

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 and rejects deviations from the collusive vertical contract. 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. When retailers are differentiated, vertical collusion plays a dual role of helping retailers collude while solving the supplier's inability to commit to charging the monopoly wholesale price.

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 before retailers set the retail price? 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 secret, they encourage

¹See 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) (stressing that information such as "... supplier or cost information ..." is commercially sensitive and should not be

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 (we later extend the model to multiple suppliers). In every period, retailers offer secret, 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 observable 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 profits 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, does not agree to pay retailers fixed fees unless they offer him a high wholesale price: The supplier expects that retailers will continue rewarding him in the future with a high wholesale price only if he maintains the collusive scheme. The higher wholesale price too has repercussions on the retailers'

shared). See similar statements in OECD (2010) and New Zealand Commerce Commission (2014).

incentives to collude: While it lowers their profits from deviating from collusion, it also lowers their profits from colluding. When retailers are homogeneous, or only slightly differentiated, a higher wholesale price even further facilitates collusion. Hence, with homogeneous (or almost homogeneous) retailers, vertical collusion is sustainable even for very impatient parties. Conversely, when retailers are differentiated, the higher wholesale price in itself (ignoring the fixed fee paid to retailers) may hinder collusion, when it considerably lowers retailers' collusive profits. To induce retailers to collude in such cases, the supplier needs to pay them a higher fixed fee. But because the supplier requires a high wholesale price to compensate him for the higher fixed fee he pays retailers, vertical collusion with differentiated retailers is not sustainable for very impatient players. Still, we show that in the case of retailer differentiation too vertical collusion is easier to sustain than ordinary horizontal collusion. Moreover, with differentiated retailers, we show that vertical collusion not only helps retailers sustain monopoly retail prices, but also solves the supplier's well-known inability to commit to a high wholesale price.

For vertical collusion to be sustainable, parties need to be induced not to deviate from these collusive vertical contracts. This is challenging when vertical contracts are secret, because one retailer does not observe whether the other retailer made a side-deal with the supplier in order to deviate from collusion. We show that when a retailer attempts to deviate from the collusive price by offering the supplier a different vertical contract without compensating the supplier, the supplier rejects the retailer's offer and refuses to sell him the product. Having to compensate the supplier to avoid such rejection renders the retailer's deviation unprofitable.

We then extend the analysis to the case of multiple suppliers competing over selling a homogeneous 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 collusive equilibrium is sustained with single-period exclusive dealing commitments. The supplier is induced to assist this vertical collusive scheme, because otherwise he makes no profits, due to intense competition from other suppliers. 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. In particular, we identify 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. In 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.

A second, related, policy implication of our results is 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. Such antitrust scrutiny can cause the vertical collusive scheme to break down in the presence of competition among suppliers.

The third 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.

Finally, 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

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

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.³

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 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. In a paper closely related to ours, Piccolo and Miklós-Thal (2012) show that retailers with bargaining power can collude by offering myopic suppliers a high wholesale price and negative fixed fees. They were the first to show how high wholesale prices, combined with slotting allowances, can help sustain ongoing collusion among retailers. Our paper contributes to theirs in that they assume the retailers observe each other’s vertical contracts with the supplier before they set the retail price, and this is what deters them from deviating from the collusive vertical contract. We contribute to this idea by assuming retailers cannot observe each other’s vertical contract and showing how a joint forward-looking supplier can replace the role of observability by each retailer of his rival’s vertical contract: in our model, what deters retailers from deviating from the collusive contract is that the supplier will reject the deviation and refuse to deal with the deviating

³ 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.

retailer, and compensating the supplier so as to cause him not to reject renders the deviation unprofitable. Second, Piccolo and Miklós-Thal also consider information exchange. They show that retailers have an incentive to credibly reveal to each other their vertical contracts, as doing so facilitates collusion. We contribute to this idea by considering a joint forward-looking supplier, who has an incentive to police adherence to the collusive scheme even when retailers do not share such information about each other. Furthermore, in section 5, where we discuss multiple suppliers, we show how communication between the supplier and each retailer about whether the competing retailer offered the supplier an exclusive dealing contract can facilitate collusion. Hence, while Piccolo and Miklós-Thal consider the case where each retailer deals with a separate supplier, we analyze the case where all retailers deal with the same supplier, either because there is only one supplier, or because retailers commit to buy only from one of the suppliers.

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. We show that additional strategic considerations come into play when both the retailers and

the supplier are forward-looking players.

The second strand of the literature concerns static games in which vertical contracts serve as a device 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 Vergé (2004) consider suppliers that make secret contract offers to retailers. They find that a supplier may behave opportunistically 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. In the base model, 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. In section 6 we show that the qualitative features of the vertical collusion scheme we identify by using the simple homogeneous case also extend to differentiated retailers.

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_M and Q_M denote the monopoly price and quantity, where p_M maximizes $pQ(p)$ and $Q_M = Q(p_M)$. The monopoly profit is $p_M Q_M$.

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. In the first stage, 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_j cannot know whether R_i signed a contract with the supplier until the end of the period, when retail prices are observable. The contract offer is valid for the current period only.⁴

In the second stage of each period, 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

⁴ 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>.

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:

$$\frac{\frac{1}{2}p_M Q_M}{1 - \delta} > p_M Q_M \iff \delta > \frac{1}{2},$$

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 $\delta = \frac{1}{2}$, 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-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

This section derives a competitive equilibrium benchmark in which the three firms have $\delta = 0$. 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. We show that in the static game, price competition dissipates all of the retailers' profits. Because contracts are secret, there are multiple equilibria. In some of them, the supplier's wholesale price is below the monopoly wholesale price. Notably, the monopoly price can still be an equilibrium when retailers are homogeneous. Yet, introducing even a slight degree of differentiation between the retailers eliminates the monopoly outcome as a static equilibrium. Furthermore, with even slight retailer differentiation, the only pure strategy

equilibrium of the static game involves wholesale prices equal to zero.

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 $(p^C - w^C)\frac{Q(p^C)}{2} - T^C$ and the supplier earns $w^C Q(p^C) + 2T^C$.

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 $T^C > 0$. There is no competitive equilibrium with $T^C < 0$ either: The supplier can profitably deviate from such an equilibrium by accepting only R_i 's offer. R_i expects that in equilibrium the supplier accepts both of the retailers' offers. 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 we solve for the set of equilibrium levels of w^C . Since firms play a game of incomplete information, there are multiple equilibria, depending on firms' out-of-equilibrium beliefs. Consider an equilibrium with a certain w^C . We assume that firms rationally anticipate the response of other firms to deviations from such an equilibrium. In particular, when R_i deviates from an equilibrium contract, the supplier and R_i rationally anticipate each other's response (i.e., how the deviation affects the supplier's incentive whether to accept R_j 's offer, and how it affects R_i 's retail price).

Consider a deviation by R_i . R_j offers $w_j = w^C$ and is not aware of R_i 's deviation. Therefore, given that the supplier accepts R_j 's offer of $w_j = w^C$ (and consequently R_j charges $p_j = w^C$), R_i has two possible deviations. First, R_i cannot benefit from deviating to $w_i < w^C$. Following such a deviation, R_i will slightly undercut w^C and capture the market. Yet, R_i and the supplier's joint profit will be slightly lower than $w^C Q(w^C)$, which is what the supplier can earn by rejecting the deviation and accepting only R_j 's offer (as we illustrate later, however, a deviation to $w_i < w^C$ is always profitable when retailers are differentiated). Second, consider a deviation by R_i to $w_i > w^C$. Such a deviation might be profitable for R_i if it motivates the supplier to accept only R_i 's offer.⁵ However, if w^C is sufficiently high, the supplier would rather accept only R_j 's offer, in which case

⁵If R_i believes that the supplier accepts R_j 's contract offer regardless of w_i , then any $w^C \in [0, p_M]$ and therefore any $\pi_S^C \in [0, p_M Q_M]$ can be an equilibrium. Such beliefs are consistent with the definition of “passive beliefs” in McAfee and Schwartz (1994).

R_i would not benefit from the deviation. This follows because if the supplier accepts only R_i 's offer, R_i is expected to set the monopoly retail price corresponding to a wholesale price of w_i , and this involves double marginalization. On the other hand, accepting only R_j 's offer induces R_j to set $p_j = w^C$, with no double marginalization. This implies that in the homogeneous retailer case (unlike the differentiated retailer case we explore later), the wholesale price in equilibrium must be strictly positive. If w^C is low enough, R_i would convince the supplier to accept $w_i > w^C$ and reject R_j 's offer. Although this too would cause double marginalization, the supplier would prefer it to accepting only R_j 's offer and earning $w^C Q(w^C)$. More specifically, let $p(w_i)$ denote the monopoly price of retailer R_i :

$$p(w_i) = \arg \max_p \{(p - w_i)Q(p)\}. \quad (1)$$

The following lemma characterizes the set of competitive static equilibria: 6

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

$$w^C Q(w^C) \geq \max_{w_i} \{w_i Q(p(w_i))\}, \quad (2)$$

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

As noted, when retailers are fully homogeneous, the monopoly outcome can be an equilibrium. To see why, suppose that R_i expects that R_j will set $w^C = p_M$. The supplier can earn the monopoly profits by accepting R_j 's offer exclusively. This is because R_j then sets $p^C = w^C = p_M$ and therefore the supplier earns $w^C Q(w^C) = p_M Q_M$ and fully internalizes R_j 's profits. This in turn implies that R_i cannot benefit from offering any wholesale price other than $w^C = p_M$. A similar logic applies to other equilibria with $w^C = p^C < p_M$.

Yet, following O'Brien and Shaffer (1992), we show in section 6 that if retailers are even slightly differentiated, the monopoly outcome is no longer an equilibrium, and all pure strategy equilibria with $w^C > 0$ collapse. Intuitively, under even slight differentiation, the w^C that induces R_j to set p_M has to be slightly below p_M , because of R_j 's profit margin

⁶Proofs of all propositions and lemma's are in Appendix A.

enabled by differentiation. Consequently, the supplier does not fully internalize all of R_j 's profits, and has an opportunistic incentive to agree to a secret discount offer by R_i . For any $w^C > 0$, the supplier and R_i would similarly agree on a wholesale price below w^C . Accordingly, all pure strategy equilibria with $w^C > 0$ (and consequently, with $T^C \neq 0$) are eliminated. This result implies that when retailers are even slightly differentiated, vertical collusion can enable the parties to simultaneously solve the supplier's inability to commit to a high wholesale price and the retailer's inability to sustain a collusive retail price.

In what follows, we solve the static and collusive equilibria under the extreme assumption of homogeneous retailers and in section 6 we extend the analysis to retailer differentiation. Since the features of the collusive scheme in the homogeneous retailer case qualitatively hold in the presence of retailer differentiation, the homogeneous case provides a tractable benchmark for examining vertical collusion with differentiated retailers. It should also be noted that retailers always benefit from collusion, including when they are homogeneous, because they earn zero in all static equilibria. The supplier may also benefit from vertical collusion in the homogeneous case, because retailers may not play the static monopoly equilibrium when such an equilibrium exists. In what follows, we assume that if vertical collusion breaks down, retailers play a static equilibrium with $\pi_S^C < p_M Q_M$.

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 $\delta < \frac{1}{2}$. 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 $\pi_S^C < p_M Q_M$. 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 equilib-

rium contract, (w^*, T^*) that the supplier accepts. Then, in stage 2, both retailers set the monopoly price, p_M , and equally split the monopoly quantity, Q_M . Given an equilibrium contract, (w^*, T^*) , in every period each retailer earns $\pi_R(w^*, T^*) = (p_M - w^*) \frac{Q_M}{2} - T^*$ and the supplier earns $\pi_S(w^*, T^*) = w^* Q_M + 2T^*$.

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_M , thereby dominating the downstream market. R_i cannot observe, however, whether this deviation is a result of R_j having a different contract than (w^*, T^*) , which motivates R_j to deviate from the monopoly price, or whether R_j offered the supplier the equilibrium contract (w^*, T^*) , but nevertheless undercut the monopoly price. 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 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_M . 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_M or does not carry the product), retailers play the competitive equilibrium defined in section 3 in all future periods. 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_S^C .⁷

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.

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_M in stage 2 rather than deviating to a slightly lower price. By deviating, R_i gains all the demand in the current

⁷Retailers may also be able to coordinate on the competitive equilibrium outcome and choose the lowest π_S^C possible, $w_L Q(w_L)$.

period, but stops future collusion. R_i will not deviate from collusion in the second stage if:

$$(p_M - w^*) \frac{Q_M}{2} - T^* + \frac{\delta}{1 - \delta} \left((p_M - w^*) \frac{Q_M}{2} - T^* \right) \geq (p_M - w^*) Q_M - T^*, \quad (3)$$

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 (3) is affected only by the retailers' discount factor and not by the supplier's.

In what follows, we show how vertical collusion can be sustainable for $\delta < \frac{1}{2}$. We proceed in the following steps, illustrated in Figure 1. First, we show that in order to ensure that retailers collude when $\delta < \frac{1}{2}$, it must be that $T^* < 0$ (that is, the supplier must pay slotting allowances to retailers). In the second step we show that if the supplier must pay slotting allowances, w^* must be sufficiently high, because otherwise the supplier will not want to participate in the collusive scheme. The ability to maintain vertical collusion also depends on the supplier's δ . In the third step, we show that a higher w^* may then have repercussions for the retailers' incentive to collude. In the homogenous retailer case we focus on in the current section, however, we show that the higher w^* further encourages retailers to collude. In section 6 we show that if retailers are differentiated, these repercussions can have a negative effect on retailers' incentive to collude. Yet, this effect may not overturn the positive effect of setting $T^* < 0$, so vertical collusion is still possible.

[Figure 1 here]

Let us first establish these results: The first step is to show the importance of slotting allowances for the collusive scheme. Solving condition (3) for T^* derives the following result:

Lemma 2 *If $\delta < \frac{1}{2}$, then any collusive equilibrium has to involve negative fees, $T^* < 0$.*

Notice that the result that $T^* < 0$ holds even when $w^* = 0$. 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 primarily the fixed fees the supplier pays retailers that motivate retailers to set the monopoly price, even though the fixed

fees paid in a particular period 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_M in the current period, the supplier will implicitly "reward" the retailer in the next periods by paying them slotting allowances. When $\delta < \frac{1}{2}$, 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 $\delta > \frac{1}{2}$, 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 ensure that the supplier, who is as short-sighted as retailers are, would not behave opportunistically and reject one of the retailers' offers. By doing so, the supplier can avoid paying fixed fees twice. Accordingly, the second necessary condition on the collusive contract is the supplier's incentive constraint:

$$\frac{w^*Q_M + 2T^*}{1 - \delta} \geq w^*Q_M + T^* + \frac{\delta}{1 - \delta}\pi_S^C. \quad (4)$$

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_M and sell Q_M , implying that in the current period the supplier earns $w^*Q_M + T^*$ and collusion breaks down in all future periods, in which the supplier earns π_S^C . Note that (4) is affected only by the supplier's discount factor.

If the right hand side of (4) 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.

When the retailers' discount factor is below $\frac{1}{2}$ and hence collusion requires $T^* < 0$, the supplier gains in the short-run by deviating from collusion and accepting the offer of only one retailer so as to pay slotting allowances only once. Hence, the second step, as illustrated in figure 1, is to show that in order to deter the supplier from such a deviation, retailers have to offer the supplier a high enough wholesale price and rely on the supplier's δ . The following lemma follows directly from lemma 2 and from condition (4):

Lemma 3 When $T^* < 0$, condition (4) requires that $w^* > \frac{\pi_S^C}{Q_M}$ and $\delta > 0$. As T^* decreases, a higher w^* is needed to maintain condition (4).

Lemma 3 highlights the importance that all three firms, including the supplier, care about future profits. A supplier with a positive discount factor that joins the collusive scheme can facilitate collusion. The supplier is willing to pay both retailers slotting allowances because the supplier expects a compensation in future periods in the form of a high wholesale price. The more the supplier cares about the future, the lower is the wholesale price that retailers need to give the supplier to ensure the supplier's participation in the collusive scheme.

The third step to notice is that raising w^* , which is needed to motivate the supplier to participate in collusion through condition (4), has a repercussion on the retailers' incentive to collude through condition (3). The condition implies that as w^* increases, the retailer's profit from both maintaining and deviating from collusion decreases. More precisely, an increase in w^* decreases R_i 's benefit from collusion by $\frac{\frac{1}{2}Q_M}{1-\delta}$, which is R_i 's discounted sum of collusive quantity, and decreases the benefit from deviating from collusion by Q_M , which is the demand facing R_i when slightly undercutting p_M . For $\delta < \frac{1}{2}$, $\frac{\frac{1}{2}Q_M}{1-\delta} < Q_M$, so the second effect dominates. Intuitively, since retailers are homogeneous, undercutting the collusive price provides the deviating retailer with a substantial increase in demand, which becomes more costly to supply – and less beneficial for the deviating retailer – the higher is w^* . Consequently, this repercussion further facilitates collusion. We should note that when retailers are differentiated, an increase in w^* may decrease the retailers' incentive to collude. In section 6, we provide a condition that ensures that if an increase in w^* has a negative effect on condition (3) then this effect is not strong enough to offset the positive effect on the supplier's incentive to collude through condition (4). As explained in section 6, this condition holds when retailers are slightly differentiated, and may also hold for higher levels of differentiation.

Given w^* , (4) places an upper threshold on T^* (that is, T^* should not be too negative), which we denote $T_S(w, \delta)$. This is while (3) places a lower threshold on T^* (that is, T^* should be negative enough), denoted $T_R(w, \delta)$. Hence, (4) and (3) imply that for vertical collusion to be sustainable, given that the collusive contract was offered and accepted, and given w^* and δ , it is required that $T_S(w, \delta) \leq T \leq T_R(w, \delta)$.

From lemma 3, $T_S(w, \delta)$ is decreasing with w . As for $T_R(w, \delta)$, in the homogeneous

retailers case it is increasing with w , since, as discussed above, increasing w has positive repercussions on retailers' incentive to collude. Accordingly, in the homogeneous case, increasing w always increases the gap between $T_S(w, \delta)$ and $T_R(w, \delta)$, making it possible to find a T^* such that $T_S(w, \delta) \leq T \leq T_R(w, \delta)$. This enables the parties, in the homogeneous case, to sustain vertical collusion for any δ .

Conditions (3) and (4) (and hence, $T_S(w, \delta) \leq T \leq T_R(w, \delta)$) ensure that if both retailers offer the collusive contract, the supplier accepts both offers and then in the second stage each retailer sets p_M . The remaining requirement is that in stage 1, R_i does not find it profitable to deviate to any other contract, $(w_i, T_i) \neq (w^*, T^*)$. In what follows, we show that the supplier is the key to prevent such deviations. Any contract deviation that enables R_i to deviate from collusion and steal R_j 's market share makes the supplier lose on his contract with R_j . Hence, absent compensation from R_i , the supplier rejects any contract deviation by R_i and refuses to supply R_i the product. To convince the supplier to accept the deviation, R_i needs to compensate the supplier accordingly. But this, in turn, renders the contract deviation unprofitable to R_i . Hence, although R_j cannot see R_i 's contract deviation, the supplier, of course, sees it, and prevents it.

The benefit to R_i and the supplier from a contract 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. The case of particular interest is $\delta < \frac{1}{2}$, since for $\delta \geq \frac{1}{2}$ retailers can sustain collusion without the supplier's aid. Suppose beliefs are "rational" in the sense that 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.

First, it can easily be shown that if they believe that collusion continues, despite the contract deviation, then the contract deviation is not profitable to R_i .⁸

⁸ The intuition follows from condition (4) holding in equality. Since the supplier is then just indifferent between maintaining and stopping collusion, R_i cannot offer the supplier a deviating contract

The case of interest is the second option, where R_i and the supplier believe the contract deviation, $(w_i, T_i) \neq (w^*, T^*)$, will cause collusion to stop. In the period of any such deviation, R_i can earn at most $p_M Q_M - (w^* Q_M + T^*)$. 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 $w^* Q_M + T^*$. Note that rational beliefs following the contract deviation (if accepted by the supplier) cannot yield pure-strategies: If the supplier believes R_i will slightly undercut p_M and capture the whole market, he will reject R_j 's offer. But if R_i anticipates this, he would rather charge a monopoly price and not price cut. However, Appendix B shows that there is a mixed-strategy equilibrium following the contract deviation, in which the supplier accepts R_j 's offer with a very small probability and R_i mixes between charging $p_M - \varepsilon$ and charging R_i 's monopoly price given $w_i, p(w_i)$. R_i 's profit from the deviation is at most $p_M Q_M - \varepsilon - (w^* Q_M + T^*)$. Then, in all future periods, collusion stops, so R_i earns 0 and the supplier earns π_S^C . The following lemma shows that whenever condition [\(3\)](#) holds, such a deviation is not profitable for R_i .

Lemma 4 *Suppose that the contract (w^*, T^*) satisfies [\(3\)](#). Then, under rational beliefs, R_i cannot profitably deviate to any contract offer $(w_i, T_i) \neq (w^*, T^*)$ that stops collusion.*

Intuitively, the joint, forward-looking supplier takes part in the collusive scheme, and if R_i attempts to deviate from the collusive contract, R_i needs to compensate the supplier for his losses, since otherwise the supplier rejects R_i 's offer and refuses to supply the product to R_i . This mechanism is different than in Piccolo and Miklós-Thal (2012), where contracts are observable, and what deters R_i from making a contract deviation is that R_j can observe the deviation in the current period.

We can conclude that for $\delta < \frac{1}{2}$, the vertical collusive contract solves:

$$\max_{(w, T)} \left\{ (p_M - w) \frac{Q_M}{2} - T \right\},$$

s.t. condition $T_S(w, \delta) \leq T \leq T_R(w, \delta)$ and $\pi_S(w^*, T^*) \geq \pi_S^C$. A collusive equilibrium exists for $\delta < \frac{1}{2}$ if the solution to the above maximization problem yields $\pi_R(w^*, T^*) > 0$.

Proposition [1](#) characterizes the unique vertical collusive 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. The proof of this statement follows directly from condition [\(4\)](#) and is available in section 1 in the online supplementary material to our paper, at: <https://www.tau.ac.il/~yehezkel/>.

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

$$w^* = \begin{cases} p_M - \frac{2\delta^2 (p_M Q_M - \pi_S^C)}{(1-\delta) Q_M}; & \text{if } \delta \in (0, \frac{1}{2}]; \\ \frac{\pi_S^C}{Q_M}; & \text{if } \delta \in [\frac{1}{2}, 1], \end{cases} \quad (5)$$

and:

$$T^* = \begin{cases} -\frac{\delta}{1-\delta} (1-2\delta) (p_M Q_M - \pi_S^C); & \text{if } \delta \in (0, \frac{1}{2}]; \\ 0; & \text{if } \delta \in [\frac{1}{2}, 1], \end{cases} \quad (6)$$

Proposition 1 shows that a vertical collusion equilibrium exists when retailers are too shortsighted to maintain horizontal collusion. This 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:

$$\pi_R^* = \begin{cases} \delta (p_M Q_M - \pi_S^C); & \delta \in (0, \frac{1}{2}]; \\ \frac{1}{2} (p_M Q_M - \pi_S^C); & \delta \in [\frac{1}{2}, 1]; \end{cases} \quad \pi_S^* = \begin{cases} (1-2\delta) p_M Q_M + 2\delta \pi_S^C; & \delta \in (0, \frac{1}{2}]; \\ \pi_S^C; & \delta \in [\frac{1}{2}, 1]. \end{cases}$$

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 2 illustrates the vertical collusion equilibrium as a function of δ .

Corollary 1 *In the vertical collusion equilibrium in the homogenous case:*

- (i) *For $\delta \in (0, \frac{1}{2}]$ 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 $\delta \in [\frac{1}{2}, 1]$ the equilibrium wholesale price and the firms' profits are independent of δ and retailers do not charge slotting allowances: $SA^* = 0$; the supplier earns its reservation profit (from the competitive equilibrium) and retailers earn the remaining monopoly profits.*

[Figure 2 here]

Figure 2 and part (i) of corollary 1 reveal that at $\delta = \frac{1}{2}$, $w^* = \frac{\pi_S^C}{Q_M}$, $SA^* = 0$ and retailers earn most of the monopoly profits. As δ decreases, w^* increases, and retailers gain a lower proportion of the monopoly profits. Moreover, the equilibrium slotting allowances are an inverse U-shaped function of δ . Finally, at $\delta \rightarrow 0$, $w^* \rightarrow p_M$, and the supplier earns all of the monopoly profits.

The intuition for these results is as follows. When $\delta = \frac{1}{2}$, retailers are indifferent between colluding or not, so no slotting allowances are needed. When δ decreases slightly below $\frac{1}{2}$, retailers rely on the supplier in the following way. First, from lemma 2, retailers set $SA^* > 0$ in order to satisfy condition (3). As we explained above, slotting allowances affect the retailers' incentive to collude because retailers expect that by colluding in the current period, the supplier will reward them with slotting allowances in the next period. Second, from lemma 3, retailers need to motivate the supplier to agree to pay them $SA^* > 0$ in every period, by raising w^* . The supplier agrees to pay slotting allowances because the supplier expects that by doing so, retailers will reward the supplier in the next period with a high $w^* > \frac{\pi_S^C}{Q_M}$. Third, the increase in w^* has repercussions on the retailers' incentive to collude, back through condition (3). As we explained when describing the intuition for lemma 3, in the homogeneous case this repercussion further increases the retailers' incentive to collude. With differentiated retailers, however, as shown in section 6, the repercussion of raising w^* on retailers' incentive to collude could be negative. Nevertheless, we provide a condition that ensures that such a negative effect of an increase in w^* is not strong enough to offset the positive effect an increase in w^* has on the supplier's incentive to collude. Hence the main result obtained in the homogeneous retailer case, according to which the collusive vertical contract makes vertical collusion easier to sustain than ordinary horizontal collusion, carries over to the case of differentiated retailers.

Corollary 1 further characterizes the case of homogeneous retailers for even lower levels of δ . As δ further decreases, both retailers and the supplier have less of an incentive to collude and the parties raise both slotting allowances and wholesale prices to enable collusion. Moreover, the shorter sighted retailers become more dependent on the supplier, who also becomes more short-sighted, which requires retailers to leave the supplier with an increasingly higher share of the collusive profit. At some point, the high slotting

allowances hinder the supplier's willingness to participate in the collusive scheme, so for even lower levels of δ , slotting allowances decline, and even higher wholesale prices are used to enable collusion.

As $\delta \rightarrow 0$, collusion is still sustainable, with slotting allowances close to zero, and wholesale prices close to the monopoly retail price. As noted in section 3 in the homogeneous retailer case, a wholesale price equal to the monopoly price is also one of the multiple equilibria of the static game, absent collusion. Vertical collusion on the monopoly outcome converges to this equilibrium as $\delta \rightarrow 0$. As we show in section 6 below, the monopoly static equilibrium collapses whenever retailers are even slightly differentiated. Hence, with any level of differentiation, monopoly pricing is not achievable in a static game. To enable monopoly pricing when retailers are too impatient, they must use vertical collusion and add the forward-looking supplier to the collusive scheme.

Part ii of Corollary 1 reveals that when $\delta > \frac{1}{2}$, 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_S^C , and do not charge slotting allowances.

We conclude this section by highlighting the policing role of the supplier. The supplier's ability to stop collusion by rejecting one of the retailers' contracts forces retailers to share the profits from collusion with the supplier. Yet, 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. To see why, 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_M . Under such a trigger strategy, the supplier's decision whether to accept a retailer's offer no longer affects future collusion. The following lemma shows that retailers cannot implement the collusive scheme with this trigger strategy:

Lemma 5 *Suppose that $\delta < \frac{1}{2}$ 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.*

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 $\delta < \frac{1}{2}$, 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 several identical suppliers S_1, S_2, \dots, S_n . S_1 discounts future profits by δ . In the first stage of every period, retailers simultaneously make secret offers to one or more suppliers. Each supplier cannot observe R_1 and R_2 's offers to other suppliers, and each retailer cannot observe the competing retailer's offers. All suppliers simultaneously 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 S_1 the contract (w^*, T^*) that S_1 accepts, and then charge consumers p_M . As before,

we assume that any observable deviation in period t triggers the competitive equilibrium from period $t + 1$ onwards.

Consider the competitive equilibrium in which all firms earn zero. That is, $\pi_S^C = 0$. Unlike the case of a monopolistic supplier, with competing suppliers $w^C = T^C = 0$ 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 S_1 . In order to maintain a collusive equilibrium, the collusive contract has to satisfy conditions (3) and (4). When $\delta > \frac{1}{2}$, the collusive equilibrium is trivially sustainable with a contract $(w^*, T^*) = (0, 0)$. 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 $\delta < \frac{1}{2}$. Now, the collusive contract needs to eliminate R_i 's incentive to deviate from collusion by offering the collusive contract to S_1 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 S_1 only, but the deviating retailer, R_i , offers S_1 the collusive contract (w^*, T^*) and at the same time makes a secret offer to one or more of the competing suppliers with $w_i = T_i = 0$. S_1 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 S_1 . Moreover, R_i can then charge consumers a price slightly below p_M , dominate the market and earn $p_M Q_M - T^*$. 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, $((p_M - w^*)\frac{Q_M}{2} - T^*)/(1 - \delta)$, are higher than a one-period deviation in which R_i buys from a competing supplier, $p_M Q_M - T^*$. However,

$$p_M Q_M - T^* > \frac{\delta p_M Q_M}{(1 - \delta)} \geq \frac{(p_M - w^*)\frac{Q_M}{2} - T^*}{1 - \delta}, \quad (7)$$

where the first inequality follows because $T^* < 0$ and $\delta < \frac{1}{2}$, and the second inequality

follows from the definition of π_R^* . This implies that R_i will deviate from this collusive equilibrium by making the secret offer to the competing supplier.⁹ The following corollary summarizes this result:

Corollary 2 *Suppose that the upstream market includes multiple homogenous suppliers S_1, S_2, \dots, S_n . Then, if retailers cannot offer one of the suppliers, with a discount factor δ , an exclusive dealing contract, and $\delta < \frac{1}{2}$, vertical collusion is not sustainable.*

Intuitively, for $\delta < \frac{1}{2}$, retailers are too short-sighted and have a strong incentive to deviate from collusion. Therefore, retailers need to involve a forward looking supplier in the collusive scheme. But when retailers can buy the product at $w = 0$ from a competitive supplier, S_1 '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 $\delta < \frac{1}{2}$, when retailers can sign exclusive dealing contracts with S_1 provided that 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 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 S_1 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 $\delta < \frac{1}{2}$. Consider a proposed collusive equilibrium in which in every period, the two retailers offer S_1 a contract (w^*, T^*, ED) , where w^* and T^* are the same as in proposition 1. S_1 accepts both offers and then retailers set p_M . This cannot be an equilibrium, because R_i will find it optimal not to make an offer to S_1 and instead offer a deviating contract $w_i = T_i = 0$ to one or more of the competing suppliers. Applying "rational beliefs" to this deviation cannot yield pure strategies: If S_1 – observing that R_i didn't made him an offer – believes that R_i obtained

⁹Notice that this argument holds for any (w^*, T^*) that satisfy conditions (3) and (4), and not just for the collusive contract that maximizes the retailers' profit.

the product from a different supplier and will undercut the monopoly price, then S_1 will not accept R_j 's equilibrium offer. But if R_i believes that S_1 will reject R_j 's equilibrium 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 following such a deviation, in which S_1 accepts R_j 's offer with a very small probability and R_i mixes between setting $p_M - \varepsilon$ and p_M . This equilibrium is consistent with rational beliefs, and R_i 's expected profit is $p_M Q_M - \varepsilon$, while the dominant supplier's expected profit is 0.¹⁰ From (7), whenever $\delta < \frac{1}{2}$, 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 S_1 to inform R_j that R_i did not offer S_1 an exclusive dealing contract. Suppose now that S_1 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 S_1 accepted them, S_1 can inform R_j that R_i deviated from the collusive contract and that S_1 didn't accept his offer. This communication is non-verifiable, and consists of "cheap talk" that S_1 can convey to retailers, regardless of whether it is true or not. R_j can then withdraw his original offer and make an alternative offer to S_1 .¹¹ The supplier then accepts or rejects the alternative contract offer and the game moves to the second stage as in our base model.¹² 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 $w_j = T_j = 0$. As we show below, such a belief is rational, because S_1 reports to R_j that R_i deviated from the collusive contract if and only if R_i indeed deviated.

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 (3) is still necessary, because it ensures that given that both retailers deal exclusively with S_1 and offered the collusive contract in the first stage, R_i will not undercut the monopoly price in the second stage.

¹⁰ For a detailed description of this mixed-strategy equilibrium see the online supplementary material.

¹¹ It is possible to show that the results remain the same when R_i cannot remove the original offer and instead can make a second offer such that S_1 can choose between the two offers.

¹² 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.

Next consider S_1 's incentive constraint. Suppose that both retailers offered S_1 the equilibrium contract. If S_1 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 S_1 will earn 0. This means that S_1 's profit from accepting only one of the equilibrium offers is $w^*Q_M + T^*$, as in our base model, and S_1 's incentive constraint is identical to (4) (after substituting $\pi_S^C = 0$). Moreover, this means that S_1 has no incentive to report a deviation to R_j when there was no deviation.¹³

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 4 and lemma 5) holds. If the deviating contract does not include an exclusive dealing clause, then regardless of w_i and T_i , S_1 will rationally believe that R_i offered a competing supplier a contract $w_i = T_i = 0$ and plans to cut the monopoly price. Given this belief, there is no point in accepting R_j 's equilibrium contract and paying him a slotting allowance, and instead S_1 will inform R_j of the deviation. R_j in turn will offer S_1 a contract $w_j = T_j = 0$ that S_1 will accept. This makes R_i 's deviation unprofitable to begin with. The following corollary summarizes this result:

Corollary 3 *Suppose that the upstream market includes homogeneous suppliers S_1, \dots, S_n . Then, if retailers can offer S_1 an exclusive dealing contract, communication and renegotiation between S_1 and retailers is possible, and $\delta < \frac{1}{2}$, there is a collusive equilibrium in which in every period the two retailers sign an exclusive dealing contract (w^*, T^*, ED) with S_1 , where (w^*, T^*) are as 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 R_i 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.

¹³ Notice that if S_1 accepts R_i 's equilibrium offer and falsely reports to R_j that R_i deviated from collusion, the supplier will earn $T^* < 0$.

6 Differentiated retailers

Suppose now that retailers are horizontally differentiated. The demand function facing R_i is $q(p_i, p_j)$, where R_i charges p_i , and $q(p_i, p_j)$ is decreasing with p_i and increasing with p_j . The demand function when only R_i sells the product is $Q(p_i) \equiv q(p_i, \infty)$. Let p_M denote the monopoly price that maximizes $p_i q(p_i, p_j) + p_j q(p_j, p_i)$ with respect to p_i (or p_j) and let $q_M \equiv q(p_M, p_M)$. As retailers are imperfect substitutes, we assume that: $q_M \leq Q(p_M) \leq 2q_M$, where the first (second) inequality becomes an equality when retailers are fully differentiated (homogeneous). Finally, let $p(w_i; p_j)$ denote R_i 's price that maximizes $(p_i - w_i)q(p_i, p_j)$ with respect to p_i , given that R_i and the supplier agree on a wholesale price w_i and R_i expects that R_j sets p_j . Notice that $p(w_i; p_j)$ is increasing with w_i .

6.1 Competitive Static Equilibrium Benchmark

In this subsection we solve for the competitive, static benchmark. Suppose that firms ignore the effect of their strategies on the equilibrium in future periods. 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 $p^C \equiv p(w^C; p^C)$. Each retailer earns $(p^C - w^C) q(p^C, p^C) - T^C$ and the supplier earns $2(w^C q(p^C, p^C) + T^C)$.

Following O'Brien and Shaffer (1992), we first show that if retailers are differentiated – in the sense that retailers can gain a positive profit margin – the monopoly outcome cannot be an equilibrium. This is established in the following Lemma.

Lemma 6 *When retailers are differentiated, retailers cannot implement the monopoly outcome in any static equilibrium.*

Intuitively, the supplier and R_i agree on a contract that maximizes their joint profit given R_j 's equilibrium contract. With differentiation, R_j gains a positive profit margin: $p(w^C; p_i) > w^C$, which R_i and the supplier do not internalize. Hence, they have an incentive to behave opportunistically and undercut p_i below the monopoly price. This enables them to make a profit at the expense of R_j . To do so, they agree on a wholesale price lower than the wholesale price R_j is paying. This causes monopoly pricing to collapse as an equilibrium. Notice that this result holds regardless of the extent to which retailers are differentiated. It only requires that retailers have a positive profit margin.

As O'Brien and Shaffer (1992) show, the same logic applies to any $w^C > 0$. In any putative equilibrium in which $w^C > 0$, the supplier and R_i will have an incentive to behave opportunistically and undercut w^C , because they don't internalize R_j 's profit margin. This leaves $w^C = 0$ as the only pure strategy equilibrium.¹⁴

In what follows, we focus on this unique pure strategy equilibrium of the static game, in which $\pi_S^C = 0$, $w^C = 0$ and $T^C = 0$. Retailers' profits in the static equilibrium are denoted by π_R^C .¹⁵

6.2 Vertical collusive equilibrium with infinitely repeated interaction

Let δ^C denote the critical discount factor under which ordinary horizontal collusion between the differentiated retailers is not sustainable, where:

$$\delta^C \equiv \frac{p(0; p_M)q(p(0; p_M), p_M) - p_M q_M}{p(0; p_M)q(p(0; p_M), p_M) - \pi_R^C}. \quad (8)$$

The purpose of this sub-section is to show that vertical collusion can be sustainable for $\delta < \delta^C$. We look at a marginal decrease in δ below δ^C and show how retailers can use the supplier for colluding with a contract that involves $T^* < 0$ and $w^* > 0$.

Suppose retailers offered the supplier a contract (w^*, T^*) that the supplier accepted.¹⁶ As in the homogeneous case, the collusive contract has to satisfy the following conditions. First, R_i needs to be induced to charge the monopoly price p_M in stage 2 rather than deviating to $p(w; p_M)$. When retailers collude, R_i earns $(p_M - w)q_M - T$ in this and all future periods. If R_i deviates to $p(w; p_M)$, R_i gains a higher demand in the current period, $q(p(w; p_M), p_M) > q_M$, but collusion stops and R_i earns π_R^C in all future periods. R_i will not deviate from collusion if:

$$\frac{(p_M - w)q_M - T}{1 - \delta} \geq (p(w; p_M) - w)q(p(w; p_M), p_M) - T + \frac{\delta}{1 - \delta}\pi_R^C. \quad (9)$$

¹⁴ For a pure strategy equilibrium to exist, R_i needs to believe that, given $w^C = 0$, R_i cannot motivate the supplier to reject R_j 's offer by offering a contract with $w_i > 0$. If R_i believes that he can convince the supplier to reject R_j 's offer, then no pure strategy equilibrium exists.

¹⁵ Our qualitative results continue to hold when the static equilibrium involves $\pi_S^C > 0$ (which may occur in a mixed strategy equilibrium). In this case too vertical collusion is still needed in order to achieve monopoly pricing, since by lemma 6, $2\pi_R^C + \pi_S^C < 2p_M q_M$.

¹⁶ To simplify notation, we will omit the "*" unless necessary.

where the left hand side of (9) is R_i 's profit from maintaining collusion and the right hand side is R_i 's profit from deviating. Notice that this condition is equivalent to condition (3) in the homogeneous case.

Next consider the supplier's incentive constraint. The supplier needs to be incentivized not to deviate from the collusive scheme by accepting only one of the retailers' offers. If the supplier accepts both offers, collusion follows to the next period and the supplier earns $2(wq_M + T)$ in every period. 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_M and sell $Q(p_M)$, implying that in the current period the supplier earns $wQ(p_M) + T$ and collusion breaks down in all future periods, in which the supplier earns 0. Accordingly, the supplier will not deviate if:

$$\frac{2(wq_M + T)}{1 - \delta} \geq wQ(p_M) + T, \quad (10)$$

where the left hand side is the supplier's sum of discounted profits from maintaining collusion, and the right hand side is the supplier's profit when breaking collusion by accepting only one of the offers.¹⁷ Notice that this condition is equivalent to condition (4) in the homogeneous case. Let $T_R(w, \delta)$ and $T_S(w, \delta)$ denote the T that solves (9) and (10) in equality, respectively. Combining the two conditions, we have that a collusive contract, (w, T) , has to satisfy: $T_S(w, \delta) \leq T \leq T_R(w, \delta)$.

Consider a case in which δ is slightly below δ^C and w is slightly above zero. The following lemma shows that slotting allowances (a negative T) are required for retailers not to deviate. Slotting allowances serve implicitly as a prize the supplier pays retailers in future periods for adhering to the collusive scheme in the current period.

Lemma 7 *(For δ slightly below δ^C and w equal to or slightly above zero, vertical collusion requires slotting allowances:) $T_R(0, \delta^C) = 0$ and $T_R(0, \delta)$ is increasing with δ .*

Now recall that, as in the homogenous retailer case, for the supplier to be willing to pay retailers slotting allowances and participate in the collusive scheme, the wholesale price they pay him needs to be positive. The supplier is willing to aid the collusive scheme

¹⁷ Taking account of communication and renegotiation as considered in section 5.2 does not change the analysis. It can easily be verified that if the supplier deviates by refusing R_i 's offer, it prefers not to reveal this to R_j , since then R_j prefers to change his offer to $(0, 0)$.

since he can use it to charge a positive wholesale price. In particular, the supplier needs to solve his own opportunism problem that prevents him from making profits in the static game:

Lemma 8 (*A positive w is necessary for the supplier to participate in the collusive scheme:*) $T_S(0, \delta) = 0$ for all δ and $T_S(w, \delta)$ is decreasing with w .

Now notice that the increase in w has repercussions regarding the retailers' incentive to collude through condition (9). This effect can be positive or negative, because an increase in w decreases both the retailers' profit from maintaining collusion and their profit when deviating from collusion.

The following lemma provides the conditions for vertical collusion to be sustainable with retailer differentiation:

Lemma 9 (*Necessary condition for sustainability of vertical collusion for δ slightly below δ^C :*) A necessary condition for $T_R(w, \delta) \geq T_S(w, \delta)$ (sustainability of vertical collusion given the vertical contract) when $\delta < \delta^C$ is:

$$\frac{\partial(T_R(w, \delta) - T_S(w, \delta))}{\partial w} \Big|_{w=0, \delta=\delta^C} = \quad (11)$$

$$\frac{1 - \delta^C}{\delta^C} \left[q(p(0; p_M), p_M) - \frac{q_M}{(1 - \delta^C)} \right] - \frac{(1 - \delta^C)}{1 + \delta^C} \left[Q(p_M) - \frac{2q_M}{1 - \delta^C} \right] > 0.$$

If (11) holds, then for δ marginally below δ^C , there is a cutoff, w^* , such that $T_R(w, \delta) \geq T_S(w, \delta)$ if $w \geq w^*$, where $w^* \rightarrow 0^+$ as $\delta \rightarrow \delta^C^-$.

Under condition (11) vertical collusion is possible for a δ slightly lower than δ^C because then a marginal increase in w above $w = 0$ creates a gap between $T_R(w, \delta)$ and $T_S(w, \delta)$. With such a gap, there exists a pair (w, T) that satisfies: $T_S(w, \delta) \leq T \leq T_R(w, \delta)$. The first term in (11) is the effect of a marginal increase in w on the retailers' incentive to collude, and the second term is the effect of a marginal increase in w on the supplier's incentive to deviate from collusion. When the former is higher than the latter, setting $T < 0$ and $w > 0$ can facilitate collusion even when δ is slightly below δ^C .

To further see the intuition, recall from (9) that as w increases, the retailer's profits from both maintaining collusion and deviating from collusion decrease. The retailer's profit from deviating from collusion decreases by the deviating quantity, $q(p(w; p_M), p_M)$,

and his profit from maintaining collusion decreases by the monopoly quantity in all future periods, $\frac{q_M}{1-\delta}$ (the effect on retailers' incentive constraint is represented by the first term in (11)). If the effect of w on the profit from deviation is higher than the effect of w on the profit from collusion, an increase in w increases the retailer's incentive to collude. When products are close substitutes, a retailer can deviate by slightly undercutting the monopoly price and gaining the competing retailer's entire demand. Recalling that when retailers are close substitutes, $\delta^C \rightarrow \frac{1}{2}$, we have that when δ decreases below δ^C , an increase in w increases the retailer's incentive to collude. Intuitively, when retailers are sufficiently close substitutes, even a small deviation by R_i from collusion substantially increases R_i 's demand, which makes the deviation less profitable the higher is w . This gives the parties more leeway to sustain vertical collusion. At the extreme, with homogenous retailers, vertical collusion becomes sustainable no matter how low δ is (see section 4). When retailers are sufficiently differentiated, however, a retailer's profit from deviation is limited, since it cannot steal the entire market share of the competing retailer by only slightly undercutting the collusive price. Then, an increase in w may encourage retailers to deviate. Indeed, when retailers are sufficiently differentiated, the first term in (11) can be negative.

Turning to the supplier's incentive constraint, it follows from (10) that any increase in w further deters the supplier from deviating from the collusive scheme (this effect is also manifested in the second term in (11)). An increase in w increases the supplier's incentive to deviate from collusion by the monopoly quantity of a single retailer, $Q(p_M)$, and increases the supplier's incentive to participate in collusion by the total collusive quantity in all periods, $\frac{2q_M}{1-\delta}$. Since $Q(p_M) \leq 2q_M$, an increase in w decreases the supplier's incentive to deviate from collusion. Accordingly, the second term in (11) is always positive. The higher is the level of differentiation, the larger the gap between $\frac{2q_M}{1-\delta}$ and $Q(p_M)$ and the more an increase in w helps induce the supplier to participate in vertical collusion. Intuitively, with high differentiation, the supplier benefits more from vertical collusion (gaining a high wholesale price on the larger demand for both retailers' outlets) and gains less from deviating from it (thereby selling only through one retailer and losing the potential demand loyal to the excluded retailer).

Since the second term in (11) is positive and the first term is positive if retailers are sufficiently close substitutes, we have that this condition always holds if retailers are

sufficiently close substitutes, and can also hold if retailers are differentiated, as long as the first term is either positive or not too negative. Moreover, the higher is (11), even a lower w^* is sufficient to satisfy $T_S(w, \delta) \leq T \leq T_R(w, \delta)$. Whether this condition holds for any degree of retailer differentiation depends on market conditions.¹⁸

It is left to check that in the first stage of every period, retailers find it optimal to offer the collusive contract. Suppose that in the first stage, R_i offers a deviating contract $(w_i, T_i) \neq (w^*, T^*)$, where (w^*, T^*) is the equilibrium contract:

Lemma 10 *When w^* is not too high (sufficiently close to 0), then (9) also ensures that R_i will not deviate to any contract that motivates R_i to defect from collusion.*

Recall that condition (9) ensures that in the second stage of every period, R_i prefers setting the collusive price instead of deviating to its best response. Lemma 10 shows that at least when w^* is sufficiently small, (9) also ensures that R_i will not deviate to any contract that motivates R_i to defect from collusion. Intuitively, the latter deviation is less profitable for R_i than the former because in the latter deviation R_i needs to compensate the supplier for the supplier's loss of revenues from R_j .

It can also be easily seen that retailers would not want to deviate from the collusive contract in a way that maintains collusion. Intuitively, any such deviation would be entirely at the expense of the supplier, and having to compensate him to convince him to agree to the deviation would render the deviation unprofitable.

Lemma's 10 and 9, taken together, show that when δ is slightly below δ^C and (11) holds, a marginal increase in w^* makes it possible to satisfy the retailers' and the supplier's incentive constraints given the collusive contract (lemma 9). The contract also deters any retailer from making a contract deviation that stops collusion at least when w^* is small enough (lemma 10), which from lemma 9 holds at least when δ is close enough to δ^C .

7 Policy Implications

Our results have several policy implications.

¹⁸In an online note (available at: <https://www.tau.ac.il/~yehezkel/>), we offer an example in which retailers are almost fully differentiated such that the first term is negative. Yet, the above condition holds and there is a collusive equilibrium for $\delta > \delta^*$, where $0 < \delta^* < \delta^C$.

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.*¹⁹ 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*,²⁰ 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."²¹ 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.²² Our results, however, imply that 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 better enforce a multi period tacit collusion scheme (e.g., because this supplier is forward looking and the competing supplier isn't). 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

¹⁹ (7th Cir.) 749 F.2d 380, 395 (1984).

²⁰ (Central District of Illinois, Peoria Division) 2016 U.S. Dist. LEXIS 136478.

²¹ Id. at 150.

²² 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 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).

the exclusive purchasing obligation.”²³ 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, 3, ... etc. 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, one 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 balance the anticompetitive threats identified here 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 5, even when both retailers exclusively buy from the same supplier, vertical collusion breaks down absent slotting allowances.²⁴

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.²⁵ As shown in section 5.2, however, if supplier 1 can reveal to one retailer that the competing retailer had not offered it an exclusive dealing contract, vertical collusion is enabled. Recall that when supplier 1 faces competition from other suppliers, the vertical collusive scheme is nevertheless sustained via exclusive dealing

²³ See also Case C-234/89 Stergios Delimitis Henninger Brau AG, [1991] ECR 935.

²⁴ See also *Insulate SB, Inc. v. Advanced Finishing Systems, Inc.*, (Court of Appeals 8th Cir.), 797 F.3d 538 (2015), denying the claim of a buyer of insulation material supplied by a dominant supplier (Graco Minnesota Inc) through distributors. According to this claim, 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.

²⁵ See supra note 3.

between both retailers and supplier 1, provided that supplier 1 can inform a retailer that the other retailer had not offered supplier 1 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. Hence, the justification for a soft antitrust approach does not hold in this case.

The third policy implication concerns the antitrust treatment of a supplier's refusal to deal with a retailer. The results of Lemma 4 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",²⁶ 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."²⁷ 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.²⁸ 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

²⁶ See *United States v. Colgate & Co.*, 250 U.S. 300 (1919).

²⁷ See *State of New York, v. Tempur-Pedic International, Inc.*, (Supreme Court of New York, 30 Misc. 3d 986 (2011)).

²⁸ 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).

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 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.²⁹

Finally, our results imply 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, Lemma 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 retailers regarding their commercial terms with a common supplier would most probably be condemned as an antitrust violation.³⁰ 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. In some cases, slotting allowances are paid by suppliers as "compensation" for intense competition among retailers over selling the supplier's brand.³¹ Our results imply that 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 implicitly punish retailers for not adhering to the collusive scheme.

²⁹ See Areeda and Hovenkamp (2015).

³⁰ See sources cited *supra* note 1.

³¹ See, e.g., Moulds (2015).

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 an implicit 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, and even when retailers are differentiated, 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. When retailers are differentiated, vertical collusion is easier to sustain, but is not sustainable for all discount factors as it is when retailers are homogenous.

This result could naturally carry over to multiple suppliers, as long as differentiation among them is strong enough. 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. Vertical collusion enables the exclusive supplier to raise the wholesale price he charges, while enabling retailers to charge monopoly retail prices, despite the potential for intense competition among suppliers and among retailers.

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; a dominant supplier's refusal to deal with a retailer on account of the retailer engaging in downstream competition deserves more antitrust attention; and slotting allowances can facilitate collusion

even when vertical contracts are secret.

Appendix A

Below are the proofs of lemma 1 – 10 and Proposition 1.

Proof of Lemma 1:

We will proceed in two steps. In the first step, we will show that if (2) 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 (2) 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 (2) does not hold, R_i can make a profitable deviation. Since $p(w) > w$ and $pQ(p)$ is concave in p :

$$\max_{w^C} \{w^C Q(w^C)\} = p_M Q_M > \max_{w_i} \{w_i Q(p(w_i))\} \geq w^C Q(w^C)|_{w^C=0},$$

implying that there is a w_L such that (1) holds for $w_C \in [w_L, p_M]$ and does not hold otherwise, where $w_L > 0$. Suppose that (2) 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:

$$(p(w_i) - w_i)Q(p(w_i)) - T_i = p(w_i)Q(p(w_i)) - w^C Q(w^C) > w_i Q(p(w_i)) - w^C Q(w^C) > 0,$$

where the first inequality follows because $p(w_i) > w_i$ and the second inequality follows because whenever (2) 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 (2) 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 $(T_i, w_i) \neq (0, w^C)$ so 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 $w_i < w^C$, so 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 sets T_i so 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 (3) can be re-written as:

$$T^* < T_R(w^*, \delta) \equiv (p_M - w^*) \frac{Q_M(2\delta - 1)}{2\delta}.$$

Moreover:

$$\pi_R(w^*, T^*) = (p_M - w^*) \frac{Q_M}{2} - T^* > 0 \Leftrightarrow T^* < T_2(w^*) \equiv (p_M - w^*) \frac{Q_M}{2}.$$

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

Proof of Lemma 3

Condition (4) holds iff:

$$T^* > T_S(w^*, \delta) \equiv -\frac{\delta(w^* Q_M - \pi_S^C)}{1 - \delta}. \quad (12)$$

Condition $0 > T^* \geq T_S(w^*, \delta)$ requires that $T_S(w^*, \delta) < 0$, which holds iff $w^* > \frac{\pi_S^C}{Q_M}$ and $\delta > 0$. Moreover, as T^* decreases, a higher w^* is needed to maintain condition (4) because $T_S(w^*, \delta)$ is decreasing with w^* . ■

Proof of Lemma 4

As shown in Appendix B, the highest expected profit that R_i can make in such a

deviation is $p_M Q_M - \varepsilon - (w^* Q_M + T^*)$. Letting $\varepsilon \rightarrow 0$, R_i does not deviate iff:

$$\frac{(p_M - w^*) \frac{Q_M}{2} - T^*}{1 - \delta} \geq p_M Q_M - (w^* Q_M + T^*),$$

which is equivalent to condition (3). ■

Proof of Lemma 5

Condition (3) 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:

$$w^* Q_M + 2T^* = w^* Q_M + T^*,$$

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, Lemma 2 showed that (3) cannot hold if $T^* \geq 0$ and $\delta < \frac{1}{2}$, implying that this alternative trigger strategy cannot maintain a collusive equilibrium. ■

Proof of Proposition 1

We first solve for the set of (w^*, T^*) that satisfy (3), (4) and $\pi_S(w^*, T^*) \geq \pi_S^C$. From condition (4), $T^* = T_S(w^*, \delta)$. Substituting $T^* = T_S(w^*, \delta)$ into condition (3) we can rewrite (3) as:

$$w^* > p_M - \frac{2\delta^2 (p_M Q_M - \pi_S^C)}{(1 - \delta) Q_M}. \quad (13)$$

Substituting $T^* = T_S(w^*, \delta)$ into $\pi_S(w^*, T^*)$ we have:

$$\pi_S(w^*, T^*(w^*)) = \frac{1 - \delta}{1 + \delta} w^* Q_M + \frac{2\delta}{1 + \delta} \pi_S^C > \pi_S^C \Leftrightarrow w^* > \frac{\pi_S^C}{Q_M}. \quad (14)$$

Comparing the right-hand-sides of (13) and (14), the former is higher than the latter iff $\delta < \frac{1}{2}$. We conclude that (3), (4) and $\pi_S(w^*, T^*) \geq \pi_S^C$ hold for any $T^* = T_S(w^*, \delta)$ and w^* , where:

$$w^* \geq w^E \equiv \begin{cases} p_M - \frac{2\delta^2(p_M Q_M - \pi_S^C)}{(1-\delta)Q_M}; & \text{if } \delta \in (0, \frac{1}{2}]; \\ \frac{\pi_S^C}{Q_M}; & \text{if } \delta \in [\frac{1}{2}, 1]. \end{cases} \quad (15)$$

Next, we solve for the w^* that maximizes $\pi_R(w^*, T_S(w^*, \delta))$, where:

$$\pi_R(w^*, T_S(w^*, \delta)) = (p_M - w^*) \frac{Q_M}{2} - \frac{\delta(\pi_S^C - w^* Q_M)}{(1 + \delta)}.$$

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

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

Therefore, the most profitable collusive equilibrium involves $w^* = w^E$ which yields (5). Substituting $w^* = w^E$ into $T_S(w^*, \delta)$ yields (6). ■

Proof of Lemma 6:

Consider a potential equilibrium in which retailers set the monopoly price. In such an equilibrium, if it were to exist, retailers need to offer the supplier $w^C = \hat{w}(p_M)$, where $\hat{w}(p_M) > 0$ is the solution to $p(\hat{w}, p_M) = p_M$. However, suppose now that R_i decides to deviate to $(w_i, T_i) \neq (w^C, T^C)$ that triggers the joint beliefs by R_i and the supplier that the supplier will accept the deviation as well as R_j 's offer and R_i will set $p(w_i; p^C)$. The supplier accepts the deviation if:

$$w_i q(p(w_i; p^C), p^C) + w^C q(p^C, p(w_i; p^C)) + T^C + T_i \geq w^C Q(p^C) + T^C,$$

where the left hand side is the supplier's profit from accepting both offers and the right hand side is the supplier's profit from rejecting R_i 's offer and accepting only R_j 's offer. Solving for T_i , R_i earns from this deviation:

$$\begin{aligned} & (p(w_i; p^C) - w_i) q(p(w_i; p^C), p^C) - T_i = \\ & [p(w_i; p^C) q(p(w_i; p^C), p^C) + w^C q(p^C, p(w_i; p^C))] - w^C Q(p_M). \end{aligned} \quad (16)$$

Equation (8) shows that as is standard in the literature on vertical relations with secret contracts, R_i sets w_i so as to maximize his and the supplier's joint profit, ignoring R_j 's profit.³² The first term in the squared brackets of (8) is the joint profit of R_i and the supplier from selling product i . The second term is the supplier's own revenue from selling product j . When retailers are perfect substitutes, then $w^C = \hat{w}(p^C) = p^C$. In such a case $w_i = w^C$ maximizes (8) and there is an equilibrium in which retailers implement the monopoly outcome by charging $w^C = p_M$. For the same reason, there are also equilibria with $w^C < p_M$. Yet, when retailers are differentiated, $p(w^C; p^C) > w^C$ (equivalently, $w^C = \hat{w}(p^C) < p^C$). In this case, R_i does not fully internalize the effect of w_i on the total profit from selling product j . Since $q(p^C, p(w_i; p^C))$ is increasing with w_i but $w^C < p^C$, R_i sets $w_i < w^C$, and the monopoly outcome cannot be an equilibrium.³³ ■

Proof of Lemma 7:

Solving (9) for T , we have:

$$T_R(w, \delta) \equiv -\frac{1-\delta}{\delta} \left[(p(w; p_M) - w)q(p(w; p_M), p_M) + \frac{\delta}{1-\delta} \pi_R^C - \frac{(p_M - w)q_M}{(1-\delta)} \right],$$

We will now show that $T_R(0, \delta^C) = 0$ and $T_R(0, \delta)$ is increasing with δ . Evaluating at $w = 0$:

$$T_R(0, \delta) = -\frac{1-\delta}{\delta} \left[p(0; p_M)q(p(0; p_M), p_M) + \frac{\delta}{1-\delta} \pi_R^C - \frac{p_M q_M}{(1-\delta)} \right].$$

The term inside the squared brackets in $T_R(0, \delta)$ is identical to that of the definition of δ^C and therefore equals 0 at $\delta = \delta^C$. The effect of δ on $T_R(0, \delta)$ is:

$$\frac{\partial T_R(0, \delta)}{\partial \delta} = \frac{p(0; p_M)q(p(0; p_M), p_M) - p_M q_M}{\delta^2} > 0,$$

where the inequality follows because $p(0; p_M)$ maximizes $pq(p, p_M)$. ■

Proof of Lemma 8:

³² Equation (8) is equivalent to equation (1) in O'Brien and Shaffer (1992).

³³ This argument also holds when R_i expects that whenever the supplier accepts the deviation, the supplier does not accept R_j 's offer. This is because in such a case R_i would like to set $w_i = 0$ to eliminate the double marginalization problem.

Solving (10) for T , we have:

$$T_S(w, \delta) \equiv -w \left[\frac{2q_M}{1-\delta} - Q(p_M) \right] \frac{1-\delta}{1+\delta}.$$

The first part of lemma 8 follows directly from the definition of $T_S(w, \delta)$. The effect of δ on $T_S(w, \delta)$ is:

$$\frac{\partial T_S(w, \delta)}{\partial \delta} = -2w \frac{Q(p_M) - q_M}{(1+\delta)^2} < 0,$$

where the inequality follows because $Q(p_M) > q_M$.

This implies that the supplier will not participate in the collusive scheme when $T < 0$ if $w = 0$. Recall that the supplier's incentive constraint requires that $T > T_S(w, \delta)$, which cannot hold when $T_S(0, \delta) = 0$ while $T < 0$. ■

Proof of Lemma 9:

We first show that condition (11) is necessary for finding a (T, w) such that $T_R(w, \delta) > T > T_S(w, \delta)$. To this end, recall from lemmas 7 and 8 that $T_R(0, \delta^C) = T_S(0, \delta^C)$, and the gap $T_R(0, \delta) - T_S(0, \delta)$ is increasing in δ . This implies that $T_R(0, \delta) < T_S(0, \delta)$ for $\delta < \delta^C$ and when condition (11) fails, $T_R(w, \delta) < T_S(w, \delta)$ for all w if $T_R(w, \delta) - T_S(w, \delta)$ is concave in w for all δ and w . The second derivative of $T_R(w, \delta) - T_S(w, \delta)$ with respect to w is:

$$\frac{\partial^2 (T_R(w, \delta) - T_S(w, \delta))}{\partial^2 w} = \frac{1-\delta}{\delta} \frac{\partial q(p(w; p_M), p_M)}{\partial p_i} \frac{\partial p(w; p_M)}{\partial w} < 0,$$

where the inequality follows (for all δ and w) because $q(p_i, p_j)$ is decreasing in p_i and $p(w; p_M)$ is increasing in w . We therefore have that $T_R(w, \delta) - T_S(w, \delta)$ is concave in w and (11) is necessary.

Next, we have that since $T_R(w, \delta)$ and $T_S(w, \delta)$ are continuous in δ , a marginal decrease in δ below δ^C results in a marginal decrease in $T_R(0, \delta) - T_S(0, \delta)$ below 0. Yet, when (11) is strictly positive then due to the concavity of $T_R(w, \delta) - T_S(w, \delta)$, there is a cutoff in w , w^* , such that $T_R(w, \delta) > T_S(w, \delta)$ when $w > w^*$, where w^* is the solution to $T_R(w^*, \delta) = T_S(w^*, \delta)$. Finally, since $T_S(0, \delta) = 0$, and $T_R(0, \delta) \rightarrow 0^-$ as $\delta \rightarrow \delta^{C-}$, we have that $w^* \rightarrow 0^+$ as $\delta \rightarrow \delta^{C-}$.

Proof of Lemma 10:

Suppose 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 (if accepted) stops collusion. That is, R_i plans to set the price $p(w_i; p_M)$. The supplier accepts the deviation if:

$$w_i q(p(w_i; p_M), p_M) + w^* q(p_M, p(w_i; p_M)) + T^* + T_i \geq w^* Q(p^M) + T^*,$$

where the left hand side is the supplier's profit from accepting both R_j 's collusive contract and R_i 's deviating contract. Solving for T_i , R_i earns from this deviation

$$p(w_i; p_M) - w_i q(p(w_i; p_M), p_M) - T_i =$$

$$[p(w_i; p_M) q(p(w_i; p_M), p_M) + w^* q(p_M, p(w_i; p_M))] - w^* Q(p_M).$$

Let $\tilde{w}(w^*)$ denote the w_i that maximizes R_i 's profit from deviating from collusion. There is no loss of generality in looking at the w_i that maximizes R_i 's profit, because any other w_i that triggers the beliefs that R_i plans to deviate from collusion makes the deviation less profitable. R_i will not deviate if:

$$\frac{(p_M - w^*) q_M - T^*}{(1 - \delta)} \geq \quad (17)$$

$$[p(\tilde{w}(w^*); p_M) q(p(\tilde{w}(w^*); p_M), p_M) + w^* q(p_M, p(\tilde{w}(w^*); p_M))] - w^* Q(p_M) + \frac{\delta}{1 - \delta} \pi_R^C,$$

or $T^* < T_{RS}(w^*, \delta)$, where:

$$T_{RS}(w^*, \delta) \equiv \delta \left[-\pi_R^C - \frac{(1 - \delta) p(\tilde{w}(w^*); p_M) q(p(\tilde{w}(w^*); p_M), p_M) - (p_M - w^*) q_M}{\delta} \right] \\ + w^* (Q(p_M) - q(p_M, p(\tilde{w}(w^*); p_M)) (1 - \delta).$$

Recall that condition [\(9\)](#) requires that $T^* < T_R(w^*, \delta)$. Consequently, when $T_{RS}(w^*, \delta) > T_R(w^*, \delta)$, condition [\(17\)](#) is not binding on the optimal contract. Let us compare $T_{RS}(w^*, \delta)$ with $T_R(w^*, \delta)$:

Evaluating $T_{RS}(w^*, \delta)$ at $w^* = 0$, the second term in $T_{RS}(w^*, \delta)$ vanishes. The term inside the squared brackets becomes identical to $T_R(0, \delta)$. To see why, notice that $\tilde{w}(0) = 0$, because when $w^* = 0$, $\tilde{w}(0) = 0$ maximizes $p(w; p_M) q(p(w; p_M), p_M)$. Hence, $T_{RS}(0, \delta) = \delta T_R(0, \delta)$. Since lemma [7](#) establishes that $T_R(0, \delta) < 0$ for $\delta < \delta^C$, and since

$\delta < 1$, we have that $T_{RS}(0, \delta) > T_R(0, \delta)$. Since $T_{RS}(w^*, \delta)$ and $T_R(w^*, \delta)$ are continuous in w^* , we have that $T_{RS}(w^*, \delta) > T_R(w^*, \delta)$ as long as w^* is not too high.

Finally, notice we consider the case where retailers are sufficiently differentiated such that if the supplier accepts R_i 's contract deviation, the supplier accepts the (equilibrium) contract of R_j . When retailers are close substitutes, the supplier may choose to accept only one of the offers. As shown in the proof of lemma 4, the results above hold also in the special case where retailers are perfect substitutes, in that condition (3) prevents R_i from making a contract deviation. ■

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

$$\gamma w_i Q(p(w_i)) + (1 - \gamma) w_i Q_M = \gamma(w^* Q_M + T^*) + (1 - \gamma)(w_i Q_M + T^*). \quad (18)$$

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 $p_M - \varepsilon$, R_i earns $(p_M - \varepsilon - w_i)Q_M$ regardless of whether the supplier accepts R_j 's offer. Hence, the equilibrium condition requires that:

$$(1 - \theta)(p(w_i) - w_i)Q(p(w_i)) = (p_M - \varepsilon - w_i)Q_M. \quad (19)$$

Notice that any $p_i \notin \{p(w_i), p_M - \varepsilon\}$ 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 $p_M - \varepsilon$.

Solving (18) and (19) yields that the equilibrium values of θ and γ , given w_i , are:

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

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

$$w^* Q_M > \pi_S^C = w^C Q(w^C) > \max_w \{w Q(p(w))\} \geq w_i Q(p(w_i)).$$

where the first inequality follows because $w^* Q_M + 2T^* > \pi_S^C$ and $T^* < 0$ implies that $w^* Q_M > \pi_S^C$ 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 $w^* Q_M - w_i Q(p(w_i)) > -T^*$. This holds because

$$w^* Q_M - w_i Q(p(w_i)) > \pi_S^C - 2T^* - w_i Q(p(w_i)) > \pi_S^C - 2T^* - \pi_S^C = -2T^* > -T^*,$$

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

Suppose now that $w_i = 0$, such that R_i sets $p(w_i) = p_M$ with probability γ and $p_M - \varepsilon$ 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 $w^* \frac{Q_M}{2} + T^*$ if R_i sets p_M and earns T^* if R_i sets $p_M - \varepsilon$. Hence, the supplier's expected profit from accepting R_j 's offer is

$\gamma(w^* \frac{Q_M}{2} + T^*) + (1 - \gamma)T^*$. The equilibrium condition requires that:

$$\gamma \left(w^* \frac{Q_M}{2} + T^* \right) + (1 - \gamma) T^* = 0. \quad (20)$$

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

$$\theta \frac{p_M Q_M}{2} + (1 - \theta)p_M Q_M = p_M Q_M - \varepsilon. \quad (21)$$

Solving (20) and (21) yields that the equilibrium values of γ and θ given $w_i = 0$, are: $\gamma(0) = \frac{-2T^*}{w^* Q_M}$, $\theta(0) = \varepsilon$, where $0 \leq \gamma(0) \leq 1$ because $T^* < 0$ and $w^* Q_M + 2T^* > 0$ and $0 \leq \theta(0) \leq 1$ because ε is positive and small.

Next we turn to showing that R_i can earn at most $p_M Q_M - \varepsilon - (w^* Q_M + T^*)$. 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

$$\gamma(w_i)w_i Q(p(w_i)) + (1 - \gamma(w_i))w_i Q_M + T_i > w^* Q_M + T^*,$$

implying that the best R_i can do is to offer:

$$T_i(w_i) = w^* Q_M + T^* - (\gamma(w_i)w_i Q(p(w_i)) + (1 - \gamma(w_i))w_i Q_M).$$

Hence, R_i 's expected profit as a function of w_i is:

$$\begin{aligned} E\pi_R(w_i; w^*, T^*) &= (1 - \theta(w_i))((p(w_i) - w_i)Q(p(w_i))) - T_i(w_i) \\ &= Q_M \left(p_M - \varepsilon - w^* + \frac{T^* (w^* - w_i)}{w_i Q(p(w_i)) - w^* Q_M} \right). \end{aligned} \quad (22)$$

The derivative of $E\pi_R(w_i; w^*, T^*)$ with respect to w_i is:

$$\frac{\partial E\pi_R(w_i; w^*, T^*)}{\partial w_i} = Q_M T^* \frac{w^* [Q_M - Q(p(w_i))] + w_i (w_i - w^*) \frac{dQ(p(w_i))}{dw_i}}{(w_i Q(p(w_i)) - w^* Q_M)^2}.$$

We have that $\frac{\partial E\pi_R(w_i; w^*, T^*)}{\partial w_i} = 0$ when $w_i \rightarrow 0$, because the term in the first squared

brackets equals zero as $Q(p(0)) = Q_M$. The second derivative, evaluated at $w_i \rightarrow 0$, is:

$$\frac{d^2 E\pi_R(w_i)}{d^2 w_i} \Big|_{w_i \rightarrow 0} = -T^* \frac{\frac{dQ(p(w_i))}{dw_i}}{Q_M w^*} < 0,$$

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

$$\text{sign} \left(\frac{\partial E\pi_R(w_i; w^*, T^*)}{\partial w_i} \right) = \text{sign} \left(w^* [Q(p(w_i)) - Q_M] + w_i \left[(w^* - w_i) \frac{dQ(p(w_i))}{dw_i} \right] \right).$$

The term in the first squared brackets is negative because $w_i \geq 0$ implies that $Q_M \geq Q(p(w_i))$, and the term in the second squared brackets is negative because $w_i \leq w^*$ and $dQ(p(w_i))/dw_i < 0$. This implies that $\frac{\partial E\pi_R(w_i; w^*, T^*)}{\partial w_i} < 0$ for all $0 < w_i \leq w^*$, and since $\frac{\partial E\pi_R(w_i; w^*, T^*)}{\partial w_i} = 0$ for $w_i = 0$, $w_i = 0$ maximizes $E\pi_R(w_i; w^*, T^*)$ among all $0 < w_i \leq w^*$. 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 $w^* < w_i$, $\frac{\partial E\pi_R(w_i; w^*, T^*)}{\partial w_i} < 0$ for $w^* < w_i$ as well, as long as w_i is not too high.

Finally, substituting $w_i \rightarrow 0$ into $E\pi_R(w_i; w^*, T^*)$ yields that at $w_i \rightarrow 0$, $E\pi_R(w_i, w^*, T^*) \rightarrow p_M Q_M - \varepsilon - (w^* Q_M + T^*)$. Evaluating $E\pi_R(w_i, w^*, T^*)$ at exactly $w_i = 0$ yields the same profit. When $w_i = 0$, equation (20) implies that the supplier's profit gross of T_i is 0, and therefore the supplier accepts the deviation as long as $w^* Q_M + T^* < T_i$. Therefore, given that R_i sets $w_i = 0$, R_i must at least offer $T_i = w^* Q_M + T^*$ and earn $p_M Q_M - \varepsilon - T_i = p_M Q_M - \varepsilon - (w^* Q_M + T^*)$.

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74c0f7ee0687/Competitor_Information_Exchanges.pdf](https://www.hunton.com/files/Publication/37824b3f-67a0-48d5-9211-712846a587e0/Presentation/PublicationAttachment/1740fa96-1c76-40bb-909f-74c0f7ee0687/Competitor_Information_Exchanges.pdf) (last visited in January 2016).
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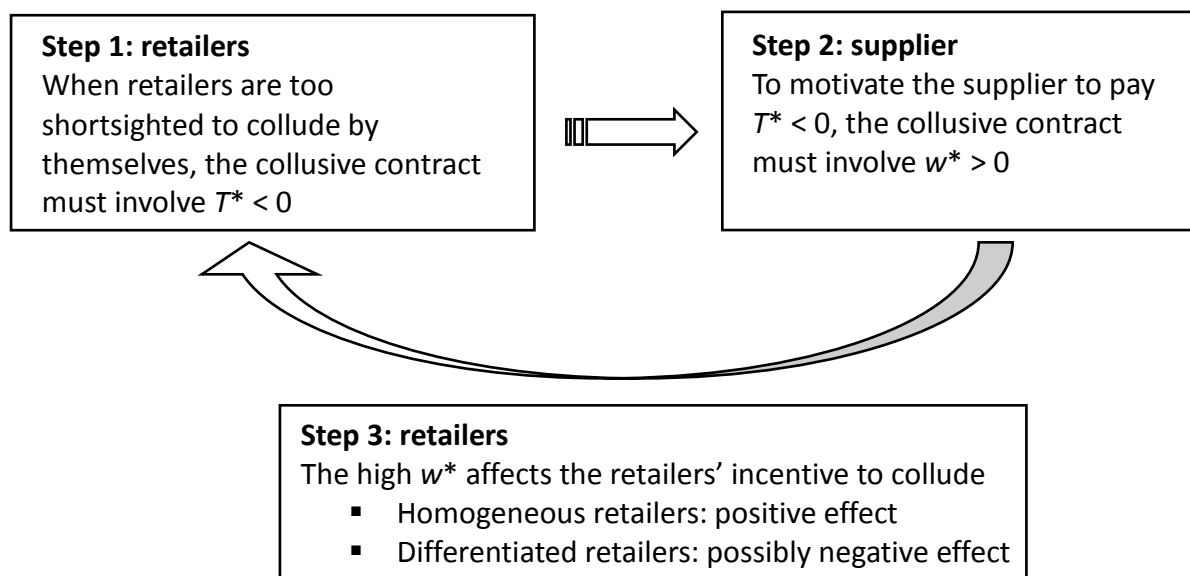
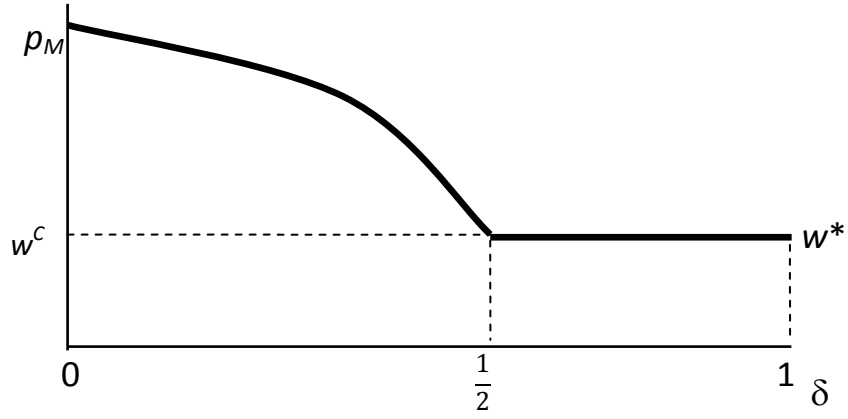
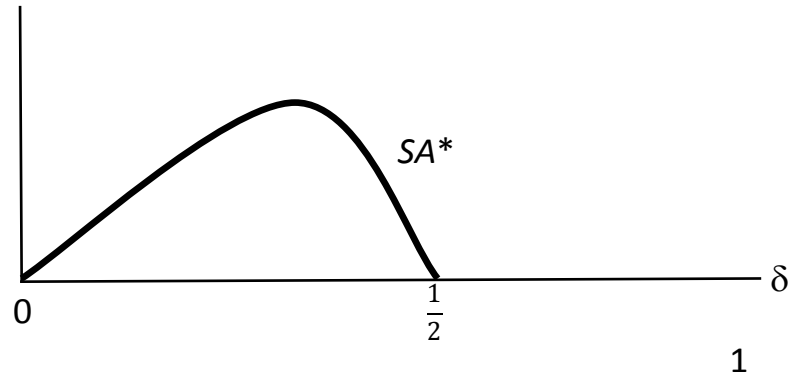


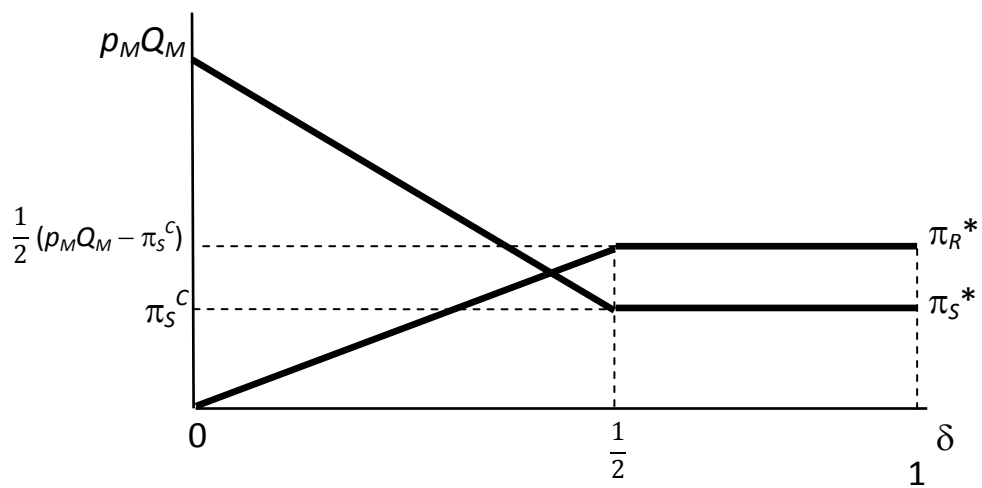
Figure 1: the mechanism that enables vertical collusion for $\delta < \delta^c$



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 $(p_M Q_M - \pi_S^C)/2 > \pi_S^C$)

Figure 2: The features of the vertical collusion equilibrium as a function of δ