, or whether R_j offered the supplier the equilibrium contract (w^*,T^*), but nevertheless undercut the monopoly price. It is only the supplier and R_j that will know which type of deviation occurred. R_i can also observe whether R_j did not carry the product in a certain period. R_i cannot tell, however, whether this is a result of a deviation by R_j (i.e., R_j offered a different contract than (w^*,T^*) that the supplier rejected) or by the supplier (i.e., R_j offered the equilibrium contract (w^*,T^*), but the

[8] It is possible to show that if retailers have "passive beliefs" according to the definition in McAfee and Schwartz (1994), then any $w^C \in [0, p^*]$ and therefore any $\pi^C \in [0, p^*Q^*]$ can be an equilibrium.

supplier rejected). Finally, another type of deviation is when R_i offers a contract different than (w^*,T^*) that the supplier accepted, but then R_i continued to set p^*. R_j will never learn of this deviation, since contracts are secret.

Because of the repeated nature of the game and the asymmetry in information, there are multiple collusive equilibria. We therefore make the following restrictions. First, suppose that whenever a publicly observable deviation occurs (i.e., a retailer sets a price different than p^* or does not carry the product), retailers play the competitive equilibrium defined in section 3 in all future periods.[9] Second, since we concentrate here on retailers with strong bargaining power, we focus on outcomes that provide retailers with the highest share of the monopoly profit that ensures the supplier at least its competitive equilibrium profit, π^C.[10]

To solve for the collusive equilibrium, we first establish necessary conditions on (w^*,T^*). Then, we construct reasonable out-of-equilibrium beliefs that support (w^*,T^*) as an equilibrium. Finally, we analyze the features of the collusive contract.

We start with necessary conditions on the collusive contract. The first necessary condition is that once retailers offered a contract (w^*, T^*) that the supplier accepted, R_i indeed charges the monopoly price p^* in stage 2 rather than deviating to a slightly lower price. By deviating, R_i gains all the demand in the current period, but stops future collusion. R_i will not deviate from collusion in the second stage if:

$$(p^*-w^*)\tfrac{1}{2}Q^*+\frac{\delta}{1-\delta}\Big((p^*-w^*)\tfrac{1}{2}Q^*-T^*\Big)\geq(p^*-w^*)Q^*\ , \qquad (2)$$

where the left hand side is R_i's profit from maintaining collusion and the right hand side is R_i's profit from deviating. Notice that condition (2) is affected only by the retailers' discount factor and not by the supplier's, because this constraint involves a deviation by a retailer assuming the supplier had not deviated: he played the equilibrium strategy and accepted the two equilibrium contract offers in stage 1.

It is straightforward to show that condition (2) requires that T^* should be sufficiently small. In particular, due to condition (2) and the condition that retailers earn positive profit, $\pi_R(w^*,T^*) > 0$, we derive the following result:

Lemma 2: *If* $\delta < ½$, *then any collusive equilibrium has to involve negative fees,* $T^* < 0$.

Proof: see the Appendix.

[9] We consider an alternative trigger strategy in section 4.3.

[10] Retailers may also be able to coordinate on the competitive equilibrium outcome and choose the lowest π^C possible, $w_LQ(w_L)$. Our qualitative results do not rely on the size of π^C, however, as long as collusion is weakly beneficial to all three firms (i.e., $\pi^C < p^*Q^*$). Accordingly, we solve for the collusive equilibrium for any arbitrary π^C.

Notice that the result that $T^* < 0$ (i.e., that to facilitate collusion the supplier must pay the retailers slotting allowances) holds even when $w^* = 0$.[11] Recall that in our framework, R_i's contract with the supplier is not observable to R_j. Hence, the wholesale price R_i pays does not serve as a signal to R_j that R_i will not find it profitable to undercut the collusive price. Instead, lemma 2 shows that it is the fixed fees that motivate retailers to set the monopoly price, even though these fixed fees are sunk in the stage when retailers set prices. These slotting allowances affect retail prices through the retailers' expectations. In equilibrium, each retailer expects that by setting p^* in the current period, the supplier will "reward" the retailer in the next periods by paying them slotting allowances. When $\delta < ½$, retailers are too shortsighted and will collude only if they expect such a reward in the future. Finally, it is straightforward to show that if $\delta > ½$, then condition (2) holds when $T^* = 0$ for any $w^* \geq 0$.

The supplier too needs to be incentivized to participate in the collusive scheme, however, for it not to break down. The parties need to assure that the supplier, who is as short-sighted as retailers are, would not behave opportunistically and reject one of the retailers' contract offers. By doing so, the supplier can avoid paying fixed fees twice while still gaining access to end consumers. Accordingly, the second necessary condition on the collusive contract is the supplier's participation constraint:

$$\frac{w^*Q^*+2T^*}{1-\delta} = w^*Q^*+T^*+\frac{\delta}{1-\delta}\pi^C. \tag{3}$$

The left hand side is the supplier's sum of discounted profits from maintaining collusion. The right hand side is the supplier's profit from accepting only one of the contracts. If the supplier rejects R_i's offer, R_j can detect this deviation only at the end of stage 2, when R_j observes that R_i didn't offer the product. Therefore, in stage 2 R_j will still charge the monopoly price p^* and sell Q^*, implying that in the current period the supplier earns $w^*Q^* + T^*$ and collusion breaks down in all future periods, in which the supplier earns π^C. If the left hand side of (3) is higher than the right hand side, then R_i has the incentive to deviate to a contract with a lower T_i, that the supplier would accept, since even with this lower T_i, the supplier prefers collusion to deviation. If the right hand side of (3) is higher than the left hand side, then when both retailers offer the equilibrium contract, the supplier will deviate from the equilibrium strategy and accept only one of the contracts. Therefore, condition (3) must hold in equality. Notice that condition (3) places a minimum boundary on w^*. Intuitively, while slotting allowances are used to induce retailers to charge the collusive retail price, a higher wholesale price is

[11] However, condition (2) becomes less binding as w^* increases. Intuitively, a high w^* makes it less profitable for the retailer to undercut the monopoly price and gain an additional quantity $Q^*/2$, which costs the retailer $w^*Q^*/2$.

used to induce the supplier to participate in the collusive scheme, despite having to pay slotting allowances to retailers.

Condition (3) is affected by the supplier's discount factor only, and not by the retailers' discount factor, because it deals with the supplier's deviation given that retailers have offered the equilibrium contracts. When the retailers' discount factor is below ½ such that collusion requires $T^* < 0$, the supplier has a short-run incentive to deviate from collusion. This is because the supplier's one-period profit from accepting both contracts is $\pi_S(w^*,T^*) = w^*Q^*+2T^*$. In the short run, if the supplier accepts only one of the contract offers, the supplier earns $w^*Q^*+T^*$ which is higher than $w^*Q^*+2T^*$ whenever $T^* < 0$. Therefore, condition (3) implies that when retailers are too short-sighted to maintain collusion by themselves (i.e., $\delta < ½$) and need to use $T^* < 0$ in order to maintain collusion, they cannot rely on a myopic supplier to help them in colluding. The following lemma follows directly from lemma 2 and from condition (3):

Lemma 3: *Suppose that retailers' discount factor is $\delta < ½$ and the supplier is myopic. Then, there is no collusive equilibrium.*

Proof: see the Appendix.

Lemma 3 highlights the importance of the requirement that *all* three firms, including the supplier, care about future profits. Only a supplier with a positive discount factor that joins the collusive scheme can enable collusion. Condition (3) means that retailers should leave the supplier with a sufficiently high share of the collusive profit in order to motivate the supplier to assist the collusive scheme.

Conditions (2) and (3) ensure that if both retailers offer the collusive contract, the supplier accepts both offers and then in the second stage each retailer sets p^*. The remaining requirement is that in stage 1, R_i does not find it profitable to deviate to any other contract, $(w_i, T_i) \neq (w^*, T^*)$. As in the competitive, static case, the benefit to R_i and the supplier from such a deviation depends on their out-of-equilibrium beliefs concerning each other's future strategies given the deviation. In particular, when deciding whether to accept the deviating contract, the supplier needs to form beliefs on whether this contract will motivate R_i to continue colluding. Likewise, if the supplier accepts the deviating contract, R_i needs to form beliefs on whether the supplier accepts R_j's equilibrium offer as well.

Consider first the case where $\delta > ½$. Determining out of equilibrium beliefs is immaterial in this case, since here retailers do not need the supplier in order to collude. In particular, retailers can implement horizontal collusion with $(w^*, T^*) = (\pi^C/Q^*, 0)$. This contract satisfies conditions (2) and (3). Moreover, as the next lemma shows, R_i will not find it profitable to deviate to any other contract, regardless of beliefs.

Lemma 4: *Suppose that retailers' discount factor is* $\delta > ½$*. Then, under any out of equilibrium beliefs,* R_i *cannot profitably deviate to any contract offer* $(w_i, T_i) \neq (\pi^C/Q^*, 0)$.

Proof: see the Appendix.

Lemma 4 ensures that for $\delta > ½$, there is a collusive equilibrium qualitatively similar to horizontal collusion. In this equilibrium, each retailer earns $\pi_R(\pi^C/Q^*, 0) = (p^*Q^* - \pi^C)/2 > 0$ which is half of the highest collusive profit possible gross of the supplier's alternative profit, while the supplier earns $\pi_S(\pi^C/Q^*, 0) = \pi^C$. In this case, collusion does not depend on the supplier's discount factor and will hold even when the supplier is myopic.

Next, we turn to the case where $\delta < ½$. Now, beliefs concerning out-of-equilibrium behavior become relevant. As in the competitive equilibrium, we adopt the concept of wary beliefs: whenever R_i offers a deviating contract, R_i and the supplier correctly anticipate each-others' unobservable and rational response to this deviation. More precisely, consider a deviation by R_i to a contract $(w_i, T_i) \neq (w^*, T^*)$. Any such (w_i, T_i) can either cause collusion to stop or cause it to continue in future periods. We assume that both R_i and the supplier understand whether the deviation will cause collusion to stop or not, and we analyze each possibility in turn.

Suppose first that R_i offered a contract $(w_i, T_i) \neq (w^*, T^*)$ such that both the supplier and R_i understand that this deviation stops collusion. It is reasonable to expect that any $w_i < w^*$ will trigger such beliefs, but the analysis below holds even when $w_i > w^*$, as long as w_i is not too high. In the period of any such deviation, R_i can earn at most $p^*Q^* - (w^*Q^* + T^*)$. This is because R_i needs to compensate the supplier for his alternative profit from rejecting the deviation, accepting R_j's equilibrium contract and earning $w^*Q^* + T^*$. Consequently, R_i cannot earn more than the monopoly profit, p^*Q^*, minus the supplier's alternative profit $w^*Q^* + T^*$.

Such a deviation may trigger the supplier's beliefs that if he accepts the deviation, there is a high probability that R_i will undercut R_j's collusive price and capture the entire demand. In such a case, the supplier loses from accepting R_j's equilibrium offer. At the same time, R_i believes that in the above scenario the supplier is likely to reject R_j's offer. Hence wary beliefs following the deviation cannot yield pure-strategies: Given that the supplier expects that R_i plans to undercut the monopoly price, the supplier will reject R_j's offer, but given that R_i expects the supplier to reject R_j's offer, R_i will not undercut the monopoly price.

However, Appendix B shows that there is a mixed-strategy equilibrium in which the supplier accepts R_j's offer with a very small probability and R_i mixes between charging $p^* - \varepsilon$ and charging R_i's monopoly price given w_i, $p(w_i)$. The supplier's expected profit equals his alternative profit from rejecting R_i's offer and accepting R_j's equilibrium contract, $w^*Q^* + T^*$. Appendix B also shows that if $w_i \leq w^*$, R_i's expected profit is concave in w_i and is maximized at $w_i = 0$.[12] R_i's maximum profit from deviation is arbitrarily close to the monopoly profit minus the supplier's alternative profit, $p^*Q^* - \varepsilon - (w^*Q^* + T^*)$. Then, in all future periods, collusion stops, so R_i earns 0 and the supplier earns π^C. The following lemma shows that whenever $p^* \geq w^*$, such a deviation is not profitable for R_i.[13]

Lemma 5: *Suppose that* $\delta < ½$ *and* $p^* \geq w^*$. *Then, under wary beliefs,* R_i *cannot profitably deviate to any contract offer* $(w_i, T_i) \neq (w^*, T^*)$ *that stops collusion.*

Proof: see the Appendix.

Next, suppose that the supplier and R_i share the beliefs that following R_i's deviation collusion is not going to stop in future periods. Then R_i and the supplier anticipate that if the supplier accepts the deviating contract, the supplier also accepts R_j's offer and collusion continues. Whenever R_i makes this deviation and the supplier accepts it and the equilibrium offer of R_j, R_i sets p^* in the current period and therefore R_j does not detect the deviation. Then, in all future periods, R_i offers the same deviating contract (w_i, T_i).[14] The supplier will accept the deviation if maintaining collusion with R_i's deviating contract provides the supplier with a higher sum of discounted profits than rejecting R_i's offer and stopping collusion. R_i will deviate from (w^*,T^*) if there is a certain (w_i, T_i) that does not cause collusion to stop that provides R_i with a higher sum of collusive discounted profits than (w^*,T^*) does. The following lemma shows that such a deviation is not profitable for R_i:

Lemma 6: *Suppose that* $\delta < ½$. *Then, under wary beliefs,* R_i *cannot profitably deviate to any contract offer* $(w_i, T_i) \neq (w^*, T^*)$, *where* (w_i, T_i) *is a deviation that maintains collusion.*

Proof: see the Appendix

[12] R_i's expected profit is concave with w_i even for $w_i > w^*$, as long as w_i is not too high.
[13] In what follows, we ignore the condition $p^* \geq w^*$. In the proof of proposition 1, we show that there is no loss of generality in focusing on $p^* \geq w^*$.
[14] In the proof of lemma 4 below we show that the results are robust in the alternative case where the supplier and R_i expect that the deviation is for only one period and that in all future periods R_i will go back to offering (w^*, T^*).

The intuition follows from condition (3). Since the supplier is just indifferent between maintaining and stopping collusion, R_i cannot offer the supplier a deviating contract that maintains collusion and that the supplier will accept. Since R_i will not deviate from the collusive retail price, any profits from such a deviation would be at the supplier's expense, and would violate condition (3). Notice that in both cases covered by Lemma's 5 and 6 beliefs are "wary" in that both R_i and the supplier correctly anticipate each other's rational response to the deviation. We do not need to make any assumptions as to whether a particular contract deviation causes collusion to break down or not. We only need to acknowledge that any deviation has to either cause collusion to stop or does not cause it to stop. As shown in lemmas 5 and 6, when R_i and the supplier share common beliefs concerning the outcome of potential deviations, conditions (2) and (3) are sufficient for ensuring that no contract deviation is profitable.

We can conclude that for $\delta < ½$, the vertical collusive contract solves:

$$\max_{(w^*,T^*)} \{(p^* - w^*)Q^*/2 - T^*\}$$

s.t. conditions (2), (3) and $\pi_S(w^*, T^*) \geq \pi^C$.

A collusive equilibrium exists for $\delta < ½$ if the solution to the above maximization problem yields $\pi_R(w^*,T^*) > 0$. Proposition 1 characterizes the unique vertical collusive contract:

Proposition 1: *Suppose that* $\delta > 0$. *Then, under wary beliefs, there is a unique vertical collusive equilibrium that maximizes the retailers' profits. In this equilibrium:*

$$w^* = \begin{cases} p^* - \dfrac{2\delta^2(p^*Q^* - \pi^C)}{(1-\delta)Q^*}; & \delta \in (0, \tfrac{1}{2}]; \\ \dfrac{\pi^C}{Q^*}; & \delta \in [\tfrac{1}{2}, 1]; \end{cases} \tag{5}$$

$$and: \qquad T^* = \begin{cases} -\dfrac{\delta}{1-\delta}(1-2\delta)(p^*Q^* - \pi^C); & \delta \in (0, \tfrac{1}{2}]; \\ 0; & \delta \in [\tfrac{1}{2}, 1]. \end{cases} \tag{6}$$

Proof: see the Appendix.

Proposition 1 shows that a vertical collusion equilibrium exists when retailers are too shortsighted to maintain horizontal collusion.[15] Substituting (5) into (4) yields that in equilibrium the retailers and the supplier earn $\pi_R^* \equiv \pi_R(w^*,T^*)$ and $\pi_S^* \equiv \pi_S(w^*,T^*)$ where:

[15] In an online Appendix, we show that the qualitative results of proposition 1 carry over to the case of strong differentiation among retailers. While vertical collusion is not sustainable for all values of δ, vertical collusion can be sustained for values of δ in which horizontal collusion cannot be sustained.

$$\pi_R{}^* = \begin{cases} \delta(p^*Q^* - \pi^C); & \delta \in (0, \tfrac{1}{2}]; \\ \tfrac{1}{2}(p^*Q^* - \pi^C); & \delta \in [\tfrac{1}{2}, 1]; \end{cases} \qquad \pi_S{}^* = \begin{cases} (1-2\delta)\,p^*Q^* + 2\delta\pi^C; & \delta \in (0, \tfrac{1}{2}]; \\ \pi^C; & \delta \in [\tfrac{1}{2}, 1]. \end{cases} \tag{7}$$

4.2. The features of the vertical collusion equilibrium

Let *SA** = –*T** denote the equilibrium slotting allowance. The following corollary describes the features of the vertical collusion equilibrium, while figure 1 illustrates the vertical collusion equilibrium as a function of δ.

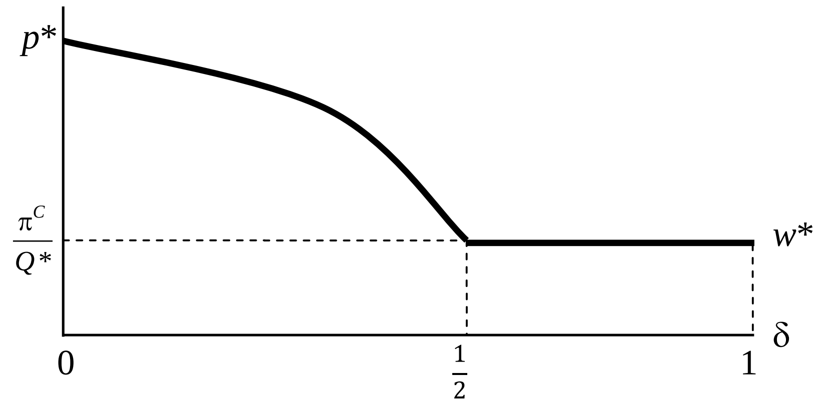
Corollary 1: *In the vertical collusion equilibrium:*

(i) *For* δ ∈ (0, ½]:

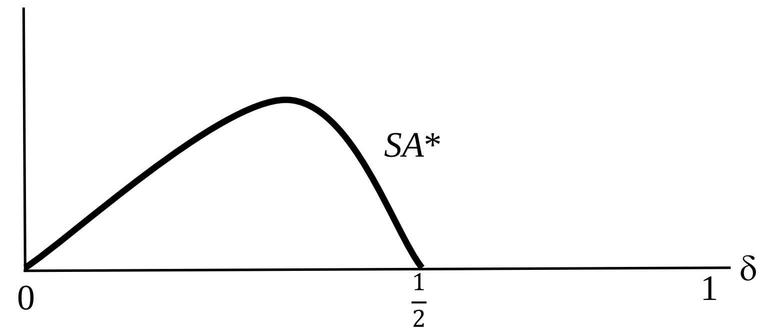
- *retailers' one-period profits are increasing with* δ *while the supplier's one-period profit is decreasing with* δ;
- *the equilibrium wholesale price is decreasing with* δ*;*
- *The supplier pays retailers slotting allowances: SA* > 0. The slotting allowances are an inverse U-shape function of* δ.

(ii) *For* δ ∈ [½, 1]:

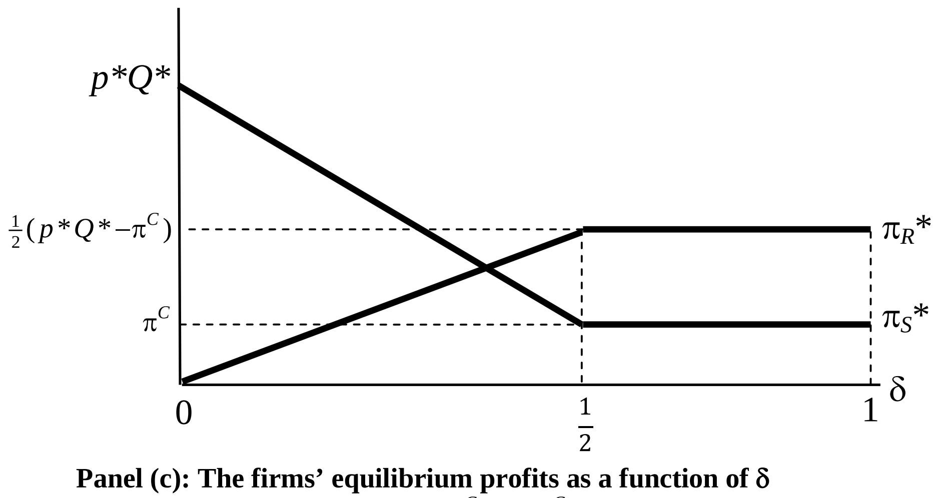
- *the equilibrium wholesale price and the firms' profits are independent of* δ *and retailers do not charge slotting allowances*: *T** = 0;
- *the supplier earns its reservation profit* (*from the competitive equilibrium*) *and retailers earn the remaining monopoly profits*.



Panel (a): The equilibrium *w as a function of δ**



Panel (b): The equilibrium *SA as a function of δ**



Panel (c): The firms' equilibrium profits as a function of δ
(when $(p^*Q^* - \pi^C)/2 > \pi^C$)

Figure 1: The features of the vertical collusion equilibrium as a function of δ

Figure 1 and part (i) of Corollary 1 reveal that at $\delta \to 0$, $w^* \to p^*$, $SA^* \to 0$ and the supplier earns most of the monopoly profits. As δ increases, w^* decreases and retailers gain a higher proportion of the monopoly profits. Moreover, the equilibrium slotting allowances are an inverse U-shaped function of δ. The basic intuition for these results is that retailers participate in the collusive scheme even when they are short-sighted, because they expect that as long as they charge the monopoly price, the supplier will continue rewarding them in the future by paying them the fixed fees. The supplier, for his part, participates in the collusive scheme even though he is short-sighted because he expects that as long as he pays the fixed fee to both retailers, retailers will reward him in the future by offering him a high wholesale price, which will provide the supplier with higher future profits than in the competitive equilibrium.

To see the intuition in more detail, consider first the case where $\delta = 0$. Since retailers do not care about the future, their expectation to receive the fixed payments from the supplier in the following periods no longer motivates them to collude. Then, the only possible w^* that would motivate a retailer to set the monopoly price in stage 2 would be $w^* = p^*$. For any other $w^* < p^*$, an individual retailer will deviate in stage 2 to a price slightly below p^* and monopolize the market, ignoring the negative effect of doing so on future profits. Since the supplier also does not care about the future, and since $w^* = p^*$, retailers cannot charge slotting allowances. To see why, notice that if R_i asks for a slotting allowance, the supplier can reject R_i's offer and earn $\pi_S(w^*) = w^*Q^* = p^*Q^*$ from accepting R_j's offer. The supplier will ignore the negative effect this has in eliminating collusion in the future, since he is myopic. As a result, with $w^* = p^*$ and without slotting allowances, a collusive equilibrium requires the supplier to gain all of the monopoly profits. However, in such a case retailers have no incentives to participate in the collusive equilibrium to begin with.

Suppose now that δ increases slightly above 0. Now retailers can ask the supplier for payment of fixed fees in the future as a reward for colluding in the previous period. If the supplier rejects R_i's offer and accepts only R_j's offer, the supplier earns a one-period profit close to the monopoly profit in the current period, but collusion breaks in future periods. Since now the supplier cares about the future, the supplier agrees to pay the fixed fee to both retailers in order to maintain collusion in the following periods and collect a higher wholesale price in future periods. Since now retailers also care about the future, the fixed fee motivates them to maintain collusion as well.

As δ increases, each retailer can better exploit the supplier's concern about future profits in order to reduce w^*. Since the supplier cares more about the future, he is willing to participate in collusion even with a smaller wholesale price. Because the higher δ is, the higher the supplier's incentive to maintain collusion, retailers can take advantage of this by offering a contract that allocates to them a higher share of the monopoly profit. As a result, the retailers' profits increase with δ while the supplier's profit decreases.

The effect of δ on the level of slotting allowances is non-monotonic, because δ has two opposite effects on the level of slotting allowances. First, there is a positive direct effect, because the more the supplier cares about the future, the higher the slotting allowances the supplier is willing to pay to maintain collusion and continue receiving the higher wholesale price. Second, an indirect negative effect, because as δ increases, w^* decreases. This in turn reduces the supplier's willingness to pay slotting allowances. The first effect dominates for low values of δ while the second effect dominates for high values of δ.

Part (ii) of Corollary 1 reveals that when $\delta > ½$, retailers sufficiently care about the future to maintain horizontal collusion without the supplier’s participation. Accordingly, retailers offer the supplier contracts that grant him his profit when collusion breaks down, π^C, and earn the remaining monopoly profits. As a result, the firms' profits and the equilibrium contract are not a function of δ. The intuition follows from the benchmark case in section 2, where two firms that compete in prices can maintain horizontal collusion on their own for $\delta >$ ½.

Corollary 1 shows that as δ increases, retailers gain a higher share of collusive profits and the supplier’s share diminishes, while when δ is small, retailers have a smaller share of the collusive profits, and most of the monopoly profits go to the supplier. This implies that even though retailers have all of the bargaining power and are asking (and receiving) slotting allowances, they are not always the main beneficiaries of the collusive scheme.

4.3 Remark: The importance of the supplier’s ability to stop collusion

In the vertical collusion scheme analyzed in the previous section, the supplier played a crucial role by rejecting R_j’s offer if R_j deviated from the equilibrium contract without compensating the supplier for his alternative profit. Since such rejection by the supplier becomes observable to R_i at the end of the period, when R_i see’s that R_j does not hold the supplier’s product, and this triggers R_i’s reversion to the competitive equilibrium forever, R_j is deterred from offering a deviating contract to the supplier. For this policing role of the supplier to work, however, even if R_j did not offer a deviating contract, the supplier’s rejection of R_j’s offer must trigger the same reversion to the competitive equilibrium. This improves the supplier’s bargaining position and enables the supplier to earn higher profits than π^C even though retailers have all the bargaining power. The purpose of this subsection is to show that retailers cannot do better by using a softer trigger strategy, which removes the bite from the supplier's ability to stop vertical collusion by rejecting a retailer’s offer.

Suppose that whenever R_i observes that R_j didn't carry the product, R_i interprets it as a deviation by the supplier rather than by R_j and continues with the collusive equilibrium. R_i stops offering the collusive contract only if R_j carried the product in the previous period but charged a different price than p^*. Under such a trigger strategy, the supplier's decision whether to accept a retailer's offer no longer affects future collusion.

It is straightforward to show that condition (2) is still necessary to support a collusive equilibrium. Turning to the supplier's participation constraint, given that both retailers offer the equilibrium collusive contracts, the supplier's decision on whether to accept both of them or just one is not going to affect the future. Hence the supplier's participation constraint could be written as:

$$Q^*w^* + 2T^* = Q^*w^* + T^*, \tag{8}$$

where the left-hand-side is the supplier's profit from accepting the two equilibrium contracts and the right-hand-side is the supplier's profit from accepting only one of them. This condition requires that $T^* = 0$. However, the proof of Lemma 2 showed that (2) cannot hold if $T^* \geq 0$ and $\delta < ½$, implying that this alternative trigger strategy cannot maintain a collusive equilibrium.

Corollary 2: *Suppose that $\delta < ½$ and retailers do not stop collusion if they observe that the supplier accepted only one of the contract offers. Then, there are no contracts* (w^*, T^*) *that can maintain a collusive equilibrium.*

Consider now the case where $\delta > ½$. In the collusive equilibrium that we defined in Proposition 1, for such discount factors, the supplier earns only its reservation profit, π^C. Hence retailers cannot do better by adopting an alternative trigger strategy.

5. Competition among suppliers, exclusive dealing and renegotiation

Until now, we have assumed that the supplier is a monopoly. Because the monopolistic supplier cares about future profits, he enables vertical collusion even for $\delta < ½$, where ordinary horizontal collusion breaks down. An important question is whether competition among suppliers causes the collusive scheme to break down. The monopoly supplier result should carry over to the case of competing suppliers that are highly differentiated. Our results suggest that if a supplier's brand is strong enough so that the supplier makes a positive profit from refusing a retailer's offer and selling only to the competing retailer, then the parties can engage in vertical collusion. The question arises, however, what does intense competition among suppliers do to the sustainability of the vertical collusion scheme?

The main conclusion of this section is that in the presence of competing suppliers, vertical collusion can be maintained when the collusive equilibrium involves one of the suppliers being offered short-term exclusive dealing agreements by both retailers. The repeated game induces both retailers to keep offering the same supplier to buy exclusively from him, provided that the supplier can inform one retailer (in the form of cheap talk) that the other retailer did not offer the supplier an exclusive dealing agreement and provided that following such transfer of information, the retailer can renegotiate his offer to the supplier. Otherwise, the vertical collusive equilibrium breaks down. We shall first discuss the case without exclusive dealing. Next we will analyze exclusive dealing without renegotiation, and then examine exclusive dealing with renegotiation.

Suppose that the market includes a "dominant" supplier, S_1, and a competitive supply market, which consists of two or more identical suppliers, $S_2 \ldots S_n$. The dominant supplier discounts future profits by δ. In the first stage of every period, retailers make secret offers to some of the suppliers. Each supplier cannot observe R_1 and R_2's offers to other suppliers, and each retailer cannot observe the competing retailer's contract offers. All suppliers decide whether to accept or reject the contract offers. Then, in the second stage of every period, retailers set prices and decide from which supplier/s to place their input orders.

We ask whether the two retailers can sustain a collusive equilibrium in which they offer only the dominant supplier, S_1, the contract (w^*,T^*) that S_1 accepts, and then charge consumers p^*. As before, we assume that any observable deviation in period t triggers the competitive equilibrium from period $t + 1$ onwards. We further assume that in this competitive equilibrium, all firms earn zero. That is, $\pi^C = 0$. Unlike the case of a monopolistic supplier, with competing suppliers $\pi^C = 0$ is an equilibrium when R_j expects that R_i offers a contract to some of the competitive suppliers with $w_i = T_i = 0$.

5.1. No exclusive dealing

Suppose first that retailers cannot commit to deal exclusively with the dominant supplier. In order to maintain a collusive equilibrium, the collusive contract has to satisfy conditions (2) and (3). When $\delta > 1/2$, the collusive equilibrium is trivially sustainable with a contract $(w^*,T^*) = (0, 0)$. Since $\pi^C = 0$, the contract $(w^*,T^*) = (0, 0)$ satisfies (2) and (3). Because retailers earn all of the collusive profits, they have no incentive to deviate to any other contract offer. The collusive equilibrium in this case is identical to horizontal collusion.

Consider now the case where $\delta < 1/2$. Now, the collusive contract needs to eliminate R_i's incentive to deviate from collusion by offering the collusive contract to the dominant supplier and at the same time making a secret offer to a competing supplier with $w_i = T_i = 0$. To see the profitability of such a deviation, suppose that R_j plays according to the proposed equilibrium by offering (w^*,T^*) to the dominant supplier only, but the deviating retailer, R_i, offers the dominant supplier (w^*,T^*) and at the same time makes a secret offer to one or more competitive suppliers with $w_i = T_i = 0$. The dominant supplier will accept both retailers' offers, because he is unaware of R_i's secret offer to the competing suppliers. Hence R_i will earn a slotting allowance, $-T^* > 0$, from the dominant supplier. Moreover, R_i can then charge consumers a price slightly below p^*, dominate the market and earn $p^*Q^* - T^*$. If this deviation is profitable for R_i even though it breaks collusion down in all future periods, the collusive equilibrium fails. Therefore, the equilibrium requires that R_i's discounted future profits from the collusive equilibrium, $((p^* - w^*)Q^*/2 - T^*)/(1 - \delta)$, are higher than a one-period deviation in which R_i buys from a competitive supplier, $p^*Q^* - T^*$. However,

$$p^*Q^* - T^* > \frac{\delta p^*Q^*}{(1-\delta)} \geq \frac{(p^*-w^*)Q^*/2 - T^*}{1-\delta}, \tag{9}$$

where the first inequality follows because $T^* < 0$ and $\delta < ½$, and the second inequality follows from Proposition 1 and equation (7), which show that in any collusive equilibrium, R_i earns $(p^* - w^*)Q^*/2 - T^* \leq \delta p^*Q^* = \pi_R^*$. This implies that R_i will deviate from this collusive equilibrium by making the secret offer to the competing supplier.[16] The following corollary summarizes this result:

Corollary 3: *Suppose that the upstream market includes a dominant supplier and a competitive supply market. Then, if retailers cannot offer the dominant supplier an exclusive dealing contract and* $\delta < ½$, *vertical collusion is not sustainable.*

Intuitively, for $\delta < ½$, retailers are too short-sighted and have a strong incentive to deviate from collusion. Therefore, retailers need to involve the supplier in the collusive scheme. But when retailers can buy the product at $w = 0$ from a competitive supplier, the dominant supplier's ability to sustain vertical collusion is eliminated.

5.2. Exclusive dealing, communication and renegotiation

Next we turn to show that vertical collusion is sustainable for $\delta < ½$, when retailers can sign exclusive dealing contracts with the dominant supplier and when each retailer and the supplier can engage in bilateral communication and renegotiation.

Consider first exclusive dealing *without* communication and renegotiation. Suppose that in every period, each retailer can offer a contract (w_i, T_i, ED) where ED denotes an

[16] Notice that this argument holds for any (w^*, T^*) that satisfy conditions (2) and (3), and not just for the collusive contract that maximizes the retailers' profit.

exclusive dealing clause according to which in the current period, the retailer cannot make contract offers to competing suppliers. The exclusive dealing clause is valid for one period only. We maintain our assumption that contracts are secret and therefore a retailer cannot observe whether the competing retailer offered the dominant supplier an exclusive dealing clause.

We first show that retailers' ability to commit to an exclusive dealing clause, by itself, is not enough to support a collusive equilibrium when $\delta < ½$. Consider a proposed collusive equilibrium in which in every period, the two retailers offer the dominant supplier a contract (w^*,T^*, ED), where w^* and T^* are the same as in proposition 1. The supplier accepts both offers and then retailers set p^*. This cannot be an equilibrium, because R_i will find it optimal not to make an offer to the supplier and instead offer a deviating contract $w_i = T_i = 0$ to one or more of the competing suppliers. Applying wary beliefs, the dominant supplier – observing that R_i didn't made him an offer – should expect that R_i is most likely to undercut the monopoly price and therefore the supplier will not accept R_j's equilibrium offer, or accept it with only a small probability. Notice that wary beliefs cannot yield pure-strategies following this deviation. To see why, note that the supplier rejects R_j's offer only given the belief that R_i will undercut the collusive retail price. But if R_i believes that the supplier will reject R_j's offer, R_i will monopolize the retail market even if he does not undercut the collusive retail price, so he would not undercut it. However, there is a mixed-strategy equilibrium in which the dominant supplier accepts R_j's offer with a very small probability and R_i mixes between setting $p^*– \varepsilon$ and p^*. This equilibrium is consistent with wary beliefs, and R_i's expected profit is $p^*Q^* – \varepsilon$, while the dominant supplier's expected profit is 0.[17] From (9), whenever $\delta < ½$, R_i prefers making this one-period deviation and earning 0 in all future periods to maintaining collusion.

The reason why collusion breaks down even when retailers can commit to an exclusive dealing contract is that we did not allow the dominant supplier to inform R_j that R_i did not offer the dominant supplier an exclusive dealing contract. Suppose now that the supplier can engage in bilateral communication, followed by renegotiation, with each retailer. In the first stage of every period, after retailers made their contract offers but before the dominant supplier accepted them, the supplier can inform R_j that R_i deviated from the collusive contract and the supplier didn't accept his offer. This communication is non-verifiable, and consists of "cheap talk" that the supplier can convey to retailers, regardless of whether it is true or not. R_j can then withdraw his original contract offer and make an

[17] For a detailed description of this mixed-strategy equilibrium see Appendix C.

alternative offer to the supplier.[18] The supplier then accepts or rejects the alternative contract offer and the game moves to the second stage as in our base model.[19] Suppose that R_j interprets any such communication as a signal that R_i deviated from the collusive contract. Accordingly, R_j finds it optimal to replace the original offer with the contract $w_j = T_j = 0$. Such beliefs are rational if the supplier reports a deviation if and only if R_i indeed deviated from the collusive contract.

To show that now the collusive contract defined in proposition 1, alongside an exclusive dealing clause, can maintain collusion, we can follow the same steps as in our base model. First, condition (2) is still necessary, because it ensures that given that both retailers deal exclusively with the dominant supplier and offered the collusive contract in the first stage, R_i will not undercut the monopoly price in the second stage.

Next consider the supplier's participation constraint. Suppose that both retailers offered the equilibrium contract. If the supplier rejects one of the offers, say, the offer of R_i, he has no incentive to report it to R_j, because then R_j will offer a contract $w_j = T_j = 0$ and the supplier will earn 0. This means that the supplier's profit from accepting only one of the equilibrium offers is $w^*Q^* + T^*$, as in our base model, and the supplier's participation constraint is identical to (3) (after substituting $\pi^C = 0$). Moreover, this means that the dominant supplier has no incentive to report a deviation to R_j when it is untrue.[20]

Finally, consider the possibility that R_i deviates in the first period by offering a contract different than (w^*, T^*, ED). If the deviating contract includes an exclusive dealing clause and differs only because $(w_i, T_i) \neq (w^*, T^*)$, the same reasoning as in our base model (lemma 5 and lemma 6) holds. If the deviating contract does not include an exclusive dealing clause, then regardless of w_i and T_i, the dominant supplier will believe that R_i offered a competing supplier a contract $w_i = T_i = 0$ and plans to cut the monopoly price. Given these beliefs, there is no point in accepting R_j's equilibrium contract, and instead the supplier will inform R_j of the deviation. R_j in turn will offer the supplier a contract $w_j = T_j = 0$ that the supplier will accept. This makes R_i's deviation unprofitable to begin with. The following proposition summarizes this result:

[18] It is possible to show that the results remain the same when R_i cannot remove the original contract offer and instead can offer a second contract such that the supplier can choose between the new contract and the original one.

[19] It can be shown that such communication and renegotiation has no effect on the collusive equilibrium when there is a monopoly supplier. The intuition is that if the monopoly supplier rejects R_j's offer, the supplier will never want to inform R_i that R_i is a monopoly retailer, since then R_i would raise his retail price.

[20] Notice that if the supplier accepts R_i's equilibrium contract offer and falsely reports to R_j that R_i deviated from collusion, the supplier will earn $T^* < 0$.

Proposition 2: *Suppose that the upstream market includes a dominant supplier and a competitive supply market. Then, if retailers can offer the dominant supplier an exclusive dealing contract, communication and renegotiation between the supplier and retailers is possible, and* $\delta < ½$, *there is a collusive equilibrium in which in every period the two retailers sign an exclusive dealing contract of* (w^*, T^*) *with the dominant supplier, where* (w^*, T^*) *is defined in proposition* 1.

Notice that the exclusive dealing contract with the joint supplier facilitates vertical collusion even though the commitment to buy exclusively from the supplier is short-termed, i.e., retailers commit to the supplier for only one period. In every period, R_i is induced by the repeated game to offer S_1 exclusivity, because he knows that if he does not, S_1 will inform R_j of this and R_j will undercut the collusive price and monopolize the market.

6. Policy Implications

Our results have several policy implications.

First, our results shed a new light on short-term exclusive dealing agreements in which buyers agree to buy from a single supplier. As shown in section 5.2, the ability of retailers to promise one of the suppliers to buy only for him, even for a single period, facilitates vertical collusion and enables monopoly retail prices. Current antitrust rules in the US and in the EU, however, see such short-term exclusive dealing agreements as automatically legal. For example, the US Court of Appeals in *Roland Machinery Company v. Dresser Industries, Inc.*,[21] ruled that "[e]xclusive-dealing contracts terminable in less than a year are presumptively lawful … ". Similarly, in *Methodist Health Services Corporation v. OSF Healthcare System*,[22] the dominant hospital in a certain region, facing competition from only one other hospital, entered exclusive dealing agreements with the local insurance companies. The District Court dismissed the antitrust claim because the exclusive dealing contracts were short term agreements. The court stresses that "[e]ven an exclusive-dealing contract covering a dominant share of a relevant market need have no adverse consequences if the contract is let out for frequent rebidding."[23] Even though the dominant hospital kept winning these bids, the court approved of the exclusive dealing commitments, because in each bid the other hospital had the opportunity to compete.[24] Our results, however, imply that

[21] (7th Cir.) 749 F.2d 380, 395 (1984).

[22] (Central District of Illinois, Peoria Division) 2016 U.S. Dist. LEXIS 136478.

[23] *Id*. at 150.

[24] *Id*. at 149. Similarly, in *Louisa Coca-Cola Bottling Co. v. Pepsi-Cola Metropolitan Bottling Co., Inc.* (US District Court for The Eastern District of Kentucky, Ashland Division) 94 F. Supp. 2d 804 (1999), Louisa Coke, a regional producer of Coca Cola, claimed that Pepsi, with a regional market share of 70%, offered retailers discounts and "advertising subsidies or rebates in exchange for the retailers' promises not to advertise, promote, display or offer shelf space for Louisa Coke products." The court

in such scenarios, one of the suppliers may keep winning these bids for the wrong reasons: not because he offers lower prices or better terms, but rather because he can help enforce a multi period tacit collusion scheme. That is, in our framework, exclusive dealing becomes self-enforcing: the collusive equilibrium repeatedly induces both retailers to offer to buy exclusively from the same supplier. The European Commission too (EC Commission (2009) says, in its guidelines, that "[i]f competitors can compete on equal terms for each individual customer's entire demand, exclusive purchasing obligations are generally unlikely to hamper effective competition unless the switching of supplier by customers is rendered difficult due to the duration of the exclusive purchasing obligation."[25] This approach too overlooks the anticompetitive effect of short-term exclusive dealing requirements exposed by our results. This anticompetitive effect does not hinge neither on the duration of the exclusive dealing obligation nor on competing suppliers' ability to compete for each retailer's entire demand. Notice that even though suppliers *2* to *n* in our model offer both retailers a perfect substitute that can fulfill all of their demand, in the collusive equilibrium we identify, retailers are nevertheless induced to offer supplier *1* exclusivity over and over again.

Therefore, if an antitrust court or agency observes that despite the presence of other suppliers offering a substitute product to retailers, the same supplier keeps winning the retailers' business over and over again with short-term exclusive dealing contracts, it should take account of the possibility of vertical collusion. In particular, the antitrust court or agency should not deem the short-term exclusivity commitments in such a case automatically legal. It should consider the threat that such exclusivity facilitates vertical collusion, and balance the anticompetitive threats with the pro-competitive benefits that could stem from the exclusivity agreements. By contrast, if the antitrust court or agency observes that different suppliers (rather than the same supplier over and over again) often win retailers' business in different periods, or alternatively that each retailer offers exclusivity to a different supplier, the case would not raise the concerns from vertical collusion identified in this paper. The results of section 5.2 also show that exclusive dealing facilitates vertical collusion only when accompanied by fixed fees paid by the exclusive supplier to the retailers. Due to Corollary 2, even when both retailers exclusively buy from the same supplier, vertical collusion breaks down absent slotting allowances.

To illustrate with another example from the case law, in *Insulate SB, Inc. v. Advanced Finishing Systems, Inc.*,[26] a buyer of fast-set spray foam equipment, used for insulation by contractors, sued the manufacturer of the product, Graco Minnesotta Inc, who possessed a

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rejected the claim without further discussing the facts of the case because the contracts' "short duration and easy terminability substantially negate their potential for foreclosing competition" (*id*. at p. 816).

[25] See also Case C-234/89 *Stergios Delimitis Henninger Brau AG*, [1991] ECR 935.

[26] (Court of Appeals 8th Cir.), 797 F.3d 538 (2015).

market share exceeding 95%, and its distributors. Interestingly, the buyer alleged that Graco and its distributors were engaged in a conspiracy designed to have the distributors buy the product exclusively from Graco, so as to enable the distributors to raise the price they charged up to supra-competitive levels. The Federal Court of Appeals dismissed the claim, however, holding that a policy announced by Graco to stop dealing with distributors who held competing products consists of unilateral behavior and is therefore deemed legal.

The second policy implication involves transfer of information between a supplier and his customers. Antitrust law generally allows a supplier to reveal to one customer what another customer had offered him.[27] As shown in section 5.2, however, if the dominant supplier can reveal to one retailer that the competing retailer had not offered it an exclusive dealing contract, vertical collusion is enabled. Recall that when the dominant supplier faces competition from other suppliers, the vertical collusive scheme is nevertheless sustained via exclusive dealing between both retailers and the dominant supplier, *provided* that the dominant supplier can inform a retailer that the other retailer had not offered the supplier exclusivity. Had such transfer of information been under the threat of antitrust liability, the vertical collusive scheme would have been more likely to break down. The general justification for allowing exchange of information between a supplier and a retailer regarding dealings of the supplier with the competing retailer is that such information is allegedly a "natural" part of negotiations between the supplier and the retailer, where the supplier is supposedly trying to improve the deal, using competition among buyers over his product. Note, however, that the competitive threat we identify does not really stem from information the dominant supplier reveals to one retailer regarding a better deal offered by the competing retailer. On the contrary, the particular type of information transfer we are discussing concerns the supplier revealing to one retailer that the other retailer actually offered him a worse deal: one without exclusive dealing.[28] Hence, the justification for a soft antitrust approach does not hold in this case.

Third, our results show that slotting allowances may, in certain circumstances, be more anticompetitive than the current economic literature predicts. According to the economic literature to date, one retailer needs to observe its rival's contract with the supplier in order for slotting allowances to facilitate downstream collusion. By contrast, Corollary 2 shows that slotting allowances might be anti-competitive even in the common case when contracts between suppliers and retailers are secret. Usually, a retailer cannot observe its rivals' contracts with the supplier. As noted, exchange of information among competing

[27] See supra note 3.

[28] Naturally, the supplier and retailers would have reached the same anticompetitive result had the supplier revealed to one retailer that the other retailer *has* offered him exclusive dealing, in which case the retailer would have deduced from the supplier's silence that the competing retailer had not done so.

retailers regarding their commercial terms with a common supplier would most probably be condemned as an antitrust violation.[29] We show that even though each retailer cannot observe the contract between the supplier and the competing retailer, retailers know that the supplier observes both contracts and has an incentive to maintain vertical collusion. Therefore, a retailer cannot profitably convince the supplier to accept a contract that motivates the retailer (and the supplier) to deviate from the collusive equilibrium.

Slotting allowances paid to supermarket chains are a widespread phenomenon. According to analysts, American retailers make more than $18 billion in slotting allowances each year. In the UK, it is estimated that the big four supermarket chains receive more in payments from their suppliers than they make in operating profits, and in Australia, it has been reported that growing supplier rebates have boosted food retailers' profit margins by an average of 2.5%, to 5.7%, over the past five years. It was further reported that this phenomenon is not associated with low retail prices (The Economist, 2015).[30] An EC study examining slotting allowances in the different European member states reports over 500 kinds of fees paid by suppliers to retailers, in addition to merely paying for shelf space.[31]

Under US case law to date, slotting allowances have rarely been condemned, under the rule of reason, and only to the extent that they are paid in exchange for dominating retailers' shelf space in a way that is likely to exclude rival suppliers.[32] In our context, by contrast, the harm to competition stems from the mere payment of fixed fees by a dominant supplier to retailers. The fees themselves need not have any exclusionary effect on rival suppliers for them to harm competition, as long as the supplier enjoys a strong brand or enjoys exclusivity in some other way. It is not their exclusionary nature which harms competition in our model, but rather the fact that they serve as a "prize" the supplier is willing to pay retailers in exchange for retailers' adherence to the collusive scheme. In the presence of competing suppliers, if slotting allowances are also paid in exchange for the retailer's promise to deal only with the supplier, their potential anticompetitive effect is exacerbated, since they help implement exclusive dealing, which in turn facilitates the collusive scheme.

In some cases, slotting allowances are paid by suppliers as "compensation" for intense competition among retailers over selling the supplier's brand.[33] Our results imply that

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[29] See sources cited supra note 1.

[30] Notably, The Economist (2015) also reports that Walmart, known for heavy discount pricing, does not collect slotting allowances from suppliers.

[31] See Stichele, Vander and Young (2008). These "excuses" include fees in consideration for promotion or advertising, or introductory allowances, listing fees, contributions for new store openings or store refurbishments, end of period bonuses, mergers and acquisitions, reimbursement of expenditures, and so forth (See also FTC (2003)). .

[32] *See, e.g., Conwood Company, L.P. v. United States Tobacco Company* (6th Cir.) 290 F.3d 768 (2010); *Church & Dwight Co. INC. v. Mayer Laboratories, INC.* 868 F.Supp.2d 876, (N.D. California 2012).

[33] See, e.g., Moulds (2015).

such scenarios deserve softer antitrust treatment, provided that the claim of compensation for intense competition is not a sham. In our framework, during or after a price war between retailers, when collusion collapses, slotting allowances are no longer used (see Lemma 1). On the contrary, when vertical collusion collapses, the supplier stops paying retailers slotting allowances in our model, in order to punish retailers for not adhering to the collusive scheme. Finally, in our framework, slotting allowances need to be in the form of fixed payments in order for them to facilitate vertical collusion. If fees in a particular case are not fixed but rather directly depend on a retailer's sales, the anticompetitive concerns raised by the threat of vertical collusion are not likely to arise. Hence, in a case by case assessment of slotting allowances under the rule of reason, antitrust courts and agencies should take account of their prospects in facilitating vertical collusion, and balance them against pro-competitive benefits that may stem from such practices.

The last policy implication concerns the antitrust treatment of a supplier's refusal to deal with a retailer. The results of Lemma's 5 and 6 and proposition 1 show that the supplier's ability to unilaterally reject a deviating retailer's contract offer plays a key role in the sustainability of vertical collusion. By contrast, under US antitrust law, a supplier's refusal to deal with a retailer due to the retailer's vigorous competition with other retailers is often deemed automatically legal. The famous "Colgate doctrine",[34] cited in recent cases as well, "protects a manufacturer who communicates a policy and then terminates distribution agreements with those who violate that policy … and a distributor is free to acquiesce in the manufacturer's demand in order to avoid termination."[35] Such behavior, if not accompanied by additional evidence of an anticompetitive agreement between the supplier and retailers, is generally considered unilateral action, invoking no antitrust claim.[36] Hence, our results suggest that antitrust courts and agencies, in appropriate cases, should be more strict toward such unilateral refusals by a dominant supplier. In particular, if evidence of the anticompetitive reasons for such refusal is presented, an illegal agreement between the supplier and retailers should be more easily inferred. Furthermore, if the evidence suggests that a dominant supplier's unilateral refusal to deal with a retailer stems from the retailer's attempt to deviate from tacit collusion, antitrust courts and agencies should be able to condemn such a refusal as illegal monopolization. When market conditions are prone to vertical collusion, had such a retailer possessed an antitrust claim against the dominant

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[34] *See United States v. Colgate & Co.*, 250 U.S. 300 (1919).

[35] *See State of New York, v. Tempur-Pedic International, Inc.*, (Supreme Court of New York, 30 Misc. 3d 986 (2011).

[36] *See Monsanto Co. v. Spray-Rite Service Corp.*, 465 U.S. 752 (1984), *Costco Wholesale Corporation v. Johnson & Johnson Vision Care, Inc.*, (United States District Court for The Middle District of Florida, Jacksonville Division), 2015 U.S. Dist. Lexis 168581*;* Kaplow (2016) (criticizing the case law's attempt to distinguish between unilateral and concerted behavior).

supplier for such refusal, vertical collusion would be more likely to break down. By contrast, US antitrust law is commonly understood not to include such a prohibition.[37]

8. Conclusion

We examine the features of collusion in a repeated game involving retailers and their joint supplier. Our model of vertical collusion has two main features. First, all three firms equally care about the future and they all participate in the collusive scheme. Second, vertical contracts are secret: a retailer cannot observe the bilateral contracting between the competing retailer and the supplier.

Retailers gain from vertical collusion, because it enables them to charge the monopoly retail price even for discount factors that would not have enabled ordinary horizontal collusion among them, and they receive slotting allowances from the supplier as a prize for participating in the collusive scheme. The supplier gains from vertical collusion, because he collects a higher wholesale price and makes a higher profit than absent vertical collusion. This occurs even when retailers have all the bargaining power, where the supplier's difficulty in receiving a high wholesale price is at its peak. Also, it occurs despite the fact retailers are too impatient to sustain horizontal collusion, and despite the fact the supplier is as impatient as retailers are.

This result could naturally carry over to multiple suppliers, as long as differentiation among them is strong enough, and we show it to carry over to differentiation among retailers. With intense competition among homogenous suppliers, vertical collusion is sustained by short-term exclusive dealing commitments by retailers with one of the suppliers. Exclusive dealing can enable vertical collusion, however, only when the supplier is allowed to tell one retailer (in the form of cheap talk) that the competing retailer did not offer an exclusive dealing contract.

Our results have various policy implications: antitrust courts and agencies should reconsider their automatic approval of short-term exclusive dealing agreements; transfer of information from a supplier to his buyer regarding whether the competing buyer offered to buy exclusively from the supplier may raise antitrust concerns; slotting allowances can facilitate collusion even when vertical contracts are secret, and a dominant supplier's refusal to deal with a retailer on account of the retailer engaging in downstream competition deserves more antitrust attention.

[37] See Areeda and Hovenkamp (2015).

Appendix

Below are the proofs of lemma 1 – 6 and Proposition 1.

Proof of Lemma 1:

We will proceed in two steps. In the first step, we will show that if (1) does not hold then R_i finds it optimal to deviate to a contract that motivates the supplier to reject R_j's offer, but this deviation is impossible if (1) holds. In the second step we show that R_i cannot profitably deviate to a contract that does not motivate the supplier to reject R_j's offer.

We first show that if (1) does not hold, R_i can make a profitable deviation. Since $p(w) > w$ and $pQ(p)$ is concave in p:

$$\max_{w^C}\{w^C Q(w^C)\} = p^* Q^* > \max_{w_i}\{w_i Q(p(w_i))\} \geq w^C Q(w^C)\Big|_{w^C=0}$$

implying that there is a w_L such that (1) holds for $w^C \in [w_L, p^*]$ and does not hold otherwise, where $w_L > 0$. Suppose that (1) does not hold. Then R_i can deviate to (T_i, w_i) such that $w_i Q(p(w_i)) > w^C Q(w^C)$. If the supplier accepts the contract, it is rational (for both the supplier and R_i) to expect that the supplier does not accept R_j's offer and that R_i sets $p(w_i)$. Given these expectations, the supplier agrees to the deviating contract if $w_i Q(p(w_i)) + T_i \geq w^C Q(w^C)$, or $T_i = w^C Q(w^C) - w_i Q(p(w_i))$. R_i earns from this deviation:

$$\begin{aligned} &(p(w_i) - w_i)Q(p(w_i)) - T_i \\ &= p(w_i)Q(p(w_i)) - w^C Q(w^C) \\ &> w_i Q(p(w_i)) - w^C Q(w^C) \\ &> 0, \end{aligned}$$

where the first inequality follows because $p(w_i) > w_i$ and the second inequality follows because whenever (1) does not hold it is possible to find w_i such that $w_i Q(p(w_i)) > w^C Q(w^C)$. Since in equilibrium R_i earns 0, R_i finds it optimal to deviate. Now suppose that (1) holds. Then, there is no w_i that ensures that the supplier does not accept R_j's offer.

Next we turn to the second step, of showing that R_i cannot make a profitable deviation when R_i anticipates that the supplier accepts R_j's equilibrium offer. Suppose that R_i deviates to $(T_i, w_i) \neq (0, w^C)$ such that if the supplier accepts the deviation, the supplier continues to play the equilibrium strategy of accepting R_j's offer, $(0, w^C)$. R_i therefore expects that R_j will be active in the market and will set $p^C = w^C$. The deviation can be profitable to R_i only if $w_i < w^C$, such that in stage 2 R_i can charge a price slightly lower than w^C and dominate the market. To convince the supplier to accept the deviating contract, R_i charges T_i such that the supplier is indifferent between accepting both offers and accepting just R_j's equilibrium offer: $w_i Q(w^C) + T_i \geq w^C Q(w^C)$, or $T_i \geq (w^C - w_i)Q(w^C)$. But then R_i earns at most $(w^C - w_i)Q(w^C) - T_i \leq 0$. We therefore have that R_i cannot offer a profitable deviation from the equilibrium $(0, w^C)$ if R_i believes that the supplier accepts R_j's equilibrium offer.

Proof of Lemma 2:

Condition (2) can be re-written as:

$$T^* < T_1 \equiv \left(p^* - w^*\right)\frac{Q^*(2\delta-1)}{2\delta}$$

Moreover:

$$\pi_R(w^*,T^*) = (p^* - w^*)Q^*/2 - T^* > 0 \quad \Leftrightarrow \quad T^* < T_2 \equiv (p^* - w^*)Q^*/2 .$$

If $p^* > w^*$, then $T_1 < 0$ and therefore $T^* < 0$. If $p^* \leq w^*$, then $T_2 < 0$ and therefore $T^* < 0$. Notice that in the special case where $p^* = w^*$, the condition $\pi_R(w^*) > 0$ requires that $T^* < 0$.

Proof of Lemma 3:

Substituting $\delta = 0$ into the supplier's participation constraint yields:

$$w^*Q^* + 2T^* \geq w^*Q^* + T^* \quad \Rightarrow \; T^* \geq 0.$$

However, condition (2), which ensures that retailers set the monopoly price, should still hold with $\delta > 0$, and from lemma 2, for $\delta < 1/2$ this condition requires $T^* < 0$.

Proof of Lemma 4:

Given $(w^*, T^*) = (\pi^C/Q^*, 0)$, each retailer earns $\pi_R(\pi^C/Q^*, 0) = (p^*Q^* - \pi^C)/2 > 0$ and the supplier earns $\pi_S(\pi^C/Q^*, 0) = \pi^C$. Since the supplier earns the same profit in both the collusive and competitive equilibrium, the supplier is indifferent between the two equilibria and therefore the supplier's beliefs concerning the future when observing a deviation to $(w_i, T_i) \neq (\pi^C/Q^*, 0)$ are irrelevant. Any contract deviation by R_i has to offer the supplier at least π^C in the current period because the supplier can earn π^C by accepting only R_j's equilibrium contract offer. This implies that given any out-of-equilibrium beliefs, R_i can earn at most $p^*Q^* - \pi^C$ in the current period, followed by 0 in all future periods. However,

$$p^*Q^* - \pi^C < \frac{\frac{1}{2}(p^*Q^* - \pi^C)}{1-\delta},$$

where the inequality follows because $p^*Q^* > \pi^C$ and $\delta > ½$.

Proof of Lemma 5:

As shown in Appendix B, the highest expected profit that R_i can make in such a deviation is $p^*Q^* - \varepsilon - (w^*Q^* + T^*)$. Letting $\varepsilon \to 0$, R_i does not deviate iff:

$$\frac{(p^*-w^*)Q/2-T^*}{1-\delta} \geq p^*Q^*-(w^*Q^*+T^*),$$
$$\Downarrow$$
$$-\frac{(1-2\delta)Q^*(p^*-w^*)}{2(2-\delta)} \geq T^* \equiv T_3.$$

Since $\delta < 1/2$ and $p^* \geq w^*$, $T_3 < 0$. Recalling that condition (2) requires that $T^* < T_1 < 0$,

$$T_3 - T_1 = \frac{(1-\delta)(1-2\delta)Q^*(p^*-w^*)}{2(2-\delta)} > 0,$$

where the inequality follows because $\delta < 1/2$ and $p^* \geq w^*$. We therefore have that $0 > T_3 > T_1$, implying that any $T^* < T_1$ also satisfies $T^* < T_3$.

Proof of Lemma 6:

Suppose that the supplier and R_i have the common beliefs that if the supplier accepts the deviation, the supplier also accepts R_j's offer and R_i maintains collusion. Whenever R_i makes this deviation, the supplier expects that R_i will set p^* in the current period and therefore R_j will not detect it. The supplier's profit from accepting the deviation depends on whether the supplier expects that in the next period R_i will offer the equilibrium contract or continue offering the deviating contract. We consider each possibility in turn.

Suppose first that the supplier expects that R_i offers a one-period deviation, (w_i, T_i), and will continue offering (w^*, T^*) in all future periods. The supplier anticipates that if he accepts this contract, the deviation will not be detected by R_j and therefore collusion is going to continue in future periods. Therefore, the supplier accepts the deviation iff:

$$\begin{aligned} &w^*Q^*/2+T^*+w_iQ^*/2+T_i+\frac{\delta}{1-\delta}\left(w^*Q^*+2T^*\right) > \\ &w^*Q^*+T^*+\frac{\delta}{1-\delta}\pi^C, \end{aligned} \tag{A-1}$$

where the left-hand-side is the supplier's profit from accepting a one-period deviation given that doing so maintains the collusive equilibrium in all future periods and the right-hand-side is the supplier's profit from accepting only R_j's contract and stopping collusion.

Extracting T^* from (3) yields:

$$T^*(w^*) = \frac{\delta(\pi^C - Q^*w^*)}{(1+\delta)}. \tag{A-2}$$

Substituting (A-2) into (A-1) and solving for T_i, the supplier accepts the deviation if:

$$T_i > \frac{\delta}{1+\delta}\pi^C + \frac{1-\delta}{2(1+\delta)}Q^* w^* - \frac{Q^* w_i}{2}. \tag{A-3}$$

R_i prefers making this one-period deviation if R_i earns a higher one-period profit than the equilibrium profit. However, R_i's profit from this deviation is:

$$\begin{aligned}&(p^* - w_i)Q^*/2 - T_i \\ &< \tfrac{1}{2}\left(p^* - \frac{1-\delta}{1+\delta}w^*\right)Q^* - \frac{\delta}{1+\delta}\pi^C = (p^* - w_i)Q^*/2 - T^*(w^*),\end{aligned} \tag{A-4}$$

where the inequality follows from substituting (A-3) into T_i in (A-4). Notice that we only need to look at the one-period profit, because if the supplier accepts the deviation then R_i's future profits are $\pi_R(w^*,T^*)$. We therefore have that R_i cannot benefit from making the deviation.

Suppose now that the supplier expects that R_i's deviation is permanent. Now, the supplier agrees to the deviation if:

$$\frac{w^* Q^*/2 + T^*(w^*) + w_i Q^*/2 + T_i}{1-\delta} > w^* Q^* + T^*(w^*) + \frac{\delta}{1-\delta}\pi^C,$$

where the left-hand-side is the supplier's profit from accepting the deviation given that the supplier expects that the deviation is permanent and the right-hand-side is the supplier's profit from accepting only R_j's offer and stopping collusion. The supplier agrees to the deviation if:

$$T_i > \frac{\delta}{1+\delta}\pi^C + \frac{1-\delta}{2(1+\delta)}Q^* w^* - \frac{Q^* w_i}{2}. \tag{A-5}$$

R_i's profit from making this deviation in the current and all future periods is:

$$\begin{aligned}&\frac{(p^* - w_i)Q^*/2 - T_i}{1-\delta} \\ &< \tfrac{1}{1-\delta}\left(\tfrac{1}{2}\left(p^* - \frac{1-\delta}{1+\delta}w^*\right)Q^* - \frac{\delta}{1+\delta}\pi^C\right) = \frac{(p^* - w_i)Q^*/2 - T^*(w^*)}{1-\delta},\end{aligned} \tag{A-6}$$

where the inequality follows from substituting T_i in (A-5) into (A-6). We therefore have that R_i cannot profitably make a permanent deviation to (w_i, T_i) that motivates R_i to maintain collusion.

Proof of Proposition 1:

We first solve for the set of (w^*, T^*) that satisfy (2), (3) and $\pi_S(w^*,T^*) \geq \pi^C$. From condition (3), T^* must satisfy (A-2). Substituting (A-2) into condition (2) we can rewrite (2) as:

$$w^* > p^* - \frac{2\delta^2(p^*Q^* - \pi^C)}{(1-\delta)Q^*}. \tag{A-7}$$

Substituting (A-2) into $\pi_S(w^*,T^*)$ we have:

$$\pi_S(w^*, T^*(w^*)) = \frac{1-\delta}{1+\delta} w^*Q^* + \frac{2\delta}{1+\delta}\pi^C > \pi^C \quad \Leftrightarrow \quad w^* > \frac{\pi^C}{Q^*}. \tag{A-8}$$

Comparing the right-hand-sides of (A-7) and (A-8), the former is higher than the latter iff $\delta < 1/2$. We conclude that (2), (3) and $\pi_S(w^*,T^*) \geq \pi^C$ hold for any $T^*(w^*)$ defined by (A-2) and w^*, where:

$$w^* \geq w^E \equiv \begin{cases} p^* - \dfrac{2\delta^2(p^*Q^* - \pi^C)}{(1-\delta)Q^*}; & \delta \in [0, \frac{1}{2}]; \\ \dfrac{\pi^C}{Q^*}; & \delta \in [\frac{1}{2}, 1]. \end{cases}$$

Next, we solve for the w^* that maximizes $\pi_R(w^*,T^*(w^*))$. Using (A-2),

$$\pi_R(w^*, T^*(w^*)) = (p^* - w^*)Q^*/2 - \frac{\delta(\pi^C - Q^*w^*)}{(1+\delta)}.$$

Differentiating $\pi_R(w^*,T^*(w^*))$ with respect to w^* yields:

$$\frac{\partial \pi_R(w^*, T^*(w^*))}{\partial w^*} = -\frac{(1-\delta)Q^*}{2(1+\delta)} < 0.$$

Therefore, the most profitable collusive equilibrium involves $w^* = w^E$ which yields (5). Substituting $w^* = w^E$ into (A-2) yields (6). Notice that $\pi_R(w^*,T^*(w^*))$ is decreasing with w^* even for $w^* > p^*$ and therefore there is no loss of generality in our focus in Lemma 5 on $w^* \leq p^*$.

Appendix B: Mixed strategy equilibrium following a deviation to a $(w_i,T_i) \neq (w^*, T^*)$ that stops collusion

Suppose that R_i deviated from collusion by offering a contract $(w_i,T_i) \neq (w^*, T^*)$ that makes both R_i and the supplier believe that collusion is going to stop, while R_j offered the supplier the equilibrium contract (w^*, T^*). In this appendix we show that the subgame induced by this deviation has a mixed-strategy equilibrium in which the supplier believes that in the end of the current period R_i sets the monopoly price given w_i, $p(w_i)$ (as defined in equation (1)) with probability γ and sets $p^* - \varepsilon$ with probability $1-\gamma$, while R_i believes that the supplier accepts R_j's offer with probability θ and rejects R_j's offer with probability $1-\theta$. We then show that the highest expected profit that R_i can make in such a deviation is $p^*Q^* - \varepsilon - (w^*Q^* + T^*)$.

Suppose that the supplier accepted the deviating contract $(w_i,T_i) \neq (w^*, T^*)$. Consider first the case $w_i > 0$, such that $p(w_i) > p^*$. When the supplier rejects R_j's equilibrium contract offer, the supplier earns (gross of T_i) $w_iQ(p(w_i))$ if R_i sets $p(w_i)$ and earns w_iQ^* if R_i sets $p^* - \varepsilon$. Hence, the supplier's expected profit from rejecting R_j's offer is $\gamma w_iQ(p(w_i)) + (1-\gamma)w_iQ^*$. When the supplier accepts R_j's offer, the supplier earns $w^*Q^* + T^*$ if R_i sets $p(w_i)$ and earns $w_iQ^* + T^*$ if R_i sets $p^* - \varepsilon$. Hence, the supplier's expected profit from accepting R_j's offer is $\gamma(w^*Q^* + T^*) + (1-\gamma)(w_iQ^* + T^*)$. The equilibrium condition requires that:

$$\gamma w_iQ(p(w_i)) + (1-\gamma)w_iQ^* = \gamma(w^*Q^* + T^*) + (1-\gamma)(w_iQ^* + T^*). \tag{A-9}$$

Next, consider R_i's equilibrium strategy. When R_i sets $p(w_i)$, R_i earns 0 (gross of T_i) if the supplier accepts R_j's offer and earns $(p(w_i) - w_i)Q(p(w_i))$ if the supplier rejects R_j's offer. If R_i sets $p^* - \varepsilon$, R_i earns $(p^* - \varepsilon - w_i)Q^*$ regardless of whether the supplier accepts R_j's offer. Hence, the equilibrium condition requires that:

$$(1 - \theta)(p(w_i) - w_i)Q(p(w_i)) = (p^* - \varepsilon - w_i)Q^*. \tag{A-10}$$

Notice that any $p_i \notin \{p(w_i), p^* - \varepsilon\}$ provides R_i with a lower expected profit than $(1 - \theta)(p(w_i) - w_i)Q(p(w_i))$ and therefore R_i only mixes between playing $p(w_i)$ and $p^* - \varepsilon$.

Solving (A-9) and (A-10) yields that the equilibrium values of θ and γ, given w_i, are:

$$\gamma(w_i) = \frac{T^*}{w_iQ(p(w_i)) - w^*Q^*}, \quad \theta(w_i) = 1 - \frac{(p^* - \varepsilon - w_i)Q^*}{(p(w_i) - w_i)Q(p(w_i))}.$$

We have that $0 < \theta(w_i) < 1$, because $p(w_i)$ maximizes $(p - w_i)Q(p)$, implying that $(p(w_i) - w_i)Q(p(w_i)) > (p^* - \varepsilon - w_i)Q^* > 0$. To see that $\gamma(w_i) > 0$, recall that $T^* < 0$. Moreover,

$$w^*Q^* > \pi^C = w^CQ(w^C) > \max_w wQ(p(w)) \geq w_iQ(p(w_i)),$$

where the first inequality follows because $w^*Q^* + 2T^* > \pi^C$ and $T^* < 0$ implies that $w^*Q^* > \pi^C$ and the second inequality follows from Lemma 1. We therefore have that both the nominator and the denominator of $\gamma(w_i)$ are negative and hence $\gamma(w_i) > 0$. To see that $\gamma(w_i) < 1$, we need to show that $w^*Q^* - w_iQ(p(w_i)) > -T^*$. This holds because

$$w^*Q^* - w_iQ(p(w_i)) > \pi^C - 2T^* - w_iQ(p(w_i))$$

$$> \pi^C - 2T^* - \pi^C = -2T^* > -T^*,$$

where the first inequality follows because $w^*Q^* + 2T^* > \pi^C$ implies that $w^*Q^* > \pi^C - 2T^*$, the second inequality follows because $\pi^C > w_iQ(p(w_i))$ and the third inequality follows because $T^* < 0$.

Suppose now that $w_i = 0$, such that R_i sets $p(w_i) = p^*$ with probability γ and $p^* - \varepsilon$ with probability $1 - \gamma$. We solve this special case because there is a discontinuity in the mixed strategy equilibrium between $w_i > 0$ and $w_i = 0$. When the supplier rejects R_j's equilibrium contract offer, the supplier earns 0 (gross of T_i) because $w_i = 0$. When the supplier accepts R_j's offer, the supplier earns $w^*Q^*/2 + T^*$ if R_i sets p^* and earns T^* if R_i sets $p^* - \varepsilon$. Hence, the supplier's expected profit from accepting R_j's offer is $\gamma(w^*Q^*/2 + T^*) + (1-\gamma)T^*$. The equilibrium condition requires that:

$$\gamma(w^*Q^*/2 + T^*) + (1-\gamma)T^* = 0. \tag{A-11}$$

Next, consider R_i's equilibrium strategy. When R_i sets p^*, R_i earns $p^*Q^*/2$ (gross of T_i) if the supplier accepts R_j's offer, and earns p^*Q^* if the supplier rejects R_j's offer. If R_i sets $p^* - \varepsilon$, R_i earns $(p^* - \varepsilon)Q^*$ regardless of whether the supplier accepts R_j's contract offer. Hence, the equilibrium condition requires that:

$$\theta\, p^*Q^*/2 + (1 - \theta)p^*Q^* = p^*Q^* - \varepsilon. \tag{A-12}$$

Solving (A-11) and (A-12) yields that the equilibrium values of θ and γ, given $w_i = 0$, are:

$$\gamma(0) = \frac{-2T^*}{w^*Q^*}, \quad \theta(0) = \varepsilon\,,$$

where $0 \le \gamma(0) \le 1$ because $T^* < 0$ and $w^*Q^* + 2T^* > 0$ and $0 \le \theta(0) \le 1$ because ε is positive and small.

Next we turn to showing that R_i can earn at most $p^*Q^* - \varepsilon - (w^*Q^* + T^*)$. Given that the deviating contract $(w_i,T_i) \neq (w^*, T^*)$ where $w_i > 0$ induces the above-mentioned mixed strategy equilibrium, the supplier accepts R_i's offer if $\gamma(w_i)w_iQ(p(w_i)) + (1-\gamma(w_i))w_iQ^* + T_i > w^*Q^* + T^*$, implying that R_i can charge at most $T_i(w_i) = w^*Q^* + T^* - \big(\gamma(w_i)w_iQ(p(w_i)) + (1-\gamma(w_i))w_iQ^*\big)$. Hence, R_i's expected profit as a function of w_i is:

$$\begin{aligned} E\pi_R(w_i) &= \big(1-\theta(w_i)\big)\big((p(w_i) - w_i)Q(p(w_i))\big) - T_i(w_i) \\ &= Q^*\left(p^* - \varepsilon - w^* + \frac{T^*\big(w^* - w_i\big)}{w_iQ(p(w_i)) - w^*Q^*}\right). \end{aligned}$$

The derivative of $E\pi_R(w_i)$ with respect to w_i is:

$$\frac{dE\pi_R(w_i)}{dw_i} = Q^*T^*\left(\frac{w^*\left[Q^* - Q(p(w_i))\right] + w_i(w_i - w^*)\dfrac{dQ(p(w_i))}{dw_i}}{\left(w_iQ(p(w_i)) - w^*Q^*\right)^2}\right).$$

We have that $dE\pi_R(w_i)/dw_i = 0$ when $w_i \to 0$, because the term in the first squared brackets equals zero as $Q(p(0)) = Q^*$. The second derivative, evaluated at $w_i \to 0$, is:

$$\left.\frac{d^2E\pi_R(w_i)}{d^2w_i}\right|_{w_i \to 0} = -T^*\frac{\dfrac{dQ(p(w_i))}{dw_i}}{Q^*w^*} < 0,$$

where the inequality follows because $T^* < 0$ and $Q(p(w_i))$ is decreasing with w_i. To see that $E\pi_R(w_i)$ is concave in w_i for all $0 \le w_i \le w^*$, notice that since $T^* < 0$,

$$\text{sign}\left(\frac{dE\pi_R(w_i)}{dw_i}\right) = \text{sign}\left(w^*\left[Q(p(w_i)) - Q^*\right] + w_i\left[(w^* - w_i)\frac{dQ(p(w_i))}{dw_i}\right]\right)$$

The term in the first squared brackets is negative because $w_i \ge 0$ implies that $Q^* \ge Q(p(w_i))$, and the term in the second squared brackets is negative because $w_i \le w^*$ and $dQ(p(w_i))/dw_i < 0$. This implies that $dE\pi_R(w_i)/dw_i < 0$ for all $0 < w_i \le w^*$, and since $dE\pi_R(w_i)/dw_i = 0$ for $w_i = 0$, $w_i = 0$ maximizes $E\pi_R(w_i)$ among all $0 < w_i \le w^*$. Notice that the term in the second squared brackets is positive if $w^* < w_i$, but since the term in the first squared brackets is still negative for $w^* < w_i$, $dE\pi_R(w_i)/dw_i < 0$ for $w^* < w_i$ as well, as long as w_i is not too high.

Finally, substituting $w_i \to 0$ into $E\pi_R(w_i)$ yields $E\pi_R(w_i \to 0) \to p^*Q^* - \varepsilon - (w^*Q^* + T^*)$. Evaluating $E\pi_R(w_i)$ at exactly $w_i = 0$ yields the same profit. When $w_i = 0$, equation (A-11) implies that the supplier's profit gross of T_i is 0, and therefore the supplier accepts the deviation as long as $w^*Q^* + T^* > T_i$. Therefore, given that R_i sets $w_i = 0$, R_i can charge up to $T_i = w^*Q^* + T^*$ and earn $p^*Q^* - \varepsilon - T_i = p^*Q^* - \varepsilon - (w^*Q^* + T^*)$.

Appendix C: Competition among suppliers-exclusive dealing absent communication-description of mixed strategy equilibrium (note 12):

Suppose that R_i offered $S_k \ne S_1$ a contract $w_i = T_i = 0$, and did not make S_1 an offer while R_j offered S_1 the equilibrium contract (w^*, T^*). Consider a mixed-strategy equilibrium in which S_1 believes that in the end of the current period R_i sets p^* with probability γ and sets $p^* - \varepsilon$ with probability $1-\gamma$ while R_i believes that S_1 accepts R_j's offer with probability θ and rejects R_j's offer with probability $1-\theta$.

If S_1 rejects R_j's offer, S_1 earns 0 regardless of R_i's actions. If S_1 accepts R_j's offer, his expected profits are:

$$\gamma\left(w^*Q^*/2 + T^*\right) + (1-\gamma)T^*.$$

The first term corresponds to the case where R_i sets p*, in which case R_i and R_j split the monopoly profit and so S_1 sells Q*/2 units to R_j and earns w*Q*/2. The second term corresponds to the case where R_i sets p* – ε, so that R_j makes no sales and hence pays nothing to S_1, who nevertheless pays R_j the equilibrium slotting allowance.

In a mixed strategy equilibrium, S_1's indifference dictates that:

$$\gamma\left(w^*Q^*/2+T^*\right)+\left(1-\gamma\right)T^*=0,$$

where the right-hand side is S_1's expected profit from rejecting R_j's offer. Hence it is straightforward to show that in a mixed strategy equilibrium:

$$\gamma=\frac{-2T^*}{w^*Q^*}.$$

Notice that indeed γ > 0. Recall that we are contemplating collusive equilibria for δ < ½, and according to Lemma 2, T* < 0 in such cases. Note also that γ ≤1. To see why, recall that S_1's one-period profit in a collusive equilibrium is w*Q* + 2T* > 0, which requires that w*Q* > –2T*.

As for R_i, when he sets p*, his expected profits are:

$$\theta p^*Q^*/2+\left(1-\theta\right)p^*Q^*.$$

The first term corresponds to the case where S_1 accepts R_j's contract, so that R_i splits the monopoly profits with R_j. The second term corresponds to the case where S_1 rejects R_j's contract, so that R_i earns the entire monopoly profit.

When R_i sets p*–ε, he makes p^*Q^*–ε regardless of whether S_1 accepts or rejects R_j's contract, since in both cases R_j makes no sales. In a mixed strategy equilibrium, R_i's indifference requires:

$$\theta p^*Q^*/2+\left(1-\theta\right)p^*Q^*=p^*Q^*-\varepsilon.$$

Hence,

$$\theta=\frac{2\varepsilon}{p^*Q^*}.$$

For an arbitrarily small and positive ε, θ too is arbitrarily small and positive.

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