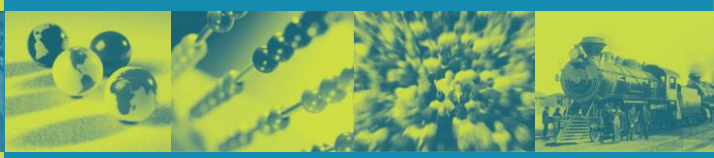
KU LEUVEN
CENTER FOR ECONOMIC STUDIES

DISCUSSION PAPER SERIES
DPS13.24

DECEMBER 2013



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Monetary and Information Economics

Faculty of Economics
And Business

Working paper. Do not cite or circulate.

Hub and Spoke Collusion By Embargo*

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May 2014

Abstract

A common supplier (the hub) could try to enforce a collusive outcome between his buyers (the spokes) if they are unable to sustain such an agreement among themselves. We derive necessary and sufficient conditions under which the hub is willing to assume the policing role in a cartel.

JEL Classification: D43, L13, L41, L42, K21

Keywords: Tacit Collusion, Refusal to deal.

*The authors gratefully acknowledge comments by R. Gibbons and F. Verboven. The usual disclaimer applies.

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1 Introduction

Antitrust authorities recently have dealt with a number of cases where collusion between downstream firms was induced or facilitated by a common supplier. Although this involves some vertical agreement between the supplier (the "hub") and his buyers (the "spokes") the legal doctrine that emerged from handling these cases was also influential for the view the European Commission holds on horizontal agreements.[1]

Economic analysis has shown the difficulties in implementing a collusive (horizontal) agreement. Firms participating in a cartel have to reach an agreement, detect defectors, and find an appropriate way to punish those who deviate from the agreement, see Osborne (1986). Subsequent contributions have introduced facilitating practices and the possibility to commit to a variety of punishment strategies to reach a tacit agreement to implement the monopoly outcome in an oligopoly market structure, see resp. Holt and Scheffman (1987) and Porter (1983).

The possible role that a common upstream supplier could play in the reach of a collusive outcome however remains relatively unexplored, see however Mathewson and Winter (1998) for a survey of the possible uses of vertical restraints to reduce interbrand competition. In the present contribution the focus lies on the possibility to reduce intra-brand competition. In its simplest format then, collusion between two downstream firms is made possible through the interaction of the downstream firms D_1 and D_2 (the "spokes") with a common, upstream supplier U (the "hub"). The present contribution investigates the role that this third party can have in disciplining the cartel. Hence it explores the incentives for U to enter into a cartel agreement where U participates in the punishment if either D_1 or D_2 deviates from the collusive agreement. Related issues involve the role that U could have in reaching an agreement between D_1 and D_2 or in detecting and disclosing defection by D_1 to D_2 or vice versa.

The model that is introduced to investigate this issue assumes that collusion between the downstream firms D_1 and D_2 is feasible and profitable. Legal analysis refers to this assumption by the requirement that there exists a "rim" to bind all the spokes together in "a single conspiracy".[2] This implies that the spokes are aware of each other's existence and conscious that interaction with the hub propagates the cartel outcome.[3]

[1] See Odudu (2010) for a recent study on the legal doctrine dealing with hub and spoke collusion and Camesasaca, Schmidt and Clancy (2010) for a critical investigation of the Draft of Guidelines on Horizontal Agreements.

[2] The need to have a collusive agreement between the downstream firms was established by the European Commission in the Pioneer decision, see Odudu (2010), o.c.

[3] A similar doctrine was used in the so called "Banana's" case where the European Commission absent a full

The question therefore is: what "contribution" to cartel stability could the hub make beyond what is in reach of the spokes when acting on their own, and when will the hub be willing to provide this support for the downstream cartel? Equivalently, in what way can the hub enlarge the strategy space as to make a difference should the game reach the punishment stage. And is the hub willing to take this action whenever necessary?

Both questions are answered in the affirmative for a strategy where the hub U cuts the deviating downstream firm from its supply chain. By refusing to further supply a downstream deviator (removing the spoke), the cartel becomes more stable compared to a cartel that has to rely on a price war on the rim for punishing deviation. The supplier prefers to take up short the downstream deviator because price wars lead to renegotiations that reduce the intermediate or "transfer" price at which the upstream player sells to the downstream firms.

Refusals to deal are far better known from industry configurations where a vertically integrated monopolist denies access to a downstream (potential) competitor, see Salop (2010).[4] A few examples illustrate that a strategy where a supplier refuses to deal further with a previous buyer that deviated from a collusive agreement, has ample empirical relevance. These examples show precisely how this type of cartel operates. French antitrust authorities (see Conseil de la Concurrence, 2004) convicted

leniency discount would have imposed higher fines upon Chiquita, a player who was in a cartel and who could foresee that his horizontal competitor and collusive partner (Dole) also was colluding with still another horizontal competitor, Weichert. The latter who did not see the gran collusive scheme, not presuming that if Dole was colluding with them, Dole was most likely also colluding with Chiquita, got away with a lower fine. This illustrates the same doctrine of being held liable for what collusive action can mean in terms of reaching a collusive outcome with others. Van Cayseele and Camesasca (2010) show why such an approach is nonsensical in terms of the economics of cartel enforcement.

[4]Interestingly, Case Law as in Trinko has been concerned with the collusive effect that could result from forcing access into the monopolist's supply chain, as a remedy. The immanent negotiations on access price are seen to possibly facilitate the operation of a cartel. Salop (2010) is critical vis-a-vis this argument since absent access, there is no downstream competition at all, or the existing monopoly situation hardly can be better than a collusive duopoly. This point undoubtedly is valid in a static context, but consider the situation where a potential entrant could pursue an innovative strategy that circumvents the essential facility of the incumbent monopoly, although at large difficulty. Compare this to the legal strategy that is far easier when refusals to deal are per se illegal. The entrant might be inclined to give up the difficult innovative path and apply for access. The incumbent might be inclined to grant this access knowing that the entrant then will abandon his research project. Once this happened, the entrant can be made a weak competitor and forced into collusion by threatening to cut him of the supply chain, precisely according to the mechanism put forward in the present article, hence "compelling negotiation between competitors may facilitate the supreme evil of antitrust: collusion" (as quoted in Salop on page 714).

TSL for the refusal to supply snow shoes to GO SPORT, a nationwide distributor of sports articles. Decathlon, a competitor to GO SPORT, had complained with TSL that it could not maintain a substantive margin if GO SPORT priced frequently below the agreed upon resale price.[5] In the same jurisdiction, one year later, Panasonic, Philips and Sony got convicted for exerting pressure on wholesalers not to supply retailers that deviated from the recommended sales price.

A similar case occurred in the US where La—Z—Boy Chair Company threatened World of Sleep, a high—volume price discounter of furniture.[6] La—Z—Boy Chair Company had conspired with competitors of World of Sleep to maintain retail prices. One of these competitors, Montgomery Ward, complained to La—Z—Boy Chair Company that World of Sleep ran a series of television commercials comparing the price of La—Z— Boy chairs to the higher prices in Montgomery Ward's catalogue. Still other examples have been noticed by the European Commission when supervising the market integration process. A supplier who divided the market in territories (that coincided with the member states) refused to supply a distributor in one country when he found out that this supplier participated in parallel imports from his own country into a neighboring one where the product was sold at a more expensive price.

□ Literature. A market in which a common supplier threatens to punish buyers who defect on a collusive agreement that exists between all of them resembles a resale price maintenance agreement. RPM has been looked at from the perspective of a (mostly forbidden) regime in which suppliers determine the end prices to consumers. Dobson and Waterson (2007) compare a RPM regime to a situation in which the suppliers only determine the intermediate prices to the distributors who then set the final consumer price in competition with the rival distributors. This model incorporates bargaining and double marginalization aspects in evaluating welfare with and without RPM. The model introduced in the present article is close to their analytical framework. But the focus is different in that we investigate a covert agreement (as opposed to an overt RPM for which an exemption on the competition rules exists) where the supplier does not determine the final consumer price but rather suggests the collusive price and then stabilizes the downstream cartel by

[5] This case is characterized by the use of an additional extension of the strategy space of Bertrand pricing games by the fact that Decathlon (the competitor) with the help of TSL (the supplier) bought the snow shoes that were offered by GO SPORT at the discounted price. The buying of a rival's output has been investigated extensively in Van Cayseele and Furth (1996). The implications for cartel arrangements notably the profit sharing rule have been made clear in Van Cayseele and Furth (2001).

[6] La—Z—Boy Chair Company told World of Sleep that: "We don't want any big price wars", and that they would do everything to get these wars stopped even "if it has to come down to being drastic about it".

refusing to deal further with those who deviate from the collusive price.

Jullien and Rey (2007) analyze RPM from the perspective of the detection of deviation from the collusive scheme. They investigate the trade-off between the increased probability of detection under RPM on the one hand against the suboptimal pricing with inflexible prices under RPM on the other hand. Price inflexibility has a cost in the presence of demand shocks. Tacit collusion is implemented by reverting to punishment after that a deviation has been detected as in the model presented in section 2 below. The main difference lies in the focus on collusion between manufacturers rather than retailers and the stochastic nature of demand that masks deviation from the agreement. In the stage game all the bargaining power resides with the manufacturer whereas in the model introduced below the relative strength of the parties matters for the outcome.

Work on two-part tariffs has indicated how competing manufacturers can maintain the monopoly outcome if they sell through a monopoly retailer, see Bernheim and Whinston (1985) and O'Brien and Shaffer (1997). In some way this industry structure mirrors the one under investigation (here): the monopoly position is on the retailer (supplier) side and hence the focus is on dampening inter(intra) brand competition. Recent work on vertical relations by Rey and Vergé (2010) and Inderst and Shaffer (2010) shows that the contractual relations between suppliers and retailers that facilitate collusion are more complex when inter-and intrabrand competition need to be dealt with at the same time. This work therefore respectively focusses on the use of RPM and Market-Share contracts to achieve the joint goal of limiting intra- and interbrand competition.

The present model casts a practice in which a supplier voluntarily contributes to the stability of a retailer cartel by refusing to supply a retailer that deviated from the cartel price. The upstream firm might be pleased with downstream collusion, as fierce competition in the downstream market can drive transfer prices (and hence upstream's profits) down to zero. Therefore, the enforcement of a cartel outcome becomes all the more important and the possibilities offered by an embargo on deviators all the more relevant.

A refusal to deal could be institutionalized by means of the frequently observed technique of non-binding retail price recommendations (RPR's). A manufacturer then "recommends" each retailer to implement their own cartel price, and communicates that deviations from this price will be met by an embargo. In order to be able to execute a strategy of stopping the supply to a retailer, the upstream firm can contractually foresee this contingency, so courts cannot force the supplier to furnish the retailer that was cut off. This could be done by including a clause that if insufficient promotional activities were undertaken, the supplier no longer is in the obligation to

provide the product. Everybody of course would understand that a price falling below the cartel price is tantamount to no longer being able to sustain sufficient promotional activity.

This is not to say that RPR's cannot serve other purposes or that industries that rely on RPR are by definition cartelized. On the contrary, Buehler and Gärtner (2010) investigate the rationale of these RPR's from the perspective of enhancing the overall efficiency of a supplier retailer relationship under asymmetry of information. In the present contribution the RPR can be seen as a trigger for punishment by the supplier whenever he chooses to participate in the policing of a downstream cartel, indicating that the motivation for such an arrangement is quite different in our model.

An interesting strand of research with a close link to the present analysis is the explanation for the existence of medieval merchant guilds by Greif, Milgrom and Weingast (1994). These organizations precisely used embargoes against foreign rulers that did not respect the property rights of the merchants that were a member of the guild. Greif, Milgrom and Weingast make several interesting points vis-a-vis the optimal organizational structure to sustain efficient levels of trade. The most prominent one is that bilateral or even multilateral reputational mechanisms are insufficient to sustain optimal levels of trade. The merchant guild needs to ensure that individual members or third parties do not circumvent the boycott. This is achieved by definition in the model investigated in this article by the fact that we focus on a single upstream supplier that can commit also his future types to no deliveries should a downstream player ever defect.

Another point raised by Greif, Milgrom and Weingast is that foreign rulers who were far more powerful than the merchant guilds nonetheless encouraged the establishment of merchant guild offices that helped monitoring and implementing a full boycott. Why would a foreign ruler that is military so powerful that he could easily avoid the establishment of such an office cede to the installation of one, even if it means that the possibility to rob a number of individual merchants ends? Because merchants understood that only a very limited number of them could trade based on individual reputational enforcement, trade would never develop to the efficient level since only the inframarginal trader was safe while the marginal one was prone to confiscation. The establishment of a guild that could punish individual traders that circumvented a full boycott then was the protection for the marginal one, allowing trade to develop to an efficient level. The ruler thus allows the building up of bargaining power "on the other side" because the leverage of the increased punishment allows the implementation of a more efficient equilibrium.

This point is fully articulated and investigated in the present context where we show that the

supplier equally allows for the building up of bargaining power on the buyer side when he cuts of a spoke. From a situation where he bargains with two buyers and therefore has a threat point to deal exclusively with one distributor, he moves toward bilateral monopoly where in failure of a deal with the remaining player, he has no outlet for his product at all. But as with the guild, this may benefit the supplier because stronger punishment achieves coordination between the buyers inducing them to remain in the cartel.

We first show that U might have a common interest with D_1 and D_2 in building up market power on the downstream market. This enables the buyers to pay a higher transfer price, which can turn out to be beneficial for U. Given this common interest, we then investigate how the supplier can contribute to the stability of the downstream cartel. We show that when one introduces a strategy where U no longer supplies a defector in the downstream cartel, punishment is harder as compared to any case where the defector can remain in the game. As such this strategy supports collusion for lower discount factors than the more lenient infinite grim strategies that rely on reversal to non-cooperative play. However, the cost of refusing to supply is borne by both the defector and the supplier, so in order for the latter to participate, a number of conditions need to be fulfilled. It is shown that only in a very limited number of cases, the supplier will participate in the punishment scheme and refuse to supply because the conditions that are required tend to be quite demanding. Only when the buyers are involved in strong price competition among themselves and they have sufficient bargaining power vis-a-vis the seller, is the seller willing to impose an embargo to stabilize the downstream cartel.

The remainder of this article then is organized as follows: in the next section we introduce the basic model and investigate four stage game outcomes of interest. Comparing these outcomes we then demonstrate the common interest in the formation of a retail cartel. In the third section we consider the repeated game and show the conditions for which hub and spoke collusion by embargo works. The fourth section expands this model in several directions while the fifth and last section concludes by pointing to the implications for the legal practice that develops at the EC by trying to lump different forms of conspiracy into one single infringement.

2 The Stage Game

2.1 Assumptions

The most basic industry configuration that can be used to investigate the impact that a supplier can have on the stability of a downstream cartel has one upstream manufacturer U and two downstream retailers denoted by D_1 and D_2. The product is manufactured by U, but the downstream firms add value by making it available to the final consumers, who have heterogeneous tastes regarding the retail shops they patronize. The manufacturer can choose which retailers he is willing to do business with. After making this supply choice, bilateral negotiations take place to determine the linear transfer price g that each retailer must pay to acquire the product. For simplicity U's cost of manufacturing the product is normalized to zero.

Following Dobson and Waterson (1997), we assume that retailer D_i's indirect demand is linear and given by the following expression:

$$p_i = 1 - q_i - \theta \sum_{j \neq i} q_j, \qquad \theta \in [0, 1) \tag{1}$$

whenever this is positive. The parameter θ measures the degree of substitutability between the different retailers. If $\theta = 0$, each retailer is considered to offer an independent service, whereas if $\theta \to 1$, retailers' products are perfect substitutes to each other. For our subsequent analysis it is useful to highlight two properties of this demand structure. First of all, aggregate demand for the final product is increasing in the number of retailers. To highlight this property it suffices to derive the direct demand for both the monopoly and duopoly downstream configuration. Whenever the downstream market is characterized by a duopoly, retailer i's direct demand is given by

$$q_i^{N=2}(p_i, p_j) = \frac{p_j - p_i}{1 - \theta^2} + \frac{1 - p_j}{1 + \theta}, \tag{2}$$

such that at equal prices total demand is given by $2(1-p)/(1+\theta)$. A monopolistic retailer i on the other hand faces the following demand:

$$q_i^{N=1}(p_i) = 1 - p_i \tag{3}$$

It is then clear that $q^{N=2}(p,p) < q^{N=1}(p) < 2q^{N=2}(p,p)$ whenever $\theta \in (0,1)$. This market expansion effect is inherent in many types of product differentiation models. From the manufacturer's point of view dealing with two retailers has the advantage of having access to a larger downstream market. Secondly, in the duopoly configuration an increase in the differentiation parameter θ de-

creases total demand and makes each retailer's demand more elastic.[7] Less differentiated retailers will thus compete more fiercely for a smaller market.

The entire game consists of a three-stage stage game that is infinitely repeated. All parties are informed and aware of actions that occurred in prior stages, and profits are discounted by a common discount factor δ. In the first stage the manufacturer indicates which retailers he is willing to trade with (conditional upon reaching an agreement on the transfer price). The manufacturer may choose to deal with both retailers or restrict the availability of his product to a single retailer. In the second stage the manufacturer negotiates with the chosen retailers over the transfer prices. The bargained transfer prices are obtained using the generalized Nash bargaining solution. The exact formulation of the Nash bargaining problem depends on the manufacturer's supply decision and retailer conduct, and will be specified later on. For now it suffices to know that $\gamma \in [0, 1)$ denotes the bargaining power of the retailer(s) relative to the manufacturer. Whenever $\gamma = 0$, the manufacturer has full bargaining power and can set the transfer price freely. We exclude the trivial case in which retailers have all bargaining power (i.e. $\gamma = 1$), as in that case transfer prices (and hence manufacturer profits) will be driven down to zero, leaving the manufacturer completely indifferent about retailer conduct. In the last stage, retailers simultaneously set the prices they charge to the final consumers, p_1 and p_2.

2.2 Stage Game Outcomes

Before proceeding to the analyze the repeated game, we first consider four particular outcomes of the stage game that are of special interest. In the first two outcomes, retailers behave non-cooperatively and the supplier decides either to supply to one retailer ("monopoly") or both retailers ("non-cooperative duopoly"). Next, we consider a situation in which retailers form a cartel ("cartel"), in which case the manufacturer always prefers to supply to both cartelizing retailers. We will then compare profits across the regimes, and demonstrate that a manufacturer might actually prefer to deal with cartel of retailers. This will lead us to ask which role the manufacturer might play in sustaining cartel stability. For the sake of evaluating cartel stability, we also consider the outcome in which one retailer deviates (optimally) from the cartel agreement ("deviation"). Such

[7] The expression for the elasticity of demand is given by

$$\varepsilon_i(p_i, p_j) = -\frac{\partial q_i^D}{\partial p_i}\frac{p_i}{q_i^D} = \frac{p_i}{(1-p_i) - \theta(1-p_j)},$$

which clearly is increasing in θ.

deviations should be unprofitable if the cartel is to survive.

Monopoly

When the manufacturer credibly commits to dealing with a single retailer only, the downstream market is characterized by a retail monopoly. Such a monopoly does not have access to the full market, but is not subjected to competitive pressure from other retailers either. A monopolistic retailer might therefore accept a higher transfer price, as it is not associated with a competitive cost-disadvantage in the downstream market due to a lack of competition.

A monopolist maximizes its profit $\pi^M(p,g) = (p-g)\,q^{N=1}(p)$ by setting its retail price equal to

$$p^M(g) = \frac{1+g}{2}, \tag{4}$$

which results in the following quantity sold

$$q^M(g) = \frac{1-g}{2}. \tag{5}$$

When the manufacturer bargains over the transfer price with a retail monopolist, the outside option for both parties is zero. This is because in case the negotiations break down, each party can not earn positive profits by dealing with a third party. If the negotiations do succeed, each party earns the respective monopoly-case profits. The transfer price g^{M*} therefore solves the following generalized Nash bargaining problem:

$$g^{M*} = \arg\max_g V = \left[\pi_D^M(g) - 0\right]^{\gamma}\left[\pi_U^M(g) - 0\right]^{1-\gamma}, \tag{6}$$

where $\pi_D^M(g) = \left[p^M(g) - g\right]q^M(g)$ and $\pi_U^M(g) = g \times q^M(g)$. The solution to this bargaining problem is given by:

$$g^{M*} = \frac{1-\gamma}{2}, \tag{7}$$

which is decreasing in γ. An increase in retailer bargaining power γ yields a more favorable outcome for the retailer and hence reduces the transfer price. The associated equilibrium price and quantity are then given by

$$p^{M*} = \frac{3-\gamma}{4} \tag{8}$$

$$q^{M*} = \frac{1+\gamma}{4} \tag{9}$$

The following lemma summarizes both parties' profits in the retail monopoly regime.

Lemma 1 *Monopoly profits are given by:*

$$\pi_D^{M*} = \frac{1}{16}(1+\gamma)^2 \tag{10}$$

$$\pi_U^{M*} = \frac{1}{8}\left(1-\gamma^2\right) \tag{11}$$

Non-Cooperative Duopoly

Next we consider what happens when both retailers are being supplied to and retailers behave non-cooperatively. Retailers now have (combined) access to a larger market, but compete against one another. This competitive pressure drives down transfer prices, as retailers are reluctant to accept a transfer price that would result in a competitive cost-disadvantage in the downstream market.

A non-cooperative retailer i sets its price as to maximize its own profit $\pi_{D_i}^{NC}(p_i,p_j) = [p_i - g_i]\, q_i^{N=2}(p_i,p_j)$, given the price set by D_j. This results in the following best-response price:

$$p_i^{BR}(p_j) = \frac{1}{2}(1 + g_i - \theta(1-p_j)) \tag{12}$$

For a given set of transfer prices, the non-cooperative price-setting equilibrium is therefore given by

$$p_i^{NC}(g_i,g_j) = \frac{2(g_i-g_j)}{\left(4-\theta^2\right)} + \frac{(1-\theta)+g_j}{(2-\theta)} \tag{13}$$

such that D_i sells the following quantity

$$q_i^{NC}(g_i,g_j) = \frac{\left[2-\theta^2\right]}{(2-\theta)(1+\theta)\left[2-\theta^2-\theta\right]}[g_j-g_i] + \frac{1}{(2-\theta)(1+\theta)}[1-g_j] \tag{14}$$

When the manufacturer bargains with two non-cooperative retailers, the outside option of each retailer is zero, as there is no alternative source of supply. The manufacturer can however deal with the remaining retailer in case negotiations break down with the other retailer. The manufacturer's disagreement payoff is therefore now positive. In line with the literature we assume that the manufacturer negotiates bilaterally with each of the retailers over a separate transfer price g_i. We also assume that if negotiations break down with one retailer, this is observed by the other retailer. The latter will therefore realize he is a monopolist and "react" accordingly by setting the monopoly price $p^M(g)$ derived earlier. The set of transfer prices $\mathbf{g}^{NC*} = \left(g_1^{NC*}, g_2^{NC*}\right)$ therefore solves the following bargaining problem:

$$g_i^{NC*} = \arg\max_{g_i} V_i = \left[\pi_{D_i}^{NC}(g_i,g_j) - 0\right]^{\gamma}\left[\pi_U^{NC}(g_i,g_j) - \pi_U^M(g_j)\right]^{1-\gamma},\ i=\{1,2\},\ j\neq i \tag{15}$$

where $\pi_{D_i}^{NC}(g_i, g_j) = \left[p_i^{NC}(g_i, g_j) - g_i\right] q_i^{NC}(g_i, g_j)$, $\pi_U^{NC}(g_i, g_j) = \sum_i g_i \times q_i^{NC}(g_i, g_j)$ and $\pi_U^M(g_j) = g_j \times q^M(g_j)$. The symmetric solution to this bargaining problem is given by:

$$g^{NC*} = \frac{(1-\gamma)(2-\theta(1+\theta))}{4-\theta(1+\theta)(2-\gamma\theta(2-\theta))} \leq g^{M*}, \tag{16}$$

which is (i) (weakly) smaller than the monopolistic transfer price g^{M*}, (ii) decreasing in γ, and (iii) decreasing θ, approaching zero when the downstream market becomes undifferentiated (i.e. $\theta \to 1$). Increasing retailer bargaining power again yields a more favorable, and hence lower, transfer price for the retailers. The degree of substitutability increases the retailer's overall bargaining power, and hence decreases the negotiated transfer price. The less differentiated the downstream market, the more fierce retailer competition becomes. Retailers are therefore unwilling to accept a high transfer price, as this would lead to an important cost disadvantage vis-à-vis their competitor. The manufacturer is willing to accept a low transfer price, as in case of disagreement it would lose a significant amount of sales by dealing with a monopolist only. Interestingly, the transfer price converges to zero when the downstream market approaches an undifferentiated market. In such a market, the manufacturer's profit approaches zero as well, which might motivate the manufacturer to undertake actions that avoid competition in the retail market.

The associated equilibrium price and quantity are given by

$$p^{NC*} = \frac{(1-\theta) + g^{NC*}}{2-\theta} \tag{17}$$

$$q^{NC*} = \frac{1-g^{NC*}}{(1+\theta)(2-\theta)} \tag{18}$$

The profits under the competitive regime are summarized in the following Lemma.

Lemma 2 *Non-cooperative profits are given by:*

$$\pi_D^{NC*} = \frac{(1-\theta)\left(1-g^{NC*}\right)^2}{(1+\theta)(2-\theta)^2} \tag{19}$$

$$\pi_U^{NC*} = \frac{2g^{NC*}\left(1-g^{NC*}\right)}{(1+\theta)(2-\theta)} \tag{20}$$

Cartel

When both retailers are being supplied to, these retailers might conspire to collude in order to remove the competitive pressure from their pricing decision. Such collusive behavior in pricing generates additional market power in the downstream market, such that the cartel is able to set a higher markups. It also implies that retailers are willing to accept a higher transfer price, as retailers

no longer have a strong incentive to have a transfer price that is lower than their competitor's. Retailers can take the cartel one step further, by also colluding during transfer price negotiations. This will allow them to negotiate a more favorable transfer price.

A downstream cartel sets its price as to maximize the joint profit, given the negotiated transfer prices. We assume that retailers also collude during transfer price negotiations, and that the outcome of the bargaining process is a single transfer price g that applies to both colluding retailers. The cartel therefore sets its prices as to maximize the joint profit $\sum_i (p_i - g) q_i^{N=2}(p_i, p_j)$. This profit is maximized by setting both retail prices equal to

$$p^C(g) = \frac{1+g}{2}, \tag{21}$$

which was also the price a monopolistic retailer would set. Retailer sales are now given by

$$q^C(g) = \frac{1-g}{2(1+\theta)} \tag{22}$$

The transfer price is determined by a bargaining procedure between the manufacturer and a single identity representing the cartelizing retailers. Whenever the negotiations fail, both parties will therefore leave empty-handed and obtain a zero profit. The transfer price g^{C*} therefore solves:

$$g^{C*} = \arg\max_g V^C(g) = \left[2\pi_D^C(g) - 0\right]^{\gamma} \left[\pi_U^C(g) - 0\right]^{1-\gamma} \tag{23}$$

where $\pi_D^C(g) = \left[p^C(g) - g\right] q^C(g)$ and $\pi_U^C(g) = g \times 2q^C(g)$. The solution to this bargaining problem is given by:

$$g^{C*} = \frac{1-\gamma}{2}, \tag{24}$$

which is the same transfer price a monopolistic retailer would be able to negotiate. Notice that the product differentiation parameter θ does not affect transfer prices, as both the surplus of the cartel and the manufacturer are proportional to $(1+\theta)^{-1}$.[8] Increasing θ reduces overall demand but does not change the collusive price. Both parties are therefore affected in the same way, so the transfer price does not change. An increase in retailer bargaining power γ yields a more favorable outcome for retailers and hence reduces the transfer price. Plugging in this transfer price we have that the resulting collusive outcome is given by

$$p^{C*} = \frac{3-\gamma}{4} \tag{25}$$

$$q^{C*} = \frac{(1+\gamma)}{4(1+\theta)} \tag{26}$$

[8] In particular, $\pi_{D_i}^C(g) = \left(\frac{1}{1+\theta}\right)\left(\frac{1-g}{2}\right)^2$ and $\pi_U^C(g) = \left(\frac{1}{1+\theta}\right) g(1-g)$.

The profits under the cartel regime are summarized in the following Lemma.

Lemma 3 *Cartel profits*

$$\pi_D^{C*} = \frac{(1+\gamma)^2}{16(1+\theta)} \tag{27}$$

$$\pi_U^{C*} = \frac{1-\gamma^2}{4(1+\theta)} \tag{28}$$

We now proceed to compare profits under the three different regimes. Unsurprisingly, retailers prefer the collusive outcome over the non-cooperative outcome, but each retailer would even more like to be a monopolist.

Proposition 4 *The retailers preferences over the different retailer configurations are characterized by* $\pi_D^{NC*} < \pi_D^{C*} < \pi_D^{M*}$.

A more interesting comparison arises with the manufacturer's profits. For the manufacturer, the trade-off between the different retailer configurations is one of sales value versus transfer price. For a given transfer price, the manufacturer's preferences over the different retailer configurations are given by $\pi_U^{NC}(g) > \pi_U^{C}(g) > \pi_U^{M}(g)$. Sales are highest when dealing with non-cooperative retailers, as they have access to a large market and charge low markups due to retailer competition. A cartel of retailers also has access to a large market, but generates fewer sales as the lack of retailer competition allows for higher retail price markups. A monopolistic retailer generates the lowest amount of sales, as such a retailer sets an equally high markup as a cartel, but only has access to a small market. Transfer price vary across the different configurations. In particular, we have that $g^{NC*} \leq g^{C*} = g^{M*}$, so that the manufacturer earns a lower transfer price by dealing with non-cooperative duopolists.

Combining both the transfer price and sales effect, it is clear that the manufacturer always prefers to deal with a cartel of retailers instead of a single monopolistic retailer. In both cases the negotiated transfer price is the same, but the cartel has access to a larger market which results in higher sales for the manufacturer. The ranking of the non-cooperative profit relative to the cartel and monopoly profit depends crucially on the relative bargaining power γ and the degree of differentiation θ. The next Proposition fully characterizes the manufacturer's preferences.

Proposition 5 *There exist two strictly decreasing functions,* $\theta_C^*(\gamma) \leq \theta_M^*(\gamma)$*, such that the manufacturer's preferences over the different retailer configurations are characterized by:*

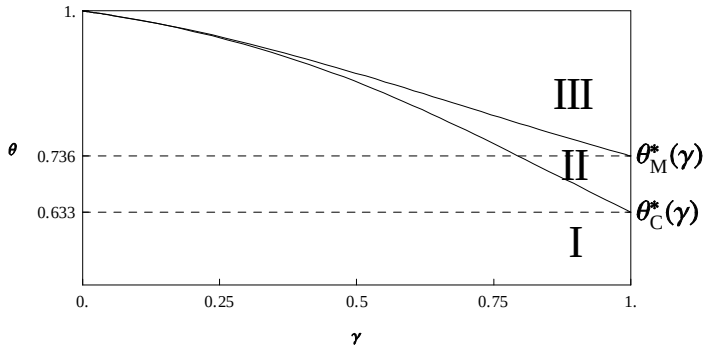

Figure 1: Manufacturer preferences

I. *If* $\theta < \theta_C^*(\gamma)$, *then* $\pi_U^{M*} < \pi_U^{C*} < \pi_U^{NC*}$

II. *If* $\theta \in [\theta_C^*(\gamma), \theta_M^*(\gamma)]$, *then* $\pi_U^{M*} < \pi_U^{NC*} < \pi_U^{C*}$

III. *If* $\theta > \theta_M^*(\gamma)$, *then* $\pi_U^{NC*} < \pi_U^{M*} < \pi_U^{C*}$

When the manufacturer fully determines the transfer price (i.e. $\gamma = 0$), the manufacturer's preferences over the three configurations boils down to choosing the regime that generates the highest amount of sales. Earlier one we saw that, irrespective of the degree of substitution, the non-cooperative duopoly always generates more sales by having complete access to the market and charging low markups. The manufacturer will therefore always want to deal with a non-cooperative duopoly when he has complete bargaining power.

When the manufacturer only has partial bargaining power (i.e. $0 < \gamma < 1$), the manufacturer's preferences depend on the degree of differentiation. When the retail market is highly differentiated (i.e. $\theta < \theta_C^*(\gamma)$), the manufacturer's preferred configuration is a non-cooperative duopoly. For intermediate ranges of differentiation (i.e. $\theta \in [\theta_C^*(\gamma), \theta_M^*(\gamma)]$), the non-cooperative duopoly outcome becomes worse than the cartel outcome, but not the monopoly outcome. When differentiation is low (i.e. $\theta > \theta_M^*(\gamma)$), the non-cooperative outcome is the worst overall outcome.

The intuition for this result if the following: When the market is highly differentiated, non-cooperative duopolists are still willing to accept a high transfer price, as competition is still quite soft. Compared to the cartel, the transfer price thus decreases, but only slightly. Retailers then pass on this cost reduction in such a way that sales sufficiently increase to overcome the lower transfer price, hence the manufacturer's profit is higher when dealing with the non-cooperative duopoly. As the market becomes less differentiated, non-cooperative duopolists become increasingly unwilling to accept high transfer prices, which eventually drives down transfer prices down to zero (when

$\theta \to 1$). At that point retailers set almost zero markups such that sales are high, but at a transfer price of almost zero the manufacturer's profits are driven down to zero as well. In that case it is clearly beneficial for the manufacturer to deal with the cartel. The manufacturer's profit when dealing with a monopolist is unaffected by differentiation and is lower than the profit from dealing with a cartel. For intermediate ranges of differentiation the non-cooperative profit will thus lie somewhere in between the cartel and monopoly profit.

The following Corollary now follows immediately from Proposition 4 and 5.

Corollary 6 *For a sufficiently low degree of differentiation (i.e. $\theta > \theta_C^*(\gamma)$), a retailer cartel is desirable for both retailers and the manufacturer.*

When there the degree of differentiation is low, there is an alignment of the preferences of both retailers and the manufacturer. Both parties would like to avoid competition in the downstream market, and see a retailer cartel be formed. Intense competition is harmful for retailers as prices are forced down, and harmful for the manufacturer by driving down the transfer price. As the manufacturer now also would like a downstream cartel, he might encourage retailers to cartelize own their own, or even participate actively in sustaining the cartel by cooperating in the punishment of a deviating retailer. We explore this possibility in the repeated game in a following section. In order to evaluate cartel stability, we also need to characterize the (optimal) retailer deviation from the cartel agreement, which will be covered first.

Deviation

Each retailers has an incentive to deviate from the cartel agreement, as charging the collusive price is not a best-response. Retailer D_i's profit from deviating when D_j charges p^{C*} and the transfer price is g^{C*}, is given by

$$\pi_{D_i}^{DEV}\left(p_i, p^{C*}\right) = \left(p_i - g^{C*}\right) q_i^{N=2}\left(p_i, p^{C*}\right) \tag{29}$$

Note that we assume that the resulting transfer price prior to deviation is the same as when both retailers would charge the collusive price. Implicit here is the assumption that during the bargaining phase that precedes the deviation, the deviating retailer acts *as if* he is going to collude and therefore obtains the same transfer price as the loyal retailer. If this were not the case then the other retailer would realize that deviation is about to take place and refrain from charging the

collusive price as well. The optimal one-shot deviation is given by

$$p_D^{DEV*} = \frac{1}{8}\left[6 - \theta - \gamma\left(2 + \theta\right)\right] < p^{C*}, \tag{30}$$

and the associated deviation quantity is given by

$$q_D^{DEV*} = \frac{1}{8}\left(1 + \gamma\right)\frac{\left(2 - \theta\right)}{1 - \theta^2} > q^{C*} \tag{31}$$

The following lemma contains the retailers profit from deviating optimally from the cartel agreement.

Lemma 7 *Optimal deviation profit*

$$\pi_D^{DEV*} = \frac{1}{64}\left(1 + \gamma\right)^2\frac{\left(2 - \theta\right)^2}{1 - \theta^2}$$

3 The Repeated Game

The repeated game consists of the aforementioned three-stage game repeated an infinite number of times. We look for a subgame perfect equilibrium that can be sustained by trigger-like strategies in which retailers fully collude in price setting.

3.1 Trigger Strategies

As there are now two types of parties involved (manufacturer and retailer, respectively), who each have a single instrument at their disposal (supply and pricing decision respectively), trigger strategies can take on a variety of forms. The trigger strategies we consider are particularly simply and only depend on the retailer's pricing behavior. Both the manufacturer and retailer's decision depend only on the following variables:

- N_t: Number of retailers being supplied to in the current period.
- I_t : Indicator variable taking on the value 1 if in any past period where both firms were being supplied (i.e. $N = 2$), at least one retailer deviated from charging p^{C*}.
- ID_t : Identity of the retailer that deviated *first* from charging p^{C*} when both firms were being supplied. If both retailers deviated first simultaneously, D_1 is taken as default.

Retailer strategy: The retailers' strategy is a slightly adjusted version of the standard grim trigger strategy. Each retailer conditions its price on (i) whether or not a deviation from the collusive price has occurred when both firms were being supplied to (i.e. I_t), and (ii) the number of retailers being supplied to in the current period (i.e. N_t). The retailer therefore ignores pricing behavior in a retailer monopoly and any past supply decisions made by the manufacturer. In particular, the retailer's strategy is given by:

$$p_{i,t}\left(N_t, I_t^{DEV}\right) = \begin{cases} p^{C*} & \text{if} \quad N_t = 2 \quad \text{and} \quad I_t = 0 \qquad \text{(collusion)} \\ p^{NC*} & \text{if} \quad N_t = 2 \quad \text{and} \quad I_t = 1 \qquad \text{(price war)} \\ p^{M*} & \text{if} \quad N_t = 1 \qquad\qquad\quad \text{(monopoly)} \end{cases}$$

Whenever both firms are being supplied to, and no price deviation has taken place in the past, retailers set the collusive price p^{C*}. If both firms are being supplied to, but a price deviation has taken place, retailers revert to non-cooperative pricing by charging p^{NC*}. Finally, when the manufacturer only supplies one retailer, this retailer acts as a monopolist and charges p^{M*}.

For the manufacturer we consider two different types of strategies. The manufacturer (explicitly) communicates which strategy he will follow at the beginning of the game, such that retailers are fully aware of the (supply) consequences their pricing decision will have.

Manufacturer strategy I (permanent supply): In the first type of strategy, the manufacturer does not actively help to sustain the retail cartel, and supplies both retailers in every period, regardless of past retailer pricing behavior. The manufacturer's strategy is thus given by:

$$S_t^{PS} = \{D_1, D_2\} \text{ (permanent supply)}$$

Manufacturer strategy II (embargo): In the second type of strategy, the manufacturer does actively help to sustain the cartel by imposing a permanent embargo on a deviating retailer. The manufacturer conditions its supply decision only on past retailers pricing behavior. In particular, the manufacturer's strategy is given by:

$$S_t^{EM}\left(I_t^D, ID_t^D\right) = \begin{cases} \{D_1, D_2\} & \text{if} \quad I_t = 0 \qquad \text{(full supply)} \\ D_i \notin ID_t & \text{if} \quad I_t = 1 \qquad \text{(embargo)} \end{cases}$$

The manufacturer starts off supplying to both firms, and continues to do so as long as no price-deviation has taken place. When price-deviation(s) takes place, the manufacturer permanently refuses to supply the retailer that deviated *first*. If both retailers deviated first simultaneously, the

manufacturer continues to deal only with retailer D_1.[9]

3.2 Equilibrium

In this section we will identify the conditions under which the proposed trigger-like strategies constitute a (subgame) perfect equilibrium of the repeated game. Given these strategies, all possible subgames are determined by the two variables on which retailers and/or the manufacturer condition their behavior, i.e. the number of retailers currently being supplied (N_t) and whether price-deviation has taken place in the past (I_t). The manufacturer's subgames only depend on I_t, whereas the retailer's subgames depend both on N_t and I_t.

Manufacturer Strategies

Retailers only condition their current pricing behavior on past pricing behavior and current supply. Consequently, the manufacturer's supply decision has no dynamic effects; it only affect the manufacturer's profit in the current period. The manufacturer should therefore choose whom to supply by maximizing the associated stage game profits. Given the retailers' strategy, there are two types of subgames for the manufacturer to consider.

In the first type of subgame, no retailer deviation has taken place in the past (i.e. $I_t = 0$). If both retailers are supplied to, they will therefore continue (or start) colluding and charge p^{C*}. Should the retailer decide not to supply to one of the retailers, the remaining retailer will act as a retail monopolist and charge a price p^{M*}. Irrespective of the manufacturer's supply decision, retailers will behave exactly the same in the next period. As the manufacturer strictly prefers to deal with a cartel instead of a monopoly (see Proposition 5), it will never refuse to supply any of the colluding retailers as long as no retail price deviation has taken place in the past.

In the second type of subgame, at least one retailer has deviated in the past (i.e. $I_t = 1$). When both retailers are now being supplied, they will behave non-cooperatively and charge p^{NC*}. If only one retailer is being supplied to, it charges p^{M*}. Retailers repeat this behavior in the next period, irrespective of the manufacturer's supply decision. By Proposition 5 the manufacturer prefers to deal with a monopolist instead of a non-cooperative duopoly if and only if (i) the manufacturer has partial bargaining power (i.e. $0 < \gamma < 1$), and (ii) the degree of differentiation is sufficiently low (i.e. $\theta > \theta_M^*(\gamma)$). As retailers are symmetric, the manufacturer is indifferent on which of the

[9] Alternatively, the manufacturer could choose randomly which retailer he continues to deal with. This would, however, not alter any of the results.

retailers should remain in the market. For the aforementioned levels of differentiation, a retailer cartel is however also beneficial for the manufacturer (as $\theta_M^*(\gamma) \geq \theta_C^*(\gamma)$). It is therefore in the manufacturer's own interest to stabilize the cartel by imposing an embargo on the deviating retailer. The following Corollary is now apparent.

Corollary 8 *The manufacturer voluntarily contributes to the stability of a retailer cartel by imposing an embargo on a deviating retailer if and only if (i) retailers have some bargaining power (i.e.* $0 < \gamma < 1$*), and (ii) the degree of differentiation is sufficiently low (i.e.* $\theta > \theta_M^*(\gamma)$*)*

For intermediate levels of differentiation (i.e. $\theta \in [\theta_C^*(\gamma), \theta_M^*(\gamma)]$) a retailer cartel is still desirable for the manufacturer, but he cannot credibly promise to impose an embargo. When differentiation is relatively high (i.e. $\theta < \theta_M^*(\gamma)$) and/or retailers have no bargaining power (i.e. $\gamma = 0$), the cartel is no longer desirable for the manufacturer and hence he will not cooperate in disciplining the cartel. In both cases the manufacturer's best-response is to permanently supply both retailers, irrespective of past retailer conduct.

In sum, we find that given the retailers' strategy, it is optimal for the manufacturer to implement either the permanent supply strategy (when $\gamma = 0$ and/or $\theta < \theta_M^*(\gamma)$) or the embargo strategy (when $0 < \gamma < 1$ and $\theta > \theta_M^*(\gamma)$). Next, we proceed to evaluate the optimality of the retailer strategy given the two manufacturer strategies.

Retailer Strategy

Each retailer conditions its pricing behavior in the current period on the manufacturer's current supply decision (N_t), and whether or not a price deviation has taken place in the past (I_t). The manufacturer's supply decision is either invariant to retailer pricing (i.e. full supply strategy), or responds only to retail price deviations (I_t, i.e. embargo strategy). For the retailer there are therefore four different subgames to consider which are given by all possible combinations of N_t and I_t. Those subgames in which $N_t = 1$ can be treated jointly, as the price set in this subgame is ignored by both manufacturer and retailers (i.e. it does not trigger punishment).

In the first type of retailer subgame, the manufacturer has chosen only to supply a single retailer in the current period (i.e. $N_t = 1$), so the downstream market is characterized by a monopoly. The active retailer's strategy implies that it should set the monopoly price. If the retailer should refrain from doing so, there are no dynamic consequences as neither the strategy of the (other) retailer nor the manufacturer is conditional upon the pricing decision in the retail monopoly situation.

The retailer's best response is therefore to maximize its current period profit, which is achieved by charging the monopoly price p^{C*}.

In the second type of retailer subgame, the manufacturer has chosen to supply to both retailers in the current period, but at least one retailer has deviated in the past (i.e. $N_t = 2, I_t = 1$). The retailer's strategy implies that it should engage in non-cooperative pricing and charge p^{NC*}. Should the retailer refrain from doing so, there are no dynamic consequences as the relevant strategy triggers have already been activated by retail price deviation in the past. When the manufacturer follows the permanent supply strategy, both retailers will be supplied in all subsequent periods, but the other retailer will revert to non-cooperative pricing. When the manufacturer follows the embargo strategy, the deviating retailer will no longer be supplied to in the subsequent periods. As the price set by the retailer does not influence the future in either case, the retailer's best response is to maximize its current period profit, which is achieved by also charging the non-cooperative price p^{NC*}.

In the last type of retailer subgame, the manufacturer has chosen to supply to both retailers in the current period, but no retailer has deviated in the past (i.e. $N_t = 2, I_t = 0$). The retailer's strategy implies that it should charge the collusive price p^{C*}. If the retailer refrains from doing so, it is punished as the relevant triggers now become activated. When the manufacturer follows the permanent supply strategy, and hence does not participate in punishment, a deviating retailer is punished by means of permanent reversion to non-cooperative pricing. A retailer will refrain from deviating if the present discount value of maintaining the cartel exceeds the present discounted value of deviating once and being punished by means of non-cooperative pricing subsequently. In other words, the following inequality should be satisfied:

$$\frac{1}{1-\delta}\pi_D^{C*} \geq \pi_D^{DEV*} + \frac{\delta}{1-\delta}\pi_D^{NC*}, \tag{32}$$

which is the case if retailers are sufficiently patient, i.e. when

$$\delta \geq \delta_{NC}^{*} = \frac{\pi_D^{DEV*} - \pi_D^{C*}}{\pi_D^{DEV*} - \pi_D^{NC*}}. \tag{33}$$

If on the other hand the manufacturer follows the embargo strategy, a deviator is punished by being permanently cut off from supply. A retailer will refrain from deviating if the present discounted value from colluding is larger than the present value of deviating and being no longer supplied subsequently. This requires that

$$\frac{1}{1-\delta}\pi_D^{C*} \geq \pi_D^{DEV*}, \tag{34}$$

which is satisfied if retailers are sufficiently patient, i.e. when

$$\delta \geq \delta^*_{EM} = 1 - \frac{\pi_D^{C*}}{\pi_D^{DEV*}} \tag{35}$$

As the market is differentiated, retailers earn a positive profit during the non-cooperative pricing, hence $\delta^*_{NC} \geq \delta^*_{EM}$. Therefore we can state without further proof:

Corollary 9 *Cartel stability is guaranteed for a larger set of discount rates when the manufacturer is willing to impose an embargo. Or discount rates too low for ensuring cartel stability between retailers if left on their own still can be sufficiently high when the manufacturer is willing to impose an embargo*

Combining all the previous findings then allows to state without further proof the following Proposition:

Proposition 10 *Necessary and sufficient conditions for the existence of tacit collusion enforced by embargo in an hub and spokes environment require that the following set of conditions is satisfied:*

$$\delta \geq \delta^*_{EM} \qquad (C.1)$$

$$0 < \gamma < 1 \qquad (C.2)$$

$$\theta > \theta^*_M(\gamma) \qquad (C.3)$$

Proposition 10 shows the limited scope of hub and spoke collusion by embargo. First of all, product differentiation between the retailers needs to be small. This implies strong price competition as if retailers are nearly perceived as offering the same homogeneous service. Further notice the restricted range of manufacturer bargaining power that sustains the collusive outcome. There must be a cap on the manufacturer's bargaining power, since otherwise the manufacturer can set the transfer price freely, and killing off a spoke only leads to a loss in sales. When retailers have some bargaining power, the characteristics of the retail market and retailer conduct will influence the negotiated transfer price. A manufacturer will therefore only cut off a spoke willingly if not doing so would result in fierce retailer competition that would drive down the transfer price all the way to zero.

Even though the scope of hub and spoke collusion by embargo is limited, the range of parameters is nonetheless an interesting one. When the degree of retailer differentiation is quite low, competition is fierce and collusion becomes all the more attractive. In such a market deviation is however quite

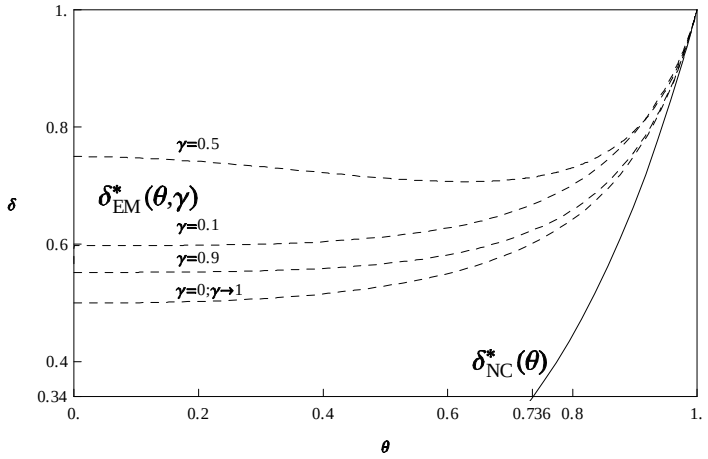

Figure 2: Critical discount factors

tempting, as consumers are easily "stolen" from the competitor, and collusion might therefore be hard to achieve. The feasibility of the embargo as a fiercer punishment can therefore obtain a collusive outcome in markets in which without it would be very difficult to conspire otherwise.

Comparative Statics

Before concluding this section, we briefly summarize the comparative statics of both discount factors.

Corollary 11 *The critical discount factor δ^*_{EM} is increasing is (i) independent of γ and (ii) increasing in θ, approaching one as the downstream market becomes undifferentiated (i.e. $\theta \to 1$).*

Corollary 12 *The critical discount factor δ^*_{NC} is non-monotonic in γ and θ, approaching one as the downstream market becomes undifferentiated (i.e. $\theta \to 1$).*

Figure 2 demonstrates both Corollaries by plotting the two types of discount factors.
A change in $x \in \{\gamma, \theta\}$ affects the critical discount factors through potentially three different channels:

$$\frac{\partial \delta^*}{\partial x} = \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{DEV*}}}_{>0} \frac{\partial \pi_D^{DEV*}}{\partial x} + \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{P*}}}_{>0} \frac{\partial \pi_D^{P*}}{\partial x} + \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{C*}}}_{<0} \frac{\partial \pi_D^{C*}}{\partial x} \tag{36}$$

The first channel operates through the profit of deviation, π_D^{DEV*}, which increases the critical discount factor. The more profitable deviation, the more tempting it becomes to deviate. Retailers therefore have to be more patient in order to refrain from deviating. The second channel operates

through the punishment profit, $\pi_D^{P*} \in \left\{\pi_D^{NC*}, 0\right\}$, which also increases the critical discount factor. To discipline the cartel, a punishment is admitted by means of a trigger strategy. In order for this punishment to be effective, a deviating retailer should earn strictly less than under collusion. The higher this punishment profit, the less severe the punishment. Retailers therefore have to be more patient in order to refrain from deviating. The last channel operates through the collusive profit, π_D^{C*}, which decreases the critical discount factor. The higher the profit from cartelization, the less attractive deviation becomes. Retailers can therefore be less patient in order to refrain from deviating.

An increase in bargaining power only effects retailer profits by lowering transfer prices; there is no direct effect on demand. This increases retailer profits in all regimes (except for the embargo regime):

$$\frac{\partial \pi_D^{DEV*}}{\partial \gamma} > 0, \qquad \frac{\partial \pi_D^{NC*}}{\partial \gamma} > 0, \qquad \frac{\partial \pi_D^{C*}}{\partial \gamma} > 0 \tag{37}$$

such that the overall effect on the critical discount factor is given by

$$\frac{\partial \delta^*}{\partial \gamma} = \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{DEV*}} \frac{\partial \pi_D^{DEV*}}{\partial \gamma}}_{>0} + \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{P*}} \frac{\partial \pi_D^{P*}}{\partial \gamma}}_{\geq 0} + \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{C*}} \frac{\partial \pi_D^{C*}}{\partial \gamma}}_{<0} \tag{38}$$

As there are both positive and negative effects, the overall impact is a priori ambiguous and depends on the magnitude of each of the effects. For δ_{EM}^*, both effects are equally strong and cancel each other out. For δ_{NC}^* on the other hand, there are both regions in which the critical discount factor increases in γ, and regions in which it decreases in γ.

The degree of substitutability affects retailer profits both directly through the demand curve, as well as indirectly through the negotiated transfer prices. This has the following effect on retailer profits

$$\frac{\partial \pi_D^{DEV*}}{\partial \theta} \lesseqgtr 0, \qquad \frac{\partial \pi_D^{NC*}}{\partial \theta} < 0, \qquad \frac{\partial \pi_D^{C*}}{\partial \theta} < 0 \tag{39}$$

such that the overall effect on the critical discount factor is given by

$$\frac{\partial \delta^*}{\partial \theta} = \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{DEV*}} \frac{\partial \pi_D^{DEV*}}{\partial \theta}}_{\lesseqgtr 0} + \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{P*}} \frac{\partial \pi_D^{P*}}{\partial \theta}}_{\leq 0} + \underbrace{\frac{\partial \delta^*}{\partial \pi_D^{C*}} \frac{\partial \pi_D^{C*}}{\partial \theta}}_{>0} \tag{40}$$

As there are both positive and negative effects, the overall impact is a priori ambiguous and depends on the magnitude of each of the effects. For δ_{EM}^*, the positive effects dominate, and the critical discount factor is increasing in θ. For δ_{NC}^* on the other hand, there are both regions in which the critical discount factor increases in θ, and regions in which it decreases in θ. Both discount factors

converge to one when the market becomes undifferentiated (i.e. when $\theta \to 1$). This is because in that case the profit of deviation becomes exceedingly large, such that even the harshest punishment does not suffice to deter deviation.

4 Extensions

Several extensions can be considered and this section only discusses two of them briefly. The obvious ones are those that involve the inclusion of more than three players.

4.1 More than Two Buyers

This is probably an interesting extension that besides quantitative differences also might generate qualitative differences if competition is local and an incentive problem arises when punishment needs to be inflicted, as in Verboven (1998). Consider the Hotelling model with 3 firms, L, M and R introduced in that article. Suppose that R deviates. Then it is shown that punishment needs to be sufficiently lenient in order that M is willing to enter the punishment stage of the game for otherwise M prefers to stay in the collusive mode given that L also still is.

Since the supplier knows the sales made by each and every player in the cartel, the hub immediately can inflict an embargo on R and M will be even better of since he now is the only player that caters for consumers on the right of the Hotelling line. At the same time the negotiation problem is mitigated in that absent an agreement on the transfer price between U and M, U still can serve the consumers in the middle when L expands. Probably the outcome will be that the limited set of conditions that sustain hub and spoke collusion by embargo is somewhat relaxed.

4.2 More than One Supplier

This extension is tantamount to having the possibility to substitute for an "outside" good, which means from the perspective of a downstream retailer that the shelves are filled with other items than those supplied by the hub. This of course immediately reduces the scope of hub and spoke collusion by embargo since an hub that disciplines a downstream retailer not only will give more bargaining power to the other downstream retailer but also a boost to the sales of his rival supplier. One needs moreover to take into account the possibility that a retailer boycotts a particular supplier, making the bargaining stage of the game even more complex.

Finally, since end consumers in general will have the availability of at least two different goods

in each location (at each retailer), one needs to include heterogeneous consumer tastes regarding the product. Otherwise the product cannot command a positive price and the room for bargaining is the empty set. The interaction of differences in consumer tastes for the product with heterogeneity regarding shop locations might entail complex patterns of multi-stop shopping when consumers compose their bundles in different ways. For hub and spoke collusion by embargo to stand a chance, suppliers need to collude in punishing, a non-trivial coordination problem that may need discipline from still another outside party.

5 Conclusions and Implications for EC Competition Policy

In industries in which there both few suppliers and buyers, transfer prices are likely to be determined by bilateral bargaining between the different parties. Such negotiations link the transfer price to the condition and conduct in the downstream market, as buyers operating in a competitive market would like to avoid a competitive cost disadvantage. When retailer competition is detrimental for the transfer price, a supplier might prefer to deal with buyers that have more market power in the downstream market. The supplier might therefore choose to enter into a cartel agreement with his downstream retailers to help them stabilizing an agreement that would be unsustainable otherwise. The strategy used would be a threat of refusing to deal. By doing so, the manufacturer can avoid a vicious price war that would drive down transfer prices if retailers were left on their own to enforce the cartel. Proposition 10 shows the limitations of the hub and spoke scenario and thereby indicates how antitrust authorities should be careful when presuming the existence of such agreements.

More in particular, the range of bargaining power that sustains this type of hub and spoke collusion is limited. If the seller has substantial bargaining power, the negotiated transfer price will be close the seller's preferred transfer price (i.e. the double marginalization outcome). By cutting off a buyer the seller will therefore only incur a loss in sales, which he will never be prepared to take. Only when buyers have substantial bargain power, such that condition and conduct in the downstream market affect the negotiated transfer, will the supplier be willing to impose an embargo.

In addition, only in industries where the retailers are perceived quite alike and there is little product differentiation between the retail service offered, we find room for hub and spoke collusion by embargo. In all other cases, the idea might be appealing but will be hard to realize and some

antitrust authorities therefore have moved towards dismissing these type of cases, indicating that much of the fact finding process of the investigative authorities is led by collecting communications between lower sales people over a hub and spoke network, but which hardly seems to have any effect.

This approach which investigates the alleged collusive mechanism in the appropriate industry context makes a lot of sense. Unfortunately EC Competition Policy more and more tends to miss this point. Rather than starting from the foundations of an economic model that casts competition (or collusion) in an industry to place the evidence into context, the starting point tends to be a narrative of "the talk of the (cartelized) town". A series of information exchanges between a varying set of players over a period of time then tends to get lumped into "a single continuous infringement". The varying group of players that are seen to interact in a collusive conspiracy can be horizontal competitors (say A with B and B with C), or vertical ones (both upstream and downstream say A with its supplier U or C with a major customer D).

This article contributed to the investigations into the blends of a vertical agreement with an horizontal one, to dampen intra-, interbrand competition, or both, see the literature survey in the first section. The focus here was on a cartel mechanism called hub and spoke collusion by embargo that is used to soften intrabrand competition between downstream retailers. Fierce competition in the downstream market can be detrimental for transfer prices. In that case the goals of upstream and downstream firms vis-a-vis downstream market power become aligned, and hence the question of how an upstream player can help in generating downstream market power (by collusion) becomes all the more relevant.

The results show that this blend indeed can achieve a collusive outcome, but also indicates the many limitations. Given the role that dominant buyers and suppliers have in settings where cartels might thrive, this type of modelling that includes both horizontal and vertical relations at the same time will undoubtedly figure more prominently in the literature on collusion. Hopefully, future policy making will take these contributions into account.

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6 Appendix

Throughout the proofs we will assume that numerical root finding algorithms may be used to find the roots of univariate polynomials.

Proof of Proposition 5

The manufacturer prefers to deal with a **retail cartel** over a non-cooperative duopoly iff

$$\Delta^C = \pi_U^{C*} - \pi_U^{NC*} > 0, \tag{41}$$

where

$$\begin{aligned}
\pi_U^{C*} &= \frac{1-\gamma^2}{4(1+\theta)} && (42)\\
\pi_U^{NC*} &= \frac{x(\gamma,\theta)}{y(\gamma,\theta)} && (43)\\
x(\gamma,\theta) &= 2(1-\gamma)(2-\theta(1+\theta)) && (44)\\
&\quad \times \left[2-\theta(1+\theta)+\gamma\left(2-\theta(1+\theta)(1-\theta)^2\right)\right] \\
y(\gamma,\theta) &= (2-\theta)(1+\theta)\left[4-\theta(1+\theta)(2-\gamma\theta(2-\theta))\right]^2 && (45)
\end{aligned}$$

We now proceed in two steps. In step (i), we derive our results in terms of γ, which boils down to finding the roots of Δ^C in terms of γ. We show that if $\theta \in (0, 0.6330)$ then for all $\gamma \in (0,1)$ we have that $\Delta^C < 0$, whereas if $\theta \in (0.6330, 1)$, there exists a unique $\gamma_C^*(\theta)$ such that $\Delta^C > 0$ iff $\gamma > \gamma_C^*(\theta)$. In step (ii), we derive our results in terms of θ, for which we have to find the roots of Δ^C in terms of θ. We show that for every $\gamma \in (0,1)$ there exists a unique $\theta_C^*(\gamma)$ such that $\Delta^C > 0$ iff $\theta > \theta_C^*(\gamma)$. Combined step (i) and (ii) imply that $\gamma_C^*(\theta)$ is a strictly decreasing function, hence $\theta_C^*(\gamma)$ is strictly decreasing as well.

Step (i)

Note that when the manufacturer has all bargaining power, we have that

$$\begin{aligned}
\pi_U^{C*}(\gamma=0) &= \frac{1}{4(1+\theta)} && (46)\\
\pi_U^{NC*}(\gamma=0) &= \frac{1}{2(2-\theta)(1+\theta)} \geq \frac{1}{4(1+\theta)} && (47)
\end{aligned}$$

so unless retailers are completely independent (i.e. $\theta = 0$), the manufacturer always prefers to deal with the non-cooperative duopoly (i.e. $\Delta^C < 0$). Multiplying π_U^{C*} by $y(\gamma,\theta)$, the sign of Δ^C

depends on the sign of the function $f^C(\gamma,\theta) = \pi_U^{C*} \times y - x$. This function is a polynomial of order 4 in terms of γ, i.e.

$$f^C(\gamma,\theta) = \sum_{i=0}^{4} a_i^C(\theta)\,\gamma^i, \tag{48}$$

which always has a root at $\gamma = 1$ (as in that case $\pi_U^{C*} = \pi_U^{NC*} = 0$). When ordered consecutively, the coefficients of f^C change sign twice:

$$\underbrace{a_4^C(\theta)}_{-} \quad \underbrace{a_3^C(\theta)}_{-} \quad \underbrace{a_2^C(\theta)}_{+} \quad \underbrace{a_1^C(\theta)}_{-} \quad \underbrace{a_0^C(\theta)}_{-}$$

By Descartes' rule of signs, the function f^C therefore has two strictly positive roots in terms of γ, and the first root lies at $\gamma = 1$. The second root lies in the interval $(0,1)$ if $\theta \in (0.6330, 1)$, and in the interval $(1,\infty)$ if $\theta \in (0, 0.6330)$. To see this, it suffices to look at

$$\begin{aligned} \frac{\partial f^C}{\partial \gamma}|_{\gamma=1} &= \frac{1}{2}\theta\left[2-\theta(1-\theta)\right]\left[2-\theta^2\right]\left[4-\theta(1+\theta)(6-\theta(4-\theta))\right] \qquad (49)\\ &> 0 \text{ iff } \theta \in (0, 0.6330), \text{ and} \\ \lim_{\gamma\to\infty} f^C &= \lim_{\gamma\to\infty} a_4(\theta)\,\gamma^4 = -\infty \qquad (50) \end{aligned}$$

Whenever $\theta \in (0,1)$, the function f^C thus converges to $-\infty$. If the derivative at the first root ($\gamma = 1$) is positive, f^C must have another root in the interval $(1,\infty)$. If the derivative at the first root is negative, f^C can not have another root in the interval $(1,\infty)$, since in that case it must have two roots in the interval. By the number of sign changes this cannot be the case, so f^C must therefore have a root in the interval $(0,1)$.

Step (ii)

The function $f^C(\gamma,\theta)$ is also a polynomial of order 9 in terms of θ, i.e.

$$f^C(\gamma,\theta) = \sum_{i=0}^{9} b_i^C(\gamma)\,\theta^i, \tag{51}$$

Whenever $\gamma \in (0,1)$, this function has a unique root $\theta_C^*(\gamma)$ in the interval $(0.633, 1)$. The proof of this result is, however, quite lengthy (as Decartes' rule of signs no longer suffices) so we only provide a sketch. The proof is an application of Sturm's theorem, a result which pins down the exact number of real roots of a given polynomial *within a certain interval*.[10] Applying Sturm's theorem, we find that $f^C(\gamma,\theta)$ has a unique root in the interval $\theta \in (0.633, 1)$.

Sketch of the proof

[10] See Rahman and Schmeisser (2002) for a detailed exposition of Sturm's theorem.

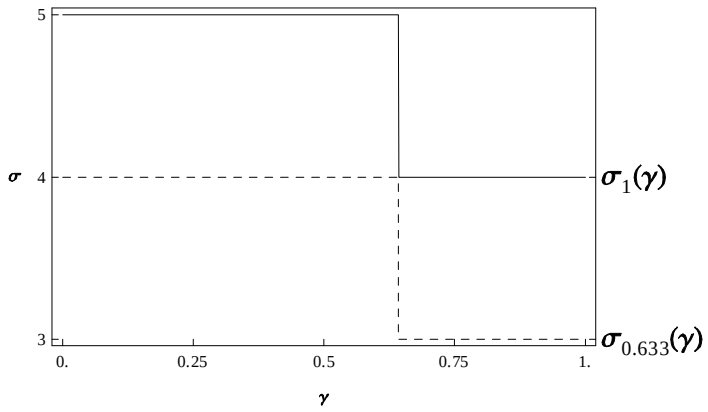

Figure 3: Sign changes

- Step (i): Create a Sturm chain $p_0(\theta), p_1(\theta), \ldots, p_9(\theta)$ for the polynomial $f^C(\gamma, \theta)$ using the following procedure:
  - $p_0(\theta) = f^C(\gamma, \theta)$
  - $p_1(\theta) = \partial f^C(\gamma, \theta)/\partial\theta$
  - $p_l(\theta) = -\text{rem}(p_{l-2}(\theta), p_{l-1}(\theta))$ for $l \in \{2, \ldots, 9\}$, where $\text{rem}(p_{l-2}(\theta), p_{l-1}(\theta))$ is the remainder when polynomial long division is used to divide $p_{l-2}(\theta)$ by $p_{l-1}(\theta)$.
- Step (ii): Evaluate the Sturm chain $p_0(\theta), p_1(\theta), \ldots, p_9(\theta)$ in $\theta = 0.633$ and $\theta = 1$, and count the number of consecutive sign changes in both chains. Denote these sign changes by $\sigma_{0.633}(\gamma)$ and $\sigma_1(\gamma)$, which are plotted in figure 3.
- Step (iii): By Sturm's theorem, the difference in the number of sign changes between both chains is equal to the number of real roots in the interval $\theta \in (0.633, 1)$. Verify that $\sigma_{0.633}(\gamma) - \sigma_1(\gamma) = 1$ for all $\gamma \in (0, 1)$, which implies there is a unique real root in the interval $\theta \in (0.633, 1)$.

The manufacturer prefers to deal with a **retail monopoly** over a non-cooperative duopoly iff

$$\Delta^M = \pi_U^{M*} - \pi_U^{NC*} > 0, \tag{52}$$

where

$$\pi_U^{M*} = \frac{1}{8}\left(1 - \gamma^2\right) \tag{53}$$

Following exactly the same procedure as before we can show that the roots of Δ^M are qualitatively the same as those of Δ^C. The only difference is that now only when $\theta \in (0.736, 1)$, there exist a unique $\gamma_M^*(\theta)$ such that $\Delta^M > 0$ iff $\gamma > \gamma_M^*(\theta)$. Similarly, there exists a unique $\theta_M^*(\gamma)$ such that $\Delta^C > 0$ iff $\theta > \theta_M^*(\gamma)$. As $\pi_U^{C*} \geq \pi_U^{M*}$, it is clear that $\Delta^C \geq \Delta^M$, hence $\gamma_M^*(\theta) \geq \gamma_C^*(\theta)$ and $\theta_M^*(\gamma) \geq \theta_C^*(\gamma)$.

Downstream profit derivatives

All downstream profits are decreasing in the transfer price g, which is decreasing in retailer bargaining power γ. An increase in γ therefore increases π_D^{C*}, π_D^{NC*}, and π_D^{DEV*}. An increase in degree of substitution θ has the following effect on downstream profits:

$$\frac{\partial \pi_D^{C*}}{\partial \theta} = -\frac{1-\gamma^2}{4(1+\theta)^2} < 0 \tag{54}$$

$$\frac{\partial \pi_D^{DEV*}}{\partial \theta} = \frac{1}{64}(1+\gamma)^2 2(2-\theta)(2\theta-1)\frac{1}{\left(1-\theta^2\right)^2} > 0 \text{ iff } \theta \in \left(0, \frac{1}{2}\right) \tag{55}$$

$$\frac{\partial \pi_D^{NC*}}{\partial \theta} < 0 \tag{56}$$

To see that the last inequality holds, write downstream profits in full:

$$\pi_D^{NC*} = \frac{l(\gamma,\theta)}{m(\gamma,\theta)} = \frac{(1-\theta)\left\{2-\theta(1+\theta)\left[1+\gamma(1-\theta)^2\right]+2\gamma\right\}^2}{(1+\theta)\left\{8-\theta\left[8-\theta\left(\gamma(2-\theta)^2(1+\theta)-2(1-\theta)\right)\right]\right\}^2} \tag{57}$$

Now define

$$h(\gamma,\theta) = \frac{\partial l}{\partial \theta} m - \frac{\partial m}{\partial \theta} l, \tag{58}$$

such that

$$SIGN\left(\frac{\partial \pi_D^{NC*}}{\partial \theta}\right) = SIGN(h(\gamma,\theta)). \tag{59}$$

The function $h(\gamma,\theta)$ can be rewritten as a product of the following three functions

$$h_1 = (2-\theta) > 0 \tag{60}$$

$$h_2 = (4-\theta(1+\theta)(2-\gamma\theta(2-\theta))) > 0 \tag{61}$$

$$h_3 = c_3(\theta)\gamma^3 + c_2(\theta)\gamma^2 + c_1(\theta)\gamma + c_0(\theta) < 0 \tag{62}$$

such that $h(\gamma,\theta) < 0$. The inequality $h_3 < 0$ follows from the fact that all c_i's are negative.