Selling to a cartel of retailers: a model of hub-and-spoke collusion

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Abstract

We develop a model of hub-and-spoke collusion between a manufacturer and two retailers. Demand is stochastic, and collusion between retailers is difficult; the best collusive equilibrium is inefficient (Rotemberg and Saloner (1986)). Hub-and-spoke collusion reduces double marginalization, but raises the ability of retailers to collude. The impact on consumer’s welfare depends on the distribution of bargaining power. When the supplier has the bargaining power, hub-and-spoke collusion is similar to vertical restraint and can be welfare improving. When retailers have the bargaining power, hub-and-spoke collusion is similar to a welfare reducing horizontal agreement.

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1 Introduction

Collusive conduct can endanger the benefits of competitive markets and be harmful to consumer welfare. Competition authorities and economists have analyzed in depth the consequences of horizontal agreements between competitors, prohibiting such practices. There is also a vast literature dedicated to the analysis of vertical agreements between firms and their suppliers. Competition law prohibits some vertical restrictions, but, in general, views vertical agreements as less harmful to competition than horizontal agreements.

Recently, some cases of collusive conduct, that can not clearly be classified as either horizontal or vertical agreements, have been investigated. The so-called hub-and-spoke collusion generally involves retail competitors and their common supplier(s). Sensitive information is passed between competitors not directly but through a supplier that facilitates price collusion. Also named A to B to C information exchange, these collusive practices have been discussed quite extensively by competition authorities.

In the latest version of its Guidelines on horizontal cooperation agreements, the European Commission dedicates a section (Section 2) to information exchanges. The Commission notes in the first paragraph of this section that

Information exchange can take various forms. Firstly, data can be directly shared between competitors. Secondly, data can be shared indirectly through a common agency (for example, a trade association) or a third party such as a market research organization or through the companies’ suppliers or retailers.

Competition authorities have prosecuted indirect exchanges of information through suppliers in a number of jurisdictions, including the United States, the United Kingdom and Belgium (see Odudu (2011) and Sahuguet and Walckiers (2013), for a recent review of the case law). In many cases, the suppliers participating in the hub-and-spoke collusion have some degree of market power. The economic mechanism behind these indirect information exchanges is not well understood. Odudu (2011) notes for instance that:

The additional challenge […] in the hub-and-spoke context is to explain why [the supplier] is involved (and thus liable) in the indirect information disclosure. It has been argued that [the supplier] has no incentive to police [the retailers’] horizontal arrangement and strong incentives to do just the opposite.

At a first sight, an undertaking with some degree of market power would fight any attempt of downstream retailers to cooperate in order to increase their margins. A Chicago School-type
of argument would support that there is only one monopoly profit, and that higher retail margins reduce the profit accruing to the supplier\(^1\).

This article builds a model of hub-and-spoke collusion in which a supplier chooses to participate in a collusive tacit agreement with retailers to help them collude more efficiently. Our benchmark is a situation in which collusion between retailers is inefficient from the point of view of the whole supply chain. Such inefficient collusion does not obtain in a simple model of Bertrand competition because the inability of retailers to collude on a high price leads to a reduction of retailers’ margins that directly benefits the supplier.

Our starting point is the model of Rotemberg and Saloner (1986)\(^2\). In their model, the difficulty to sustain collusion derives from a stochastic demand, which varies from period to period. To deter deviations from collusive prices, retailers need to rationally limit their collusive activity in periods of high demand, when a potential deviation is most profitable. Such a collusive scheme is not only inefficient for retailers but also harms the supplier. In the high demand state, when collusion on high prices is not sustainable, better coordination benefits all parties. Thus, the supplier can improve the efficiency of the vertical chain by taking part in a collusive scheme (hub-and-spoke agreement).

The hub-and-spoke collusive equilibrium works through an exchange of information between supplier and retailers. Retailers inform the supplier about the state of demand, allowing the supplier to increase his wholesale price when demand is high, thereby relaxing retailers’ deviation constraint (because there is less to gain from deviation with a higher wholesale price). Collusion in the high demand state becomes more efficient and leads to increased profits for the vertical chain. Indeed, the supplier reduces the effect of double marginalization by varying the wholesale price across the demand cycle. For retailers to agree, the scheme needs to provide them with profits as high as the profits they would get if they did not inform the supplier about the state of demand. An important feature of the analysis is that hub-and-spoke collusion increases the profits of the vertical chain through a better coordination and not at the expense of others actors in the market (another supplier or other retailers). The logic of the hub-and-spoke collusion in the model is not based on the exclusion of competitors (downstream or upstream).

The economic effects of the hub-and-spoke collusion are ambiguous. The distribution of bargaining power in the vertical chain is crucial to evaluate the welfare consequences and thus to decide whether such agreements should be forbidden. We show that when the supplier has most of the bargaining power, hub-and-spoke collusion displays the features of vertical agreements, solving some of the problems associated with double marginalization. As is

\(^1\)This argument has been put forward by practitioners in their informal economic analysis of the effects of hub and spoke conspiracies. See for instance http://www.crai.be/ecp/assets/Effects_Analysis_in_Hub_and_Spoke_Cartels.pdf

\(^2\)The main reason we use the Rotemberg and Saloner’s model is that it delivers inefficient collusion while remaining tractable. We believe that the logic of hub and spoke collusion would extend to many other models in which collusion between retailers is inefficient.
well-known in the literature on vertical relations, such agreements can be welfare improving. However, when retailers have the bargaining power, hub-and-spoke agreements lead to improved collusion between retailers. As most horizontal agreements, consumers are hurt by retailer driven hub-and-spoke collusion.

In terms of competition policy recommendations, our analysis thus does not find that hub-and-spoke agreements are necessarily undesirable. However, in the presence of buyer power, the welfare effects of hub-and-spoke conspiracy appear to be adverse because it mostly helps the retailers to improve their collusive conduct.

**Related literature**

The economic literature on hub-and-spoke collusion is rather scant. Odudu (2011) discusses relevant legal cases and gives some informal economic arguments about the logic of this type of agreement. Van Cayseele (2013) models a hub-and-spoke collusion as a cartel in which the supplier disciplines the retailers with the threat of refusing to sell to a retailer that would not conform to the agreement. Kuhn (2001) discusses the consequences of information exchanges for competition policy but does not explicitly deal with hub-and-spoke agreements. Gerlach (2009) studies information exchange in a model of collusion with varying demand. He shows that communication between horizontal firms can in some circumstances improve collusion and consumer welfare by facilitating coordination. Athey and Bagwell (2001) and Athey et al. (2004) also analyze the exchange of private information about costs in a model of collusion.

The papers that are closest to ours can be grouped into two categories. A first group of papers studies how vertical restraints and more specifically contractual agreements between suppliers and retailers (such as resale price maintenance) can help implementing horizontal collusion. They usually study bilateral duopolies and focus on the incentives of upstream suppliers to design contractual agreements with downstream retailers (such as resale price maintenance) to facilitate upstream collusion. Shafer (1991) shows that downstream firms’ competition can be softened if upstream firms introduce slotting allowances. Jullien and Rey (2007) explain that resale price maintenance yields more uniform prices downstream, which facilitates tacit collusion upstream, by making deviations easier to detect. Rey and Vergé (2010) study “interlocking relationships”: resale price maintenance, associated with two-part tariffs, serves to dampen interbrand competition (upstream) and intrabrand competition (downstream) and restore monopoly prices and profits. Dobson and Waterson (2007) assume that manufacturers use (inefficient) linear wholesale prices and show that resale price maintenance contractual agreements can be socially desirable when retailers are in a weak bargaining position, to reduce the effect of double-marginalization problems. In all those papers, competition is present in both upstream and downstream markets, but contractual agreements enable firms to soften competition and thus to create more profit industry-wide. Our model studies a hub-and-spoke conspiracy without vertical contractual agreement.

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3 See also Miklos-Thal, Rey and Vergé (2011).
A second group of papers focuses on non-binding vertical agreements within the value chain. Buehler and Gärtner (2012) model retail-price recommendations that are non-binding, that is, in contrast to resale price maintenance agreements, the manufacturer does not control the retail price directly and does not require means of pressuring retailers into adherence. They show that retail-price recommendations are irrelevant in a static set-up, but when suppliers and retailers interact repeatedly, retail-price recommendations can become part of a self-enforcing relational contract (Levin, 2003) that serves to maximize joint surplus. In their model, non-binding price recommendations act as a communication device within the value chain that conveys private supplier information on production costs and consumer demand to his retailer. The information exchange is at the core of the vertical agreement and no contract is needed to enforce the collusive mechanism. However, they do not consider the case of multiple retailers and how this type of agreement would work in the presence of competition or collusion between retailers.

Our paper also shares similarities with Piccolo and Miklos-Thal (2012), who show that retailers can collude more easily in the downstream market if they can also collude on the wholesale tariffs they offer to suppliers. By agreeing on a wholesale price as high as the retail price (in a two-part tariff), retailers can completely eliminate their own incentives to undercut the retail price. The main difference is that they consider competition between competing hierarchies where each supplier only interacts with a single retailer. Their set-up is thus not one of hub-and-spoke collusion.

The idea that a third party can help organize collusion⁴ and can benefit from it has been studied in other contexts. Greif, Milgrom and Weingast (1994) analyze the relations between a city with merchants. They model the interaction as a repeated game of trust. They show that in order to credibly promise protection to the merchant, the city may have an interest to help the merchants get organized in a guild that can effectively punish the city when it breaks its protection promises. See also Dessi and Piccolo (2012) for an extension to a set-up closer to the present paper.

Our model finally contributes to the literature on information exchanges in oligopolies. In static models, the issue of information exchange has been analyzed extensively (see for instance Vives (1984)). The incentives to exchange information and the impact on consumer welfare depend on the details of the modelling (whether goods are substitutes or complements and whether firms choose prices or quantities). The analysis has been extended to include vertical information exchanges (see Li (2002) and Zhang (2002)). These papers take an operation management perspective and analyze the best ways to coordinate efficiently a supply-chain and do not discuss the consequences of such information exchanges for competition policy analysis.

⁴See also Bernheim and Whinston (1987) on the role of marketing common agency to improve collusion.
2 Model

We consider a vertically related industry with one supplier and two retailers. The supplier produces a consumption good at constant marginal cost, which we normalize to 0 for simplicity. The good is sold to consumers by two retailers with zero costs. Consumers view the products sold by retailers as homogeneous and buy from the retailer that proposes the lowest price.

We consider an infinite-horizon setting with discrete time $t = 1, 2...$ and a discount factor $\delta$ common to all players of this infinitely-repeated game.

As in Rotemberg and Saloner (1986), demand is stochastic and varies from period to period. We assume that $\varepsilon_t$, the random variable denoting the demand shock in period $t$, can take two values, 0 and 1, with probability $\lambda$ and $1 - \lambda$. The random variables representing the demand shocks $\varepsilon_t$ are assumed to be independently and identically distributed. We also assume that the state of demand is commonly observed at the beginning of period $t$ by the retailers but not by the supplier. The demand function takes the form:

$$Q_t = (1 + \varepsilon_t) (1 - p_t)$$

Retailers compete in price. The retailer with the lowest price sells to all consumers at his quoted price.

Each period the timing of the game is as follows:

1. The state of demand is revealed to retailers.
2. Retailers can decide to truthfully\footnote{The assumption that communication is truthful corresponds to the case of hard, verifiable information. When information is soft, the analysis becomes more complex. Incentives to lie about the state of the world should be taken into account. See Athey and Bagwell (2001) and Gerlach (2009) for models of collusion with strategic communication.} reveal the state of demand to the supplier.
3. The supplier sets the wholesale price $w$, potentially as a function of the information revealed by retailers.
4. Retailers set final prices.

The first-best outcome from the perspective of the industry chain (supplier and retailers) is that the supplier sets a wholesale price equal to his marginal cost of production, and that retailers collude on the monopoly price that depends on market demand. This arrangement leads to monopoly prices, quantities and profits for the vertical chain in every period. An alternative way to reach the first best is for the supplier to set the wholesale price equal to
the first-best price and that retailers compete in every period so that the retail price equals
the wholesale price.

**Proposition 1  First best profits for the supply chain**

The retail price that maximizes the vertical chain’s profits is \( p = 1/2 \) in both states of demand. The optimal quantities are \( q_L = 1/2 \) when demand is low, and \( q_H = 1 \) when demand is high. Profits to be shared by the vertical chain are \( \Pi^B_L = 1/2 \) when demand is low, and \( \Pi^B_H = 1 \) when demand is high.

To reach the first best, not only do the parties need to be able to communicate, but side-payments must be used to share the surplus. Given that competition policy forbids explicit colluding practices, we limit the type of contractual arrangements available within the supply chain. The supply chain needs to overcome at least two types of issues. First, retailers’ tacit collusion must be sustainable: retailers need to have an incentive to maintain prices in all states of demand. Second, retailers need to be willing to communicate the state of demand to the supplier. The supplier also needs to keep in mind double-marginalization; in particular, when the supplier helps retailers’ collusion, he may exacerbate the double marginalization problem.

### 2.1 Collusion between retailers

Consider retailers in isolation, and suppose that they pay a wholesale price \( w \) in every period. The best collusive scheme is to share the market between them by setting the (same) retail price that maximizes their joint profits. This price corresponds to the double marginalization retail price, given the wholesale price imposed by the supplier. Denote \( \Pi_L(w), \Pi_H(w) \) the maximum joint profit in each state of demand.

There exists an equilibrium in which both retailers set \( p = w \) in every period. Both retailers make zero-profit. This price-war equilibrium will be used as a threat to sustain collusion. In what follows we focus on the best equilibrium that retailers can sustain through tacit collusion. If retailers could sustain a perfect collusive agreement, they would share the market in every period setting the optimal retail price \( (1 + w)/2 \).

The value of perfect collusion is thus: \( \frac{1}{1-\delta} \left( \lambda \Pi_L(w) + (1 - \lambda) \Pi_H(w) \right) \).

Collusion is sustainable if retailers do not want to cut their price to capture the whole market, knowing that this leads to a break-down of collusion in the future and a reversion to the zero-profit equilibrium. The gain from a deviation is larger in the high state of demand. The relevant incentive constraint is:

\[
\Pi_H \leq \frac{\delta}{1-\delta} (\lambda \Pi_L + (1 - \lambda) \Pi_H).
\]
Rewriting the constraint as

\[ \Pi_H \leq \frac{\delta \lambda}{(1 - \frac{\delta}{1 - \delta} (1 - \lambda))} \Pi_L = k \Pi_L, \]

we see that for \( k < 2 \), a perfect collusive agreement is not sustainable. As in Rotemberg and Saloner (1986), the best collusive scheme that retailers can sustain is described as follows: in the state of low demand, retailers collude perfectly, and in the high state of demand, they set a price that leads to a profit \( \Pi_H^{\text{max}} = k \Pi_L \). With such a price, a deviation in the high state of demand is not profitable.

That price \( p_H^{\text{max}} \) is computed as follows:

\[ 2 (1 - p_H^{\text{max}}) (p_H^{\text{max}} - w) = k \Pi_L = k(1 - w)^2 / 4. \]

The price \( p_H^{\text{max}} \) is the smallest number that solves this equation. We get:

\[ p_H^{\text{max}} = \frac{1}{2} (1 + w) - \frac{1}{2} (1 - w) \sqrt{1 - k/2}, \]
\[ q_H^{\text{max}} = (1 - w) \left( 1 + \sqrt{1 - k/2} \right). \]

**Proposition 2** Retailers’ optimal tacit collusion

*Given the wholesale price \( w \), if \( k = \frac{\delta \lambda}{(1 - \frac{\delta}{1 - \delta} (1 - \lambda))} < 2 \), retailers cannot tacitly collude to set double marginalization retail prices in both states of demand. The profit maximizing equilibrium for retailers consists in setting the double marginalization retail price when demand is low and the highest price \( p_H^{\text{max}} \) that leads to sustainable collusion when demand is high.*

\[ p_L = (1 + w) / 2, \quad q_L = (1 - w) / 2, \]
\[ p_H^{\text{max}} = \frac{1}{2} (1 + w) - \frac{1}{2} (1 - w) \sqrt{1 - k/2}, \]
\[ q_H^{\text{max}} = (1 - w) \left( 1 + \sqrt{1 - k/2} \right), \]
\[ \Pi_L = (1 - w)^2 / 4, \quad \Pi_H^{\text{max}} = k (1 - w)^2 / 4. \]

Thus, \( k \) parametrizes the friction in the ability to collude of retailers. When \( k \) is larger than 2, optimal collusion is possible. When \( k \) decreases, the retailers’ profits that are sustainable with tacit collusion also decrease. Given that \( k \) increases in both \( \delta \) and \( \lambda \), it becomes easier to sustain perfect collusion when retailers become more patient and when the low demand becomes more likely.

In our model, based on Rotemberg and Saloner (1986), the friction in retailers’ ability to collude stems from the instability of demand, which puts an upper limit on the sustainable collusive price in the high demand period. More broadly, it is usually accepted that it
is more difficult for companies to achieve a collusive outcome in markets which are too complex, insufficiently transparent, concentrated, or symmetric (see for instance para. 77 of The European Commission’s Guidelines on Horizontal cooperation agreements). Our results are likely to extend to other constraints on collusion, to the extent that imperfect cooperation negatively affects the supplier’s profits.

Collusion is not only inefficient for retailers, but also for the entire vertical chain. The reason behind this inefficiency is that the importance of the double-marginalization problem varies with the demand. The hub-and-spoke agreement mitigates the inefficiency and creates surplus to be shared between the supplier and retailers. This intuition is central to our explanation of the workings of hub-and-spoke collusion. When demand is low, retailers collude perfectly and the supplier would be willing to decrease his wholesale price to mitigate double marginalization. When demand is high, retailers set a relatively low price and double marginalization is less problematic for the supplier who would like to set a higher wholesale price. This inefficient collusion leaves room for improvement in the vertical chain through exchanges of information.

2.2 Choice of wholesale price when the supplier does not know the state of demand

We now solve for the optimal choice of wholesale price $w$ by the supplier, when retailers do not communicate their information about demand and retailers use the best possible collusive equilibrium, as derived above.

The profit of the supplier is thus:

$$\Pi^S (w) = w \left( \lambda q^L + (1 - \lambda) q^H \right)$$

$$= w \left( 1 - w \right) \left( \lambda / 2 + (1 - \lambda) \left( 1 + \sqrt{1 - k / 2} \right) \right).$$

The optimal wholesale price for the supplier is $w^* = 1/2$. This choice of wholesale price implicitly assumes that the supplier has all the bargaining power. If retailers had most of the bargaining power, the supplier would set a wholesale price close to the marginal cost of production of 0. We can parametrize the relative bargaining power of the supplier by $\alpha \in [0, 1]$ and the corresponding wholesale price $w(\alpha) = \alpha / 2$. We show in the appendix how this can be microfounded using a Nash bargaining model.

**Proposition 3** Wholesale price without communication

When the supplier does not know the state of demand, the wholesale price depends on the relative bargaining power $\alpha$ of the supplier. The optimal wholesale price for the supplier is $w = 1/2$. The optimal wholesale price for the retailers is $w = 0$. The result of the bargaining leads to a wholesale price $w(\alpha) = \alpha / 2$. 

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The retailers use the best collusive strategy given the wholesale price $\alpha/2$.

### 2.3 Hub-and-spoke collusive equilibrium

We now analyze a hub-and-spoke collusive scheme in which retailers communicate the state of demand to the supplier. In turn, the supplier sets the wholesale prices $w_L$ and $w_H$ as a function of demand. Retailers subsequently coordinate on the best collusive equilibrium, given these wholesale prices. We first consider the situation in which the supplier has all the bargaining power and sets the wholesale prices without taking into account the incentives of retailers to communicate the state of demand. We then consider retailers’ incentives to reveal their information to the supplier. To do so, the supplier sets wholesale prices so that retailers’ profits are the same as when they do not reveal the state of demand. Finally, we consider the case in which the supplier and the retailers bargain on the details of the hub-and-spoke agreement.

The supplier chooses wholesale prices $w_L, w_H$ to maximize his expected profit:

$$\text{Max}_{w_L, w_H} \{\lambda w_L q_L + (1 - \lambda) w_H q_H\}$$

$$\iff \text{Max}_{w_L, w_H} \{\lambda w_L \left(\frac{1 - w_L}{2}\right) + (1 - \lambda) w_H \left(1 - w_H + \sqrt{w_H^2 - 2w_H - 2k\Pi_L + 1}\right)\}.$$

For a given $w_L$, the supplier chooses $w_H$ to maximize his profits when demand is high under the constraint that retailers’ profits when demand is high are $k$ times larger than when demand is low. This means that the choice of $w_L$ influences the profits when demand is high, but that the choice of $w_H$ does not influence the profits when demand is low. The choice of $w_L$ and $w_H$ can be made independently.

The optimal choice of $w_H$ solves:

$$\text{Max}_{w_H} \{q_H w_H\}$$

$$\text{st} : \Pi_H = q_H (1 - q_H/2 - w_H) = k\Pi_L.$$

We can rewrite the constraint as $q_H (1 - q_H/2) = k\Pi_L + qw_H$. The supplier in fact chooses $q_H$ to maximize the total profits of the chain $q_H (1 - q_H/2)$. The optimal quantity is the monopoly quantity $q_H = 1$. The wholesale price $w_H$ is then adjusted so that retailers’ profits $\Pi_H$ equal $k\Pi_L$ and collusion is sustainable. The corresponding wholesale price is $w_H^* = 1/2 - k\Pi_L$. The supplier always chooses $w_H$ such that retailers collude on the monopoly quantity in the high-demand state and sets the wholesale price in such a way that retailers’ profits satisfy the incentive constraint for collusion when demand is high.

We now turn to the choice of the wholesale price when demand is low. Given that retailers’
profits \( \Pi_L \) are equal to \( ((1 - w_L)/2)^2 \), the supplier maximizes:

\[
Max_{w_L} \left\{ \lambda \left( \frac{1 - w_L}{2} \right) w_L + (1 - \lambda) \left( 1/2 - k \left( (1 - w_L)/2 \right)^2 \right) \right\}.
\]

Taking first order conditions, we get that the supplier sets \( w^*_L \) equal \( \frac{\lambda + (1-\lambda)k}{2\lambda + (1-\lambda)k} \).

Acting in his best interest, the supplier would increase the \( w_L \) in order to decrease retailers’ profits and extract more profits when demand is high. However, retailers must be willing to reveal their information to the supplier. Assuming that only truthful information can be revealed but that retailers can conceal information if it is in their interest to do so, the supplier needs to choose wholesale prices in such a way that retailers’ profits are at least as high as in the scenario without communication.

Retailers’ profits when demand is low directly impact their profits when demand is high, and thus their total expected profits. The supplier can therefore insure retailers’ willingness to communicate by setting \( w_L \) equal to the wholesale price he sets when he has no information. This guarantees that retailers make the same profits and accept to reveal their information.

**Proposition 4** Hub-and-spoke collusive equilibrium.

*In the optimal hub-and-spoke equilibrium, retailers transmit their information on the state of demand to the supplier. The supplier adjusts the wholesale price to the state of demand, with a higher wholesale price when demand is high. For a given \( w_L \), retailers collude on the optimal price and quantities, while when demand is high, they sell the vertical chain monopoly quantity. The profits of the supplier are higher in the hub-and-spoke equilibrium, while retailers’ profits remain the same.*

The supplier uses wholesale prices to improve upon the supply chain’s inefficiency, which derives from the retailers’ inability to collude when demand is high. The collusive scheme is proposed by the supplier to the retailers as a take-it-or-leave-it offer, with the supplier taking all the surplus created by the conspiracy, just making sure that retailers agree to reveal the state of demand. Retailers’ profits are the same under hub-and-spoke collusion and under the scheme derived in the previous subsection.

### 3 Welfare analysis and recommendations for competition policy

#### 3.1 Take-it-or leave it offer from the supplier

The previous section showed that hub-and-spoke collusion between a supplier and retailers can be sustained as a tacit agreement. Retailers communicate the state of demand to the
supplier and the supplier adjusts his wholesale price to the state of demand, while retailers collude in the best possible way, taking wholesale prices as given. We first evaluate the welfare consequences of the hub-and-spoke agreement, when the supplier makes a take-or-leave-it offer to the retailers. This means that the supplier has all the bargaining power in the organization of the hub-and-spoke conspiracy; however, we maintain the assumption that the bargaining power in the scenario with no hub-and-spoke collusion is given by the parameter \( \alpha \).

To assess the consequences of the hub-and-spoke equilibrium on consumer welfare, we compare two scenarios:

1. Scenario 1 in which there is no hub-and-spoke agreement, the supplier does not know the state of demand, sets a unique wholesale price and retailers tacitly collude in the best possible way,

2. Scenario 2 in which the supplier and the retailers play the hub-and-spoke collusive equilibrium described in the previous section.

From the perspective of consumer welfare, quantities consumed, when demand is low, are the same in both scenarios. Therefore, evaluating the welfare aspects of hub-and-spoke boils down to comparing quantities sold when demand is high: \( q_{\text{max}}^h \) in the absence of hub-and-spoke collusion, and 1 with hub-and-spoke collusion.

We show in the appendix that if \( w(\alpha) < \frac{k}{k^2} (k + \sqrt{2\sqrt{2} - k - 2}) \) then \( q_{\text{max}}^H > 1 \) and the hub-and-spoke agreement leads to lower consumer welfare. Thus the impact of hub-and-spoke collusion depends on the distribution of bargaining power. Assuming that \( 1 \leq k \leq 2 \), (so that perfect collusion between retailers is not possible), there is a maximum value of \( \alpha \) for which the hub-and-spoke agreement is welfare improving.

When \( k = 1 \), the condition boils down to \( w(\alpha) < \sqrt{2} - 1 \); when \( k = 2 \) the condition boils down to \( w < 0 \). The higher \( k \), the more bargaining power needs to be in the hands of retailers for the hub-and-spoke agreement to be welfare improving.

**Proposition 5  Welfare analysis.**

The hub-and-spoke agreement decreases consumer welfare, when \( w(\alpha) < \frac{k}{k^2} (k + \sqrt{2\sqrt{2} - k - 2}) \), that is when the retailers have a relatively high bargaining power, i.e. when the wholesale price is relatively low in the absence of communication. In contrast, when the supplier enjoys a significant bargaining power, a hub-and-spoke agreement increases consumer welfare.
3.2 Supplier and retailers bargain upon the hub-and-spoke agreement

In practice, the surplus generated by the agreement is likely to be bargained upon and the division of surplus will depend on the retailers’ bargaining power. Given that the hub-and-spoke agreement is fully characterized by the wholesale price when demand is low, the supplier and retailers bargain about that price to share the surplus created by the agreement. The wholesale price when demand is high is adjusted so that the profits of collusion are sustainable as an equilibrium. The disagreement points of the bargaining process are $\Pi_S$ and $\Pi_R$, the profits made by the supplier and retailers in the equilibrium with no communication.

We have that $\Pi_S(w) = w(\lambda(1-w)/2 + (1-\lambda))$ and $\Pi_R(w) = (\lambda + (1-\lambda)k)(\frac{1-w}{2})^2$.

The disagreement points are:

$\Pi_R = (\lambda + (1-\lambda)k)(\frac{1-\alpha/2}{2})^2$,

$\Pi_S = \alpha/2 (1-\alpha/2)\left(\frac{\lambda}{2} + (1-\lambda)\left(1 + \sqrt{1-k/2}\right)\right)$.

The wholesale price $w_{HS}$ when demand is low solves:

$Max_w \{(\Pi_S(w) - \Pi_S)^\alpha (\Pi_R(w) - \Pi_R)^{1-\alpha}\}$.

Given that retailers prefer a low wholesale price (they would choose $w = 0$), and the supplier prefers a high wholesale price (he would choose $w = 1/2$), the result of the bargaining lies in the interval $[w, \alpha/2]$; the end points of the interval are determined by the wholesale prices corresponding to the disagreement point of the bargaining parties. The result of the bargaining will be closer to $\alpha/2$, when the supplier has substantial bargaining power, and closer to $w$ when retailers enjoy the bargaining power.

To evaluate the economic effects of the hub-and-spoke agreement, there is a trade-off between the impact of the agreement on the quantities sold in both states of demand. When demand is high, the quantity sold under the hub-and-spoke agreement is $q_H = 1$. When demand is low, the quantity produced is $(1-w_{HS}/2)/2$ which is higher than $(1-\alpha/2)/2$ which is produced in the no communication equilibrium.

When $q_{H}^{max} \leq 1$, the hub-and-spoke agreement improves consumer welfare.

When $q_{H}^{max} > 1$, the hub-and-spoke agreement does not always decrease consumer welfare. There exists $\alpha^*$ such that for $\alpha < \alpha^*$ the hub-and-spoke agreement hurts consumer welfare.

The result derived when the supplier makes a take-it-or-leave-it offer thus extends to the case in which the surplus of the hub-and-spoke collusion is shared between the supplier and the retailers. When retailers’ bargaining power is significant, the hub-and-spoke collusive
equilibrium is essentially of an horizontal nature, and decreases consumer welfare. The fact that welfare consequences of an agreement between suppliers and retailers depend on the relative bargaining position of the supplier and the retailers is reminiscent of Dobson and Watson (1997). They showed in a different context that the welfare effects of resale price maintenance depends on whether retailer power is strong or not.

4 Conclusion

We developed a model of repeated interaction between a supplier and two retailers. The main result is that a hub-and-spoke collusive equilibrium can be sustained with retailers providing information to the supplier about market demand and with the supplier adjusting his wholesale price, taking into consideration the fact that the retailers are colluding over prices.

In a static interaction, retailers would not communicate their information to the supplier who would take advantage of it. This leads to a bad coordination of the industry chain with inefficiently low production in the state of low demand (due to high wholesale prices). This lack of coordination also has negative consequences in terms of consumer welfare. The hub-and-spoke scheme leads to a Pareto-improvement in the chain. Coordination improves profits of retailers and of the supplier. Under imperfect collusion, profits in the high demand state do not really matter because retailers cannot collude efficiently in that state of demand. Transmitting information increases coordination at a lower cost for retailers. The supplier is clearly better off because it can adjust his wholesale price to the state of demand. The effect on consumer welfare is ambiguous. On the one hand, the hub-and-spoke conspiracy reduces double marginalization, which can improve welfare. On the other hand, it fosters horizontal coordination, which reduces welfare. When the retailers have the bargaining power, the supplier essentially acts a go between in order to achieve horizontal agreement, which is detrimental to consumer welfare.

As highlighted throughout the paper, our model, based on Rotemberg and Saloner (1986), is one in which retailers’ inability to collude derives from stochastic demand. Our paper shows that the supplier has an incentive to police downstream collusion, because inefficient collusion is even more costly. We believe that this result extends to other constraints on collusion (such as market complexity, insufficient transparency or concentration, or excessive asymmetry between firms).
5 References


6 Appendix

6.1 The wholesale price is determined by bargaining

We model bargaining game between the supplier and the cartel of retailers using the Nash bargaining solution (Nash 1950). The Nash bargaining solution over the wholesale price $w$ corresponds to the maximand of the Nash product:

$$(\Pi^S)^\alpha (\Pi^R)^{1-\alpha}$$

As shown in section 2.2, the expected profit of the supplier is:

$$\Pi^S = w \left( \lambda q^L + (1 - \lambda) q^H \right)$$
$$= w \left( 1 - w \right) \left( \lambda/2 + (1 - \lambda) \left( 1 + \sqrt{1 - k/2} \right) \right).$$

The expected profit of the cartel is:

$$\Pi^R = \lambda \left( \frac{1 - w}{2} \right)^2 + (1 - \lambda) k \left( \frac{1 - w}{2} \right)^2$$
$$= \left( \lambda + (1 - \lambda) k \right) \left( \frac{1 - w}{2} \right)^2.$$

The parameter $\alpha$ represents the relative bargaining power of the supplier. It captures factors that influence the outcome of the negotiation.

The solution is $w^* = \alpha/2$. It is a weighted average of the wholesale price preferred by the supplier which is $1/2$ and the wholesale price preferred by the cartel, which is $0$.

6.2 Derivation of the condition for welfare improving hub-and-spoke agreement

We need to compare the quantities consumed in the high state of demand. In the hub-and-spoke agreement, the supplier sets the wholesale price so that the quantity is equal to $1$. In the original equilibrium without communication, we have that $q_{\text{max}}^H = (1 - w) \left( 1 + \sqrt{1 - k/2} \right)$. The condition is just
Given that we assumed that $1 \leq k \leq 2$, (so that perfect collusion between retailers is not possible), we get a condition on the maximum value for which the hub-and-spoke agreement proposed by the supplier is welfare improving. When $k = 1$, the condition boils down to $w < \sqrt{2} - 1$; when $k = 2$ the condition boils down to $w < 0$. The higher $k$, the bargaining power needs to be in the hands of the retailers for the hub-and-spoke agreement to be welfare improving.