Dynamic downstream collusion with secret vertical contracts

[PRELIMINARY AND INCOMPLETE]

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Abstract: We consider dynamic, infinitely repeated downstream price competition. In every period, a retailer cannot observe the contract that the competing retailer offers to a joint supplier. We find that even though contracts are secret, they enable retailers to collude. The more the retailers and the supplier care about future profits, retailers obtain a higher share of the monopoly profits. We also find that implementing collusion requires retailers to commit to deal exclusively with the joint supplier and to charge slotting allowances. Hence, slotting allowances can eliminate competition even when contracts are unobservable to competing retailers.

Keywords: vertical relations, tacit collusion, opportunism, slotting allowances

JEL Classification Numbers: L41, L42, K21, D84

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1. Introduction

In recent years, large multi-branch retailers have been gaining considerable bargaining power vis a vis suppliers. Because such retailers have national coverage and access to an extremely large customer base, suppliers, even those with powerful brands, cannot afford not to be present on retailers' shelves.[1] Nevertheless, it is often the case that in a certain geographic area, retailers fiercely compete over end consumers. Retailers would prefer to collude at the expense of consumers, but competition among them is often too fierce to support such collusion. Previous literature shows that a strong supplier can help retailers collude by charging them a publicly observable high wholesale price, thereby discouraging retailers from price-cutting. Strong retailers can reap the proceeds of collusion by charging the supplier slotting allowances. 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. Such a discount encourages a retailer to deviate from a collusive scheme. Thus, supposedly, retailers would hesitate to collude with secret contracts in the first place. Moreover, supposedly, buyer power erodes the market power of a supplier with a strong brand, further helping consumers.

This paper asks whether the combination of retailer power and retail competition act in the favor of consumers or to their disadvantage, in the common case where contracts are secret? Can it help erode the market power of strong suppliers? Can secret vertical contracts between retailers and suppliers facilitate collusion?

The main conclusion of this paper is that secret vertical contracts can facilitate price collusion in a dynamic game when competing retailers and their joint supplier are strategic players who care about future profits. In such a situation, the supplier is willing and able to aid retailers' collusion even though vertical contracts are secret. Retailers share their collusive profits with the supplier. Hence, even though retailers does not observe the supplier's price cuts to one retailer at the expense of the other, the supplier himself has an incentive to police his own and retailers' adherence to the collusive scheme. Our results imply that buyer power and secret vertical contracts do not necessarily promote consumer welfare. Instead, even with secret vertical contracts, buyer power can be used to relax competition among retailers and harm consumers. Furthermore, despite buying power, the supplier's power to raise wholesale prices, thereby indirectly harming consumers, remains intact.

We consider two competing retailers and a joint monopoly supplier in an infinitely repeated game, when all three firms care about the future. In every period retailers offer take-it-or-leave-it secret two-part-tariff contracts to the supplier and then compete in prices. The

[1] See, e.g., OEC (2013). Many of these suppliers are multi-brand suppliers and not all of their brands are as strong. This can raise suppliers' dependency on supermarket chains.

contracts are secret such that a retailer can never know, not even at the end of the period, what was the contract that the competing retailer offered to the supplier. Moreover, at the pricing stage a retailer cannot observe whether the competing retailer and the supplier signed a contract. At the end of the period retailers can only observe the retail prices of their competing retailers, if indeed they carried the product.

We solve for an infinitely repeated collusive equilibrium. In every period the two retailers offer a two-part-tariff contract that motivates them to collude on the monopoly price without observing the contract of the supplier and the competing retailer. This raises the potential for opportunistic behavior by a retailer who can offer the supplier a different contract than the equilibrium one and then undercut the monopoly price or by the supplier who can reject the equilibrium contract of one of the retailers.

We find that for any discount factor there is an equilibrium in which retailers collude on the monopoly price. To do so, retailers share the profits from collusion with the supplier, despite of their bargaining power. The more firms care about the future, retailers can maintain a higher share of the monopoly profit at the expense of their joint supplier. We also find that the equilibrium contract involves a wholesale price above marginal costs and negative fees of the form of slotting allowances. The level of slotting allowances is non-monotonic in the firms' discount factor: the more firms care about their future profits the level of slotting allowances first increases and then decreases.

Our paper is related to several strands of the economic literature. The first strand concerns literature on static games in which vertical contracts serve as a devise for reducing price competition between retailers. Bonanno and Vickers (1988) consider vertical contracts when suppliers have the bargaining power and offer contracts to their retailers. They find that suppliers use two-part tariff 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, but since retailers have bargaining power, suppliers pay fixed fees to retailers. This result can explain why retailers such as supermarkets and drugstores ask for slotting allowances, i.e., upfront payments suppliers pay retailers in order to secure shelf space.

The above literature suggests that slotting allowances may have the anti-competitive effect of enabling retailers to relax price competition.[2] However, Shaffer (1991) points out

[2] 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. The conflicting effects of slotting allowances on welfare led to investigations by antitrust authorities (FTC (2001) and 2003) and the Israeli Antitrust Authority (2003), for example).

that slotting allowances can relax competition only when vertical contracts are observable. The main contribution of our paper to this literature is by considering slotting allowances within a dynamic game and when vertical contracts are unobservable. In our model, a retailer cannot observe the terms of the contract between the supplier and the competing retailer.

The second strand of literature involves static vertical relations when retailers cannot observe the vertical contracts of competing retailers. Hart and Tirole (1990), O'Brien and Shaffer (1992), McAfee and Schwartz (1994) and Rey and Verg´e (2004) consider suppliers that make secret contract offers to retailers. They find that a supplier may behave opportunistically (depending on the retailers' beliefs regarding the supplier's offer to the competing retailers) and offer secret discounts to retailers. Anticipating this, retailers will not agree to pay high wholesale prices and the supplier cannot implement the monopoly outcome. We contribute this strand of literature by showing that a dynamic game can resolve the opportunism problem. If a supplier and a retailer in our model behave opportunistically in a certain period, the competing retailer stops cooperating in the next period. Since the two retailers and the supplier care about future profits, this will serve as a punishment against opportunistic behavior.

The third strand of literature involves vertical relations in a dynamic, infinite horizon collusive game. Schinkel, Tuinstra and Rüggeberg (2007) consider collusion in vertical relations when suppliers can forward some of the collusive profits to downstream firms in order to avoid private damage claims. Normann (2009) and Nocke and White (2010) find that vertical integration can facilitate collusion between a vertically integrated firm and independent retailers. Piccolo and Reisinger (2011) find that exclusive territories agreements between suppliers and retailers can facilitate collusion. Piccolo and Miklós-Thal (2012) show that retailers with bargaining power can collude by offing perfectly competitive suppliers a high wholesale price and negative fixed fees. Doyle and Han (2012) consider retailers that can achieve the monopoly outcome by forming a buyer group that jointly offers contracts to suppliers. The above literature focused on the case where information concerning vertical contracts is either publicly observable or can be credibly conveyed by retailers to competing retailers. Our contribution to the above literature is that we focus on secret vertical contracts that cannot be observed, nor conveyed, to competing retailers.

The most closely related papers to ours concern dynamic collusion in vertical relations when vertical contracts are secret. Nocke and White (2007) consider dynamic vertical relations when a vertically integrated firm competes against independent retailers. In an appendix, they show that their results hold under both observable and secret contracts when upstream firms make their contract offers to retailers at the same time that retailers set prices to consumers. Our paper focuses on the case where retailers set their prices after their own contract offer to the supplier, and without observing the competing retailer's contract with the supplier. Jullien and Rey (2007) consider an infinite horizon model with competing suppliers that offer retailers secret contracts. Their paper studies how suppliers can use resale price maintenance to facilitate collusion, in the presence of stochastic demand shocks. There are three main differences between their model and our paper. First, we do not consider a demand shock, which is the main focus of their paper. Second, Jullien and Rey (2007) assume that each supplier serves a different retailer, while we consider two retailers that buy from a joint supplier. Third, Jullien and Rey (2007) assume that suppliers care about the future while retailers are myopic. In our paper all three firms – the two retailers and their joint supplier – care about the future. Because of these features – both retailers buy from a joint supplier and both retailers and the supplier care about the future – the collusive equilibrium in our model involves dividing the monopoly profit among all three firms. Under such profit sharing all three firms – the supplier and both retailers have an incentive to maintain the collusive equilibrium. Reisinger and Thomes (2015) consider dynamic competition between two competing and long-lived manufacturers that makes secret contracts to short-lived retailers. They find that colluding though independent, competing retailers is easier to sustain and more profitable to the manufacturers than colluding through a joint retailer. Our paper contributes to this paper by considering a different market structure in which two competing retailers make secret offers to a joint supplier and by considering the case where both upstream and downstream firms care about the future.

2. The model

Consider two homogeneous downstream retailers, R_1 and R_2 that compete in prices. Retailers can obtain a homogeneous product from an upstream supplier. Production and retail costs are zero. Consumers' demand for the homogeneous product is $Q(p)$, where p is the final price and $pQ(p)$ is concave in p. Let p^* and Q^* denote the monopoly price and quantity, where p^* maximizes $pQ(p)$ and $Q^*=Q(p^*)$. The monopoly profit is p^*Q^*.

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

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

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

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

When there is no upstream supplier such that the product is available to retailers at marginal costs, 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 Bertand game with two identical firms. Then, a standard result is that collusion at the monopoly price is possible if:

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

where the left hand side is the retailer’s sum of infinite discounted profit from colluding on the monopoly price and gaining half of the demand and the right hand side is the retailer's profit from slightly undercutting the monopoly price and gaining all the demand in the current period, followed by a perfectly competitive Bertrand game with zero profits in all future periods. Given this benchmark value of $\delta = 1/2$, we ask how vertical relations – the retailers’ ability to sign two-part-tariff contracts with a joint supplier – affect the retailers’ ability to profit from collusion, when the two-part-tariffs are unobservable to the competing retailer throughout the game.

3. Competitive static equilibrium benchmark

In this section we solve for a competitive equilibrium benchmark in which the three firms have $\delta = 0$. This can also be an equilibrium when $\delta > 0$ and the three firms expect that their strategies in the current period will not affect the future. This benchmark is needed for our analysis because we will assume that observable deviation from collusion will result in playing the competitive equilibrium in all future periods. The main result of this section is that in the static game the usual Bertrand paradox holds, in which strong price competition dissipates all of the retailers' profits. Moreover, since contracts are secret and the supplier has an incentive to act opportunistically, there are equilibria in which the supplier earns below the monopoly profits.

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

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

Next, consider the equilibrium w^C. The equilibrium value of w^C depends on the beliefs regarding out-of-equilibrium strategies. When R_i makes a deviating offer that the supplier accepted, R_i cannot observe whether the supplier accepted the equilibrium contract of R_j as well, but the motivation of R_i to deviate from the equilibrium depends on R_i's beliefs regarding the response of the supplier to this deviation. Suppose that the three firms share the beliefs that when R_i deviates to a contract that makes it worthwhile for the supplier to accept R_i's offer exclusively, R_i rationally expects that the supplier rejects the contract offer of R_j. These beliefs are close in nature to "*wary beliefs*" in McAfee and Schwartz (1994) and in what follows we adopt the same terminology.[3] Intuitively, the optimal deviation for R_i and the supplier is to a contract with $w_i = 0$ that the supplier accepts exclusively. Then R_i can set p^*, maximize their joint profit and share them with the supplier through T_i. However, when $w_i = 0$, the supplier has the incentive to behave opportunistically and accept the contract of R_j. Under "*wary beliefs*", a rational R_i expects this opportunistic behavior and will take it into account when choosing the deviating offer.

[3] In their model, under "wary beliefs" a retailer believes that if a supplier deviates from its equilibrium offer to the retailer, the supplier offers the competing retailer a contract that maximizes the joint profit of the supplier and competing retailer.

More precisely, suppose that R_i deviates by offering the supplier a contract $(w_i, T_i) \neq (w^*, T^*)$. Let $p(w_i)$ denote the price that maximizes R_i's monopoly profits, $(p - w_i)Q(p)$. Notice that for any $w^C \in [0, p^*]$ and $w_i \geq 0$, $p(w_i) > w^C$, because $p(w_i) > p(0) = p^* > w^C$. If R_i offers a deviating contract that the supplier accepts, it is rational for R_i to believe that the supplier rejects the contract of R_j and it is rational for the supplier to believe that R_i will set the monopoly price given w_i, $p(w_i)$, when: $w_iQ(p(w_i)) > w^CQ(w^C)$ (notice that T_i has no affect on the supplier's decision to accept or reject the contract of R_j). To see why, notice that given that R_i believes that supplier rejects the contract of R_j, R_i finds it optimal to set $p(w_i)$. Likewise, given that the supplier believes that R_i sets $p_i(w_i)$, the supplier finds it optimal to reject the contract of R_j because if the supplier accepts R_j's offer, R_j sets the equilibrium price $p^C = w^C < p(w_i)$ and the supplier earns $w^CQ(w^C)$ while if the supplier rejects R_j's offer the supplier earns $w_iQ(p(w_i))$. If however $w_iQ(p_i(w_i)) < w^CQ(w^C)$, then even if the supplier accepts R_i's deviating contract and R_i expects that the supplier does not accept the contract of R_j, the supplier behaves opportunistically and accepts the contract of R_j that will undercut R_i, making the deviation unprofitable for R_i. The following lemma characterizes the set of equilibria under *wary beliefs*:

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

$$\max_{w_i}\{w_iQ(p(w_i))\} < w^CQ(w^C)\,, \tag{1}$$

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

Proof: see the Appendix.

The result that retailers cannot earn positive profit in the competitive equilibrium suggests that in a dynamic, infinitely repeated game, retailers may have an incentive to engage in tacit collusion. When the competitive equilibrium involves $\pi^C < p^*Q^*$, the supplier may have an incentive to collaborate with the two retailers in the tacit collusion equilibrium. In what follows, suppose that the three firms expect that the competitive equilibrium involves $\pi^C < p^*Q^*$ such that all three firms can improve their position by collaborating in a collusion equilibrium. As we will show, our results do not qualitatively depend on the value of π^C as long as $\pi^C < p^*Q^*$.[4]

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

4. Collusion equilibrium in an infinitely repeated interaction

4.1. The condition of the collusive equilibrium

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 both retailers offer the same equilibrium contract, (w^*,T^*) that the supplier accepts. Then, in stage 2 both retailers set the monopoly price, p^*, and equally split the monopoly quantity, Q^*. Given an equilibrium w^*, each retailer earns in every period $\pi_R(w^*) = (p^* - w^*)Q^*/2 - T^*$ and the supplier earns in every period $\pi_S(w^*) = w^*Q^* - 2T^*$.

Since contracts are secret, we can distinguish between potential deviations from the collusive equilibrium that are publicly observable to the three firms ex-post, after the end of the period, and deviations that are only partially observable to the supplier and one of the retailers but will never be detected by the second retailer. The publicly observable deviation from collusion is when R_i sets a different retail price than p^*, but such a deviation can be the result of two unobservable deviations. First, if the deviation is to $p_i < p^*$, which result in R_i dominating the market, R_j cannot know whether the deviation occurred because R_i and the supplier agreed on a different contract than (w^*,T^*) that motivates R_i to deviate from the monopoly price or because R_i offered the equilibrium contract but then chose to deviate from p^*. Second, if R_i didn't carry the product in a certain period (which corresponds to a deviation to $p_i = \infty$), R_j cannot tell whether this is because R_i offered a different contract than (w^*,T^*) that the supplier rejected, or R_i offered the equilibrium contract but the supplier deviated from its equilibrium strategy and accepted only the contract of R_j. The partially observable deviation from collusion which will never be detected by one of the retailers is when R_i offers a contract different than (w^*,T^*) that the supplier accepted, but then R_i continued to set p^*. R_j will never learn of this deviation, since contracts are secret. In order to support the collusive scheme, the contract (w^*,T^*) must prevent the above-mentioned deviations.

Because of the dynamic 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 different price than p^* or does not carry the product), retailers play in all future periods the competitive equilibrium defined in section 3.[5] Second, we focus on the equilibrium that maximizes the profits of the two retailers subject to the constraint that the supplier earns at least its profit in the competitive equilibrium, π^C. In the background of our model it is possible to think of a preliminary stage in which the three firms coordinate their equilibrium strategies and their beliefs concerning potential deviations. Since the focus of our model is on retailers with

[5] We consider an alternative trigger strategy in section 4.4.

strong bargaining power, we focus on outcomes that provide retailers with the highest share of the monopoly profit that ensures the supplier at least the profit in the competitive equilibrium. It is reasonable to expect that retailers may also be able to coordinate on the competitive equilibrium outcome and choose the lowest π^C possible, $w_L Q(w_L)$. Our qualitative results do not relay on the actual size of π^C as long as collusion is weakly beneficial to all three firms (i.e., $\pi^C < p^*Q^*$) and therefore we solve the collusive equilibrium for any arbitrary π^C.

To solve for the collusive equilibrium, we first consider necessary conditions on (w^*,T^*). Then, we show that they are also sufficient. The first condition is that once retailers offered a contract (w^*, T^*) that the supplier accepted, R_i indeed plays in stage 2 the monopoly price p^* instead of deviating to a slightly lower price. By deviating R_i gains all the demand in the current period but stops future collusion. R_i will not deviate from collusion in the second stage if:

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

where the left hand side is R_i's profit from maintaining collusion and the right hand side is R_i's profit from deviating. Notice that condition (2) is affected only by the retailers' discount factor and not by the supplier's because this constraint involves with the retailers' deviation possibility in stage 2 given that the supplier played the equilibrium strategy of accepting the two equilibrium contract offers in stage 1.

The second necessary condition is the supplier's participation constraint:

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

The left hand side is the supplier's profit from accepting the two equilibrium contracts and thereby maintaining collusion. The right hand side is the supplier's profit from accepting only one of the contracts. If the supplier rejects the contract of R_i, then R_j can detect this deviation only at the end of stage 2, when R_j observes that R_i doesn't offer the product. Therefore, R_j will still charge in stage 2 the monopoly price p^* and sell Q^*, implying that the supplier earns in the current period $w^*Q^* + T^*$ and collusion breaks in all future periods in which the supplier earns π^C. If the left hand side of (3) is higher than the right hand side, then R_i has the incentive to deviate to a contract with a lower T_i such that the supplier will accept in order to maintain the collusion in the future. If the right hand side of (3) is higher than the left hand side, then when both retailers offer the equilibrium contract the supplier will deviate from the equilibrium strategy in stage 2 of accepting the two contracts and will accept only one of the contracts. Therefore, condition (3) has to hold in equality. Notice that this condition is affected by the supplier's discount factor only and not by the retailers' discount factor because it concerns with the supplier's deviation possibility given that retailers offer the equilibrium contracts.

Extracting T^* from (3) and substituting into $\pi_R(w^*)$, we can rewrite R_i's one-period profits as a function of w^* as:

$$\pi_R(w^*) = \left(p^* - \frac{1-\delta}{1+\delta} w^*\right) Q^*/2 - \frac{\delta}{1+\delta}\pi^C, \quad \pi_S(w^*) = \frac{1-\delta}{1+\delta} w^* Q^* + \frac{2\delta}{1+\delta}\pi^C. \qquad (4)$$

Notice that $\pi_R(w^*)$ is decreasing with w^* while $\pi_S(w^*)$ is increasing with w^*.

The two conditions above ensure that the supplier accepts the two equilibrium contracts and that a retailer sets p^* if the supplier accepts its equilibrium contract. The remaining requirement is that R_i does not find it profitable to deviate in stage 1 to any other contract $(w_i, T_i) \neq (w^*, T^*)$. The benefits of R_i and the supplier from such a deviation depend on their out-of-equilibrium beliefs concerning each other's future strategies given the deviation. That is, whether the supplier will accept the contract offers of both retailers of just one of them and whether R_i will continue colluding or not. We apply wary beliefs as follows. Suppose that given any deviation to $(w_i, T_i) \neq (w^*, T^*)$, the supplier and R_i share common beliefs on whether this contract is going to motivate R_i to maintain collusion in the stage 2 or not. Given these common beliefs, the supplier accepts the contract offers of both retailers only if it is profitable for the supplier to do so.

Proposition 1 shows that given conditions (2), (3) and $\pi_S(w^*) \geq \pi^C$ and given wary beliefs, R_i cannot profitably deviate to any other $(w_i, T_i) \neq (w^*, T^*)$. Therefore, conditions (2), (3) and $\pi_S(w^*) \geq \pi^C$ are also sufficient for the collusion equilibrium. Proposition 1 also characterizes the unique collusive contract that maximizes the retailers' profits subject to (2), (3) and $\pi_S(w^*) \geq \pi^C$.

Proposition 1: *Suppose that* $\delta > 0$. *Then, under wary beliefs, there is a unique collusive equilibrium that maximizes the retailers' profits subject to* (2), (3) *and* $\pi_S(w^*) > \pi^C$. *In this equilibrium:*

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

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

Proof: see the Appendix.

Substituting (5) into (4) yields that the retailers and the supplier earns in equilibrium $\pi_R^* \equiv \pi_R(w^*)$ and $\pi_S^* \equiv \pi_S(w^*)$ where:

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

4.2. The features of the retailers' most profitable collusive equilibrium

Let $SA^* = -T^*$ denote the equilibrium slotting allowance. The following corollary describes the features of the retailers' most profitable collusive equilibrium. Figure 1 illustrates the retailers' most profitable collusion equilibrium as a function of δ.

Corollary 1: *In the retailers' most profitable collusion equilibrium:*

(i) *For* $\delta \in (0, 1/2]$:

- *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*;*
- *retailers pay slotting allowances:* $SA^* > 0$*. The slotting allowances are an inverse U-shape function of* δ.

(ii) *For* $\delta \in [1/2, 1]$:

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

Proof: follows directly from (5), (6) and (7).

Figure 1 and part (i) of Corollary 1 reveal that at $\delta \to 0$, $w^* \to p^*$, $SA^* \to 0$ and the supplier earns most of the monopoly profits. As δ increases, w^* decreases and retailers gain a higher proportion of the monopoly profits. Moreover, the equilibrium slotting allowances are an inverse U-shape function of δ. The intuition for these results is the following. Consider first the case where $\delta = 0$. Since retailers do not care about the future, the only possible w^* that motivates a retailer to set in stage 2 the monopoly price is $w^* = p^*$. For any other $w^* < p^*$, an individual retailer will deviate in stage 2 to a price slightly below p^* and monopolize the market, ignoring the negative effect of doing so on future profits. Since the supplier also does not care about the future and since $w^* = p^*$, retailers cannot charge slotting allowances. To see why, notice that if R_i asks for slotting allowances, the supplier can reject R_i's contract and earn $\pi_S(w^*) = w^*Q^* = p^*Q^*$ from accepting the contract of R_j and ignoring the negative effect of breaking collusion in the future. As a result, with $w^* = p^*$ and without slotting allowances, a collusive equilibrium requires the supplier to gain all of the monopoly profits. However, notice that in such a case retailers have week incentives to coordinate on the collusion equilibrium to begin with.

Suppose now that δ increases slightly above 0. In this case retailers have two complementary ways to collect a positive share of the monopoly profit from the supplier. First, now R_i can charge slotting allowances. If the supplier rejects R_i's contract and accepts only R_j's contract, the supplier earns a one-period profit close to the monopoly profits in the current period, but collusion breaks in future periods. Since now the supplier cares about the future, R_i can ask for slotting allowances, which the supplier accepts, just in order to maintain collusion in the next period. The second option that R_i can use in order to gain a positive share of the monopoly profit is by reducing w^* below p^*. Intuitively, a low w^* increases R_i's short-term profit from deviating from p^* in stage 2. To see why, notice that whenever R_i sets p^*, R_i earns in the current period the profit margin of $p^* - w^*$ on half of the monopoly quantity, while by deviating to a slightly lower price than p^*, R_i can earn the profit margin $p^* - w^*$ on all the monopoly quantity. For this reason, when $\delta = 0$ the only possible collusion wholesale price is $w^* = p^*$. However, when δ is slightly higher than 0, now R_i also cares about the future and in stage 2 R_i will charge the monopoly price even when $w^* < p^*$ because doing so maintains the collusive equilibrium in future periods. Since the supplier knows that R_i cares about the future, the supplier agrees to a contract offer that includes $w^* < p^*$ and anticipates that collusion will continue in future periods. To summarize, when $\delta > 0$, R_i can exploit the supplier's concern about future profits (through condition (3)) in order to charge slotting allowances and can exploit its own concern about future profits (through condition (2)) in order to reduce w^*. Therefore, in equilibrium, retailers both ask for slotting allowances and set $w^* < p^*$ which enable them to gain a positive share of the monopoly profit. As δ increases, the supplier's incentive to maintain collusion in the future increases and retailers can take advantage of it by offering a take-it-or-leave-it contract that allocates a higher share of the monopoly profit to retailers. As a result, the retailers' profits increase with δ while the supplier's profit decreases with δ.

The equilibrium w^* decreases with δ because as δ increases retailers have more of an incentive to maintain the collusive equilibrium and therefore a lower w^* is sufficient for motivating retailers not to undercut the monopoly price in stage 2. The effect of δ on the level of slotting allowances is non-monotonic, because δ has two opposite effects on the level of slotting allowances. First, there is a positive direct effect because the more the supplier cares about the future the higher the slotting allowances the supplier is willing to pay to maintain collusion. Second, an indirect negative effect, because as δ increases, w^* decreases. This in turn reduces the supplier's willingness to pay slotting allowances. The first effect dominates for low values of δ while the second effect dominates for high values of δ.

Part (ii) of Corollary 1 reveals that when $\delta > 1/2$, retailers sufficiently care about the future to maintain collusion without charging slotting allowances. Retailers keep the supplier on its alternative profit from stopping collusion, π^C, and earn the remaining monopoly profits. As a result, the firms' profits and the equilibrium contract are not a function of δ. The intuition follows from the benchmark case in section 2 where two firms that compete in prices produces their own inputs and can maintain collusion for $\delta > 1/2$.

4.3. The Implications for antirust policy

The results of Corollary 1 have two implications for antitrust policy. The first policy implication involves the use of slotting allowances – the fees that retailers, especially supermarkets and drugstores, ask from suppliers in order to secure shelf space. In the context of this model, the following corollary shows that when the retailers' most profitable collusive equilibrium involves asking for slotting allowances: $\delta \in (0, 1/2]$, firms cannot maintain any collusive equilibrium with $T^* \geq 0$.

Corollary 2: *If* $\delta < 1/2$, *then there are no contracts* (w^*, T^*) *that can maintain a collusive equilibrium with* $T^* \geq 0$.

Proof: see the Appendix.

As we explained in the literature review, the result that retailers can use slotting allowances in order to relax downstream competition is not new. The main contribution of Corollary 2 is in showing that slotting allowances can be anti-competitive even when contracts are secret, when competing retailers buy their inputs from the same supplier. 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 collusion. Therefore, a retailer cannot profitably convince the supplier to accept a contract that motivates the retailer (and the supplier) to deviate from the collusion equilibrium. For antitrust policy, this result implies that the anti-competitive effect of slotting aloneness is not immune to retailers' ability to make secret offers to a joint supplier.

Corollary 2 and proposition 1 also indicate that the anti-competitive effect of slotting allowances is not necessarily related to their size. When δ is close to zero, even though firms are very shortsighted such that it should be very difficult for them to maintain collusion along time, still a small size of slotting allowances is enough to maintain the collusion equilibrium. As firms care more about future profits, even though it becomes easier for them to collude, the size of the slotting allowances increases. Then, after a certain threshold of δ, the easier it becomes to sustain collusion (δ increases), the size of the slotting allowances decreases. For antitrust policy, this result indicates that antitrust authorities cannot undermine the potential anti-competitive effect of slotting allowances because of their size.

The second implications of the results concerns with deterring collusive behavior. In this model the collusive behavior involves upstream and downstream firms. We can therefore ask whether it is more effective for antitrust authorities to deter collusive behavior by panelizing the retailers or by panelizing the supplier. As Corollary 1 shows, when δ is small, retailers have little to gain in the collusive equilibrium as most of the monopoly profits goes to the supplier. In such a case, retailers are the "weak-link" in the collusive equilibrium and imposing penalties on retailers can be an effective tool for deterring collusion. As δ increases, retailers can gain a higher share of the monopoly profit and therefore the "weak-link" is the supplier how now has less to gain by maintaining collusion. Panelizing the supplier becomes more effective as δ increases.

4.4 Alternative trigger strategy

The previous section shows that for $\delta < 1/2$ the supplier earns higher profits than π^C even though retailers have the bargaining power to make take-it-or-leave-it contracts and can coordinate on their most profitable collusive equilibrium. This result is driven by the assumption that if R_i observes that R_j didn't carry the product, R_i interprets it as a deviation by R_j and stops collusion. Such a trigger strategy provides the supplier with market power because the supplier can benefit from rejecting an equilibrium offer. In this subsection we ask whether retailers can earn higher profits by using a softer trigger strategy that reduces the supplier's bargaining power.

Suppose that whenever R_i observes that R_j didn’t carry the product, R_i interprets it as a deviation by the supplier and continues with the collusion 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^*. The benefit from this alternative trigger strategy is that it may help retailers to obtain a higher share of the monopoly profits because now the supplier loses the ability to defect from collusion when both retailers made the equilibrium offers. The cost of this strategy is that it increases the retailers' benefit from defecting from the collusive equilibrium in the first stage of every period, as now the supplier cannot punish a retailer who deviated from the collusive contract.

With this alternative trigger strategy, condition (2) is still necessary to support a collusive equilibrium because this condition prevents R_i from defecting from collusion in the second stage of the period. Turing 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. The new supplier's participation constraint is:

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

where the left-hand-side is the supplier's profit from accepting the two equilibrium contracts and the right-hand-side is the supplier's profit from accepting only one of them. This condition requires that $T^* = 0$. However, the proof of Corollary 2 showed that (2) cannot hold if $T^* \geq 0$ and $\delta < 1/2$ implying that this alternative trigger strategy cannot maintain a collusive equilibrium.

Corollary 3: *Suppose that* $\delta < 1/2$ *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.*

The intuition for this result is that collusion for low values of δ requires retailers to give up on their market power to their joint supplier and share with the supplier their collusive profit. The alternative trigger strategy eliminates the supplier's bargaining power and consequently does not provide the supplier with the power to policy the two retailers.

Consider now the case where $\delta > 1/2$. In collusive equilibrium that we defined in Proposition 1 the supplier earns only its reservation profit, π^C. Given our assumption that in any collusive equilibrium the three firms should earn at least their profit from the competitive equilibrium, retailers cannot do better by adopting the alternative trigger strategy.

5. Conclusion

We consider collusion in a dynamic game between two retailers and a joint supplier. Our model has two main features. First, vertical contracts are secret: a retailer cannot observe the bilateral contracting between the competing retailer and the supplier. Second, all three firms care about the future. We find that the combination of these two features can sustain a collusive equilibrium. In this equilibrium, retailers share the collusive profits with the joint supplier and ask for slotting allowances. As the three firms care more about future profits, retailers can obtain a higher share of the monopoly profits in the expense of the supplier and the level of slotting allowances is first increasing and then decreasing.

Appendix

Below are the proofs of Lemma 1, Proposition 1 and Corollary 2.

Proof of Lemma 1:

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

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

$$\max_{w_i}\{w_i Q(p(w_i))\} < \max_{w^C}\{w^C Q(w^C)\},$$

$$\max_{w_i}\{w_i Q(p(w_i))\} > w^C Q(w^C)\Big|_{w^C=0}, \text{ and: } \max_{w_i}\{w_i Q(p(w_i))\} < w^C Q(w^C)\Big|_{w^C=p^*},$$

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

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

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

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

Proof of Proposition 1:

We will move in three steps. In the first step we solve for the set of (w^*, T^*) that satisfy (2), (3) and $\pi_S(w^*) \geq \pi^C$. In the second step we show that the set of (w^*, T^*) ensures that R_i cannot profitably deviate to (w_i, T_i) ≠ (w^*, T^*). We will assume wary beliefs such that R_i expects that the supplier accepts the contract of R_j only if it is profitable for the supplier to do so. In Lemma *A1* we will show that if the supplier expects that by accepting both R_i's deviating offer and R_j's offer R_i will defect from collusion, then the supplier will not accept both offers to begin with. This implies that if the supplier accepts a deviating offer by R_i in the first stage of a certain period, the supplier accepts the equilibrium offer of R_j only if the supplier expects that R_i will maintain collusion at the second stage. We can therefore restrict attention to the following two cases that we examine in Lemma *A2* and Lemma *A3*. Lemma *A2* shows that R_i cannot profitably deviate to a contract (w_i, T_i) ≠ (w^*, T^*) such that if the supplier accepts the deviating offer of R_i, the supplier also accepts and the equilibrium offer of R_j and then R_i continues to maintain collusion. We do not impose constraints on the set of possible (w_i, T_i) that ensures that R_i indeed maintains collusion given the deviating contract because we show that even the unconstrained set of (w_i, T_i) is never profitable for R_i. In Lemma *A3* we show that R_i cannot profitably deviate to a contract (w_i, T_i) ≠ (w^*, T^*) such that if the supplier accepts the deviating offer of R_i, the supplier does not accept and the equilibrium offer of R_j. Again we show that this holds for any (w_i, T_i) and therefore we do not need to impose restrictions on the set of possible (w_i, T_i) that support such beliefs. In the third step we solve for the (w^*,T^*) that maximizes the retailers' profits subject to (2), (3) and $\pi_S(w^*) \geq \pi^C$.

Starting with the first step, extracting T^* from (3) yields:

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

Substituting (A-1) into (3) we can rewrite (2) as:

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

Substituting (A-1) into $\pi_S(w^*)$ we have:

$$\pi_S(w^*) = \frac{1-\delta}{1+\delta} w^* Q^* + \frac{2\delta}{1+\delta}\pi^C > \pi^C \quad \Leftrightarrow \quad w^* > \frac{\pi^C}{Q^*}. \tag{A-3}$$

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

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

Next, we turn to the second step of showing that the set of $w^* \geq w^E$ and $T^*(w^*)$ ensures that R_i cannot profit from deviating to another $(w_i,T_i) \neq (w^*, T^*)$.

We first show that given that the supplier accepts a deviating offer by R_i, the supplier does not accept the equilibrium contract of R_j if the deviating contract motivates R_i to deviate from the collusive price in the second stage of the period.

Lemma *A1*: *Suppose that in the first stage of a certain period R_i offers a deviating contract $(w_i,T_i) \neq (w^*, T^*)$ that motivates R_i to deviate from the collusive price at the second stage of the period. Under wary beliefs R_i cannot rationally expect that if the supplier accepts R_i's contract, the supplier also accepts the equilibrium contract offer of R_j.*

Proof: We will show that for all $w^* \geq w^E$, $T^*(w^*) \leq 0$. Consequently, the supplier cannot make positive profits from R_j by accepting both offers because the supplier expects that R_j cannot make positive sales while accepting the offer of R_j result in paying: $-T^*(w^*)$. To see why $T^*(w^*) \leq 0$, for $\delta < 1/2$:

$$T^*(w^*) = \frac{\delta(\pi^C - Q^* w^*)}{1+\delta} \leq \frac{\delta(\pi^C - Q^* w^E)}{1+\delta} = -\frac{\delta}{1-\delta}(1-2\delta)(p^* Q^* - \pi^C) < 0,$$

where the first inequality follows because $w^* \geq w^E$ and the second inequality follows because $\delta < 1/2$ and $p^*Q^* > \pi^C$. For $\delta > 1/2$, $T^*(w^*) \leq T^*(w^E) = T^*(\pi^C/Q^*) = 0$.

Lemma *A1* implies that if the supplier accepts a deviating offer by R_i in the first stage of a certain period, the supplier accepts the equilibrium offer of R_j only if the supplier expects that R_i will maintain collusion at the second period. Below we show that if there is such a deviating contract, $(w_i,T_i) \neq (w^*, T^*)$, R_i will not offer it. We do not impose constraints on (w_i, T_i) that support these beliefs but show that given any (w_i, T_i) that support these beliefs, the deviation is not profitable to R_i.

Lemma ***A2*****:** *Suppose that in the first stage of a certain period R_i offers a deviating contract $(w_i,T_i) \neq (w^*, T^*)$ such that the supplier and R_i expects that if the supplier accepts the deviation, the supplier also accepts the offer of R_j and R_i maintains collusion in the second stage of this period. Than, R_i cannot profit from making such a deviation.*

Proof: Suppose that the supplier and R_i have the common beliefs that if the supplier accepts the deviation, the supplier also accepts the offer of R_j and R_i maintains collusion. Whenever R_i makes this deviation, the supplier expects that R_i will set p^* in the current period and therefore R_j will not detect it. The supplier's profit from accepting the deviation depends on whether the supplier expects that R_i will offer in the next period the equilibrium contract or continue offering the deviating contract. We consider each possibility in turn. Suppose first that the supplier expects that R_i offers a one-period deviation, (w_i, T_i), and will continue offering (w^*,T^*) in all future periods. The supplier anticipates that by accepting this contract, this deviation will not be detected by R_j and therefore collusion is going to maintain in future periods. Therefore, the supplier accepts the deviation iff:

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

where the left-hand-side is the supplier's profit from accepting a one-period deviation given that doing so maintains the collusion equilibrium in all future periods and the right-hand-side is the supplier's profit from accepting R_j's contract and stopping collusion. Substituting (A-1) into (A-4) and solving for T_i, the supplier accepts the deviation if:

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

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

$$(p^*-w_i)Q^*/2-T_i<\tfrac{1}{2}\left(p^*-\frac{1-\delta}{1+\delta}w^*\right)Q^*-\frac{\delta}{1+\delta}\pi^C=\pi_R(w^*). \tag{A-6}$$

where the inequality follows from substituting (A-5) into T_i in (A-6). Notice that we only need to look at the one-period profit because if the supplier accepts the deviation then R_i's future profits are $\pi_R(w^*)$. We therefore have that R_i cannot profit from making the deviation. Suppose now that the supplier expects that R_i's deviation is permanent. Now, the supplier agrees to the deviation if:

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

where the left-hand-side is the supplier's profit from accepting the deviation given that the supplier expects that the deviation is permanent and the right-hand-side is identical to (A-4). The supplier agrees to the deviation if:

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

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

$$\frac{(p^*-w_i)Q^*/2-T_i}{1-\delta} < \tfrac{1}{1-\delta}\left(\tfrac{1}{2}\left(p^* - \frac{1-\delta}{1+\delta}w^*\right)Q^* - \frac{\delta}{1+\delta}\pi^C\right) = \frac{\pi_R(w^*)}{1-\delta}, \tag{A-8}$$

where the inequality follows from substituting T_i in (A-7) into (A-8). We therefore have that R_i cannot profitably make a permanent deviation to (w_i, T_i) that motivates R_i to maintain collusion.

Next we turn to the last deviating option for R_i, which is to deviate to a contract such that if the supplier accepts the deviation, the supplier does not find it profitable to accept the equilibrium contract of R_j. In the following lemma we show that if there is such a deviating contract, (w_i,T_i) $\neq$(w^*, T^*), R_i will not offer it. As with Lemma *A2*, we do not impose constraints on the set of (w_i, T_i) that support these beliefs but show that given any unconstrained set of (w_i, T_i) that support these beliefs, the deviation is not profitable to R_i.

Lemma *A3*: *Suppose that in the first stage of a certain period R_i offers a deviating contract* (w_i,T_i) $\neq$(w^*, T^*) *such that if the supplier accepts the contract, the supplier does not accept offer of R_j. Than, R_i cannot profit from making such a deviation.*

Suppose that R_i deviates to (w_i, T_i) given the beliefs that if the supplier accepts the deviation, the supplier rejects the contract of R_j. The supplier accepts the deviation if $w_iQ(p(w_i)) + T_i > w^*Q^* + T^*(w^*)$, or:

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

R_i earns from this deviation:

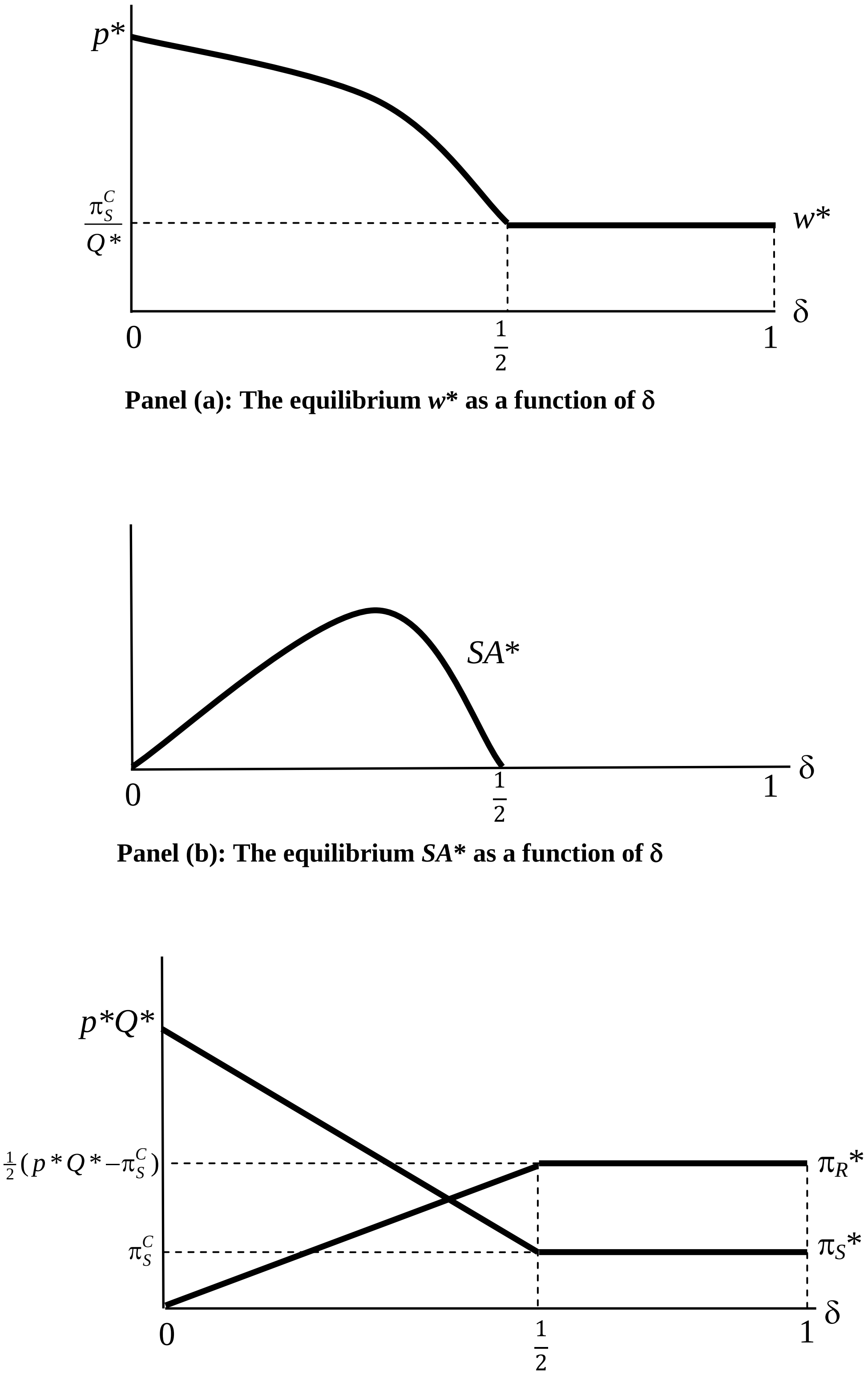
$$
\begin{aligned}
&(p(w_i) - w_i)Q(p(w_i)) - T_i \\
&< p(w_i)Q(p(w_i)) - w^*Q^* - T^*(w^*) \\
&= Q^*\left(p^* - \frac{w^*}{1+\delta}\right) - \frac{\delta}{1+\delta}\pi^C \qquad , \\
&< \frac{\pi_R(w^*)}{1-\delta}
\end{aligned}
\tag{A-10}
$$

where the first inequality follows from substituting the right-hand-side of (A-9), the equality follows from substituting (A-1) and the second inequality holds iff $w^* > w^E$, implying that this deviation is not profitable for R_i for $w^* > w^E$.

Finally, we turn to the last step of solving for the collusive equilibrium that maximizes the retailers' profits subject to (2), (3) and $\pi_S(w^*) > \pi^C$. From (4), $\pi_R(w^*)$ is decreasing with w^* and therefore the most profitable equilibrium is $w^* = w^E$. Substituting w^E into (A-1) yields (5) and (6).

Proof of Corollary 2:

Suppose that retailers have choose a collusive equilibrium subject to the constraint $T(w^*) \geq 0$. From (A-1), $T(w^*) \geq 0$ requires $w^* \leq \pi^C Q^*$. However, (3) requires that $w^* > w^E > \pi^C Q^*$ where the last inequality holds for all $\delta < 1/2$. Therefore, it is impossible to obtain a collusive equilibrium with $T^*(w^*) > 0$ for $\delta < 1/2$.



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

Figure 1: The features of the retailers' most profitable equilibrium as a function of δ

References

[1] Bonnano, Giacomo and John Vickers, J. 1988. "Vertical Separation." *Journal of Industrial Economics*, Vol. 36 (1988), pp. 257- 265.

[2] Chu, Wujin. 1992. "Demand Signaling and Screening in Channels of Distribution." *Marketing Science*, 11(4): 327-347.

[3] Desai, Preyas S. 2000. "Multiple Messages to Retain Retailers: Signaling New Product Demand." *Marketing Science*, 19(4): 381-389.

[4] Dovrat-Meseritz, Adi. 2014. "Who's to Blame for Israel's High Food Prices?", *Haaretz*. Available in: http://www.haaretz.com/business/.premium-1.619805 (last visited on 8/10/2014).

[5] Doyle, Chris and Martijn A. Han, M.A. 2012/ "Efficient Cartelization through Buyer Groups." Amsterdam Center for Law & Economics Working Paper No. 2009-03, University of Amsterdam.

[6] Federal Trade Commission. 2001. "Report on the FTC Workshop on Slotting Allowances and Other Marketing Practices in the Grocery Industry." Available at: http://www.ftc.gov/os/2001/02/slottingallowancesreportfinal.pdf (last visited on June 2012).

[7] Federal Trade Commission. 2003. "Slotting Allowances in the Retail Grocery Industry: Selected Case Studies in Five Product Categories." Available at: http://www.ftc.gov/os/2003/11/slottingallowancerpt031114.pdf (last visited on June 2012).

[8] Hart, Oliver and Jean Tirole. 1990. "Vertical Integration and Market Foreclosure." Brookings Papers on Economic Activity, pp. 205-276.

[9] Hendel, Igal, Lach Saul and Yossi Spiegel. 2014 "Social Media and Consumer' Countervailing Power: The Cottage Cheese Boycott," Working paper. Available at: http://www.tau.ac.il/~spiegel/papers/HLS.pdf (last visited on October 2014).

[10] Innes, Robert and Stephen F. Hamilton. 2006. “Naked Slotting Fees for Vertical Control of Multi-Product Retail Markets,” *International Journal of Industrial Organization*, 24: 308-18.

[11] Israel Antitrust Authority. 2003. IAA stands on trade terms between suppliers and retailers (Hebrew).http://www.antitrust.gov.il/NR/rdonlyres/DF964E92-53CB-4981-9F13-6A0D04331F20/0/hesderim.pdf (last visited on June 2012).

[12] Jullien, Bruno and Patrick Rey. 2007. “Resale Price Maintenance and Collusion.” *Rand Journal of Economics*, Vol. 38, pp. 983–1001.

[13] Lariviere, Martin A and V. Padmanabhan. 1997. "Slotting Allowances and New Product Introductions," *Marketing Science*, 16(2): 112-128.

[14] McAfee, Preston and Marius Schwartz, M. 1994. "Opportunism in Multilateral Vertical Contracting: Nondiscrimination, Exclusivity, and Uniformity," *The American Economic Review*, Vol. 84, pp. 210-230.

[15] Nocke, Volker and Lucy White. 2007. “Do Vertical Mergers Facilitate Upstream Collusion?” *The American Economic Review*, Vol. 97, pp. 1321–1339.

[16] Nocke, Volker and Lucy White. 2010. “Vertical Merger, Collusion, and Disruptive Buyers.” *International Journal of Industrial Organization*, Vol. 28, pp. 350–354.

[17] Normann, Hans Theo. 2009. Vertical Integration, Raising Rivals’ Costs and Upstream Collusion. *European Economic Review*. Vol. 53, pp. 461–480.

[18] O’Brien, Daniel P. and Greg Shaffer. 1992. “Vertical Control with Bilateral Contracts”, *Rand Journal of Economics*, Vol. 23, pp. 299 –308.

[19] Piccolo, Salvatore and Markus Reisinger. 2011. “Exclusive Territories and Manufacturers’ Collusion.” *Management Science*, Vol. 57, pp. 1250–1266.

[20] Piccolo, Salvatore and Jeanine Miklós-Thal. 2012. "Colluding Through Suppliers," *Rand Journal of Economics*, Vol. 43, pp. 492–513 .

[21] Rey, Patrick Jeanine Miklos-Thal and Thibaud Verge. 2011. "Buyer Power and Intraband Coordination", *Journal of the European Economic Association*, Vol. 9, pp. 721-741.

[22] Rey, Patrick and Thibaud Verge. 2004. "Bilateral Control with Vertical Contracts." *Rand Journal of Economics*, Vol. 35, pp. 728–746.

[23] Rey, Patrick and Michael D. Whinston. 2013. "Does Retailer Power Lead to Exclusion?" *Rand Journal of Economics*, Vol. 44, pp. 75 – 81.

[24] Reisinger, Markus and Tim Paul Thomes. 2015. "Distribution Channels and Collusion of Manufacturers: Common versus Independent Retailers," working paper.

[25] Schinkel, Maarten Pieter. Tuinstra, Jan and Jakob Rüggeberg. 2008. "Illinois walls: How Barring Indirect Purchaser Suits Facilitates Collusion," *Rand Journal of Economics*, Vol. 39, pp. 683–698.

[26] Shaffer, Greg. 1991. "Slotting Allowances and Resale Price Maintenance: A Comparison of Facilitating Practices," *Rand Journal of Economics*, Vo. 22, pp. 120-135.

[27] Shaffer, Greg. 2005. "Slotting Allowances and Optimal Product Variety," *Advances in Economic Analysis & Policy*, Vol. 5, Article 3.

[28] Yehezkel, Yaron. 2014. "Motivating a Supplier to Test Product Quality." *Journal of Industrial Economics*, Vol. 62, pp. 309 - 345