INTRINSIC IMPEDIMENTS TO CATEGORY CAPTAINSHIP COLLABORATION

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ABSTRACT. Category captainship, the approach where retailers use manufacturer-retailer collaboration, is a common way to leverage resources and capabilities in order to improve the sales/shelf performance ratio. However, evidence suggests that the depth and effectiveness of category captains and collaboration in retail are not as high as theory or best practice would predict. Suppliers and retailers suspect each other of opportunistic behaviour detrimental to both. In a stylized dyadic supply chain model prior to the effective contracting of the category captain, we show why information asymmetry between both is preferred: the retailer will hint at or develop retaliatory power to keep the supplier in check whereas the supplier will try to extract a rent by taking advantage of available information about relationship specific investment. We model single-period interaction when the retailer has to invest in relationship specific assets and alternative category manager grooming. We provide normative and positive support both to the captain’s potential opportunistic behaviour as well as the retailer’s investment decision in alternative captains and monitoring ability. In a two-period extension, we show how the retailer can discipline the captain ex ante. The model and its results complement and extend research in pre-contractual category captainship and supplier-retailer collaboration and coordination. They represent a departure from the usual vision in which sharing information and collaborating generate higher supply chain rent.

1. Introduction. The Efficient Customer Response non-profit organization has been promoting the use of category management (CM) as an efficient coordination mechanism between suppliers and retailers [23]. However, in 2014, almost twenty years after, the deployment of category management in fast moving consumer goods retail is still patchy. Only 39% of polled decision-makers in retail have mentioned having set up category management in France [24]. Carrefour has required several years to set up the corresponding management organization [9]. Intermarché only set it up in 2012 (LSA, nr2225, 26 April 2012 and nr2261, 14 February 2013). Research has proven the rewards brought on by CM to all of consumers, retailers

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and manufacturers [47]. The biggest manufacturers (e.g., international corporations like P&G or L’Oréal) have already developed and honed category management skills to be deployed in conjunction with local retailers in all countries they serve [3]. Research suggests that retailers can significantly enhance category performance and supply chain rent by allowing a key supplier to assume the role of “category captain” for a limited period of time [31] because of their better knowledge of the particulars of category consuming behaviour. On the contrary, poor coordination between retailer and manufacturer has been shown to result in significant loss of supply chain rent [26, 40, 49].

Several explanations may be given for such patchy adoption of CM. For CM to be adopted requires that both the retailer and the manufacturer agree that it is in their best interest. We conjecture that one explanation may be the difficulty in understanding and evaluating the required reorganization, investment in new technology and processes on the part of the retailers. This difficulty is compounded by the lack of proper and precise information about the returns that the retailers can achieve. We purport that part of this difficulty stems from the information retention by both manufacturer and retailer which would facilitate the evaluation of the potential benefit of mutual interaction. In this paper, we provide a model which explains why both the supplier and the retailer have an interest, before entering into a category captainship contract, in mis-representing vital information to the other party. Our results show that, because of this mis-representation, the potentially best pairing of supplier as category captain (CC) and retailer may not happen, impairing supply chain efficiency. We show why the supplier will under-estimate the representation of the captainship profit he can obtain to the retailer. We also show why the retailer will exaggerate the necessary relationship specific assets to be invested in hoping to achieve two goals: (a) make the supplier believe that he has the ability to monitor the supplier’s effort and detect potential anti-competitive opportunistic behaviour, and (b) induce the supplier into increasing the fee offered by the supplier to obtain the category captainship.

Research has centered its attention on the workings of the relationship between category captain and retailer once the contract for it has been signed. [21, 41] show that retailer relationships with category managers are fraught with difficulties. [36, 37] characterize the power of large international manufacturers when dealing with small retailers and the resentment generated. [29, 31] focus on the conflicts of interest and rent allocation between retailer and suppliers according to who holds the captainship. [41] center their attention on the opportunistic behaviour of the category captain once a relationship has started. None, to our knowledge, focuses on the impediments to establishing such collaboration. Once the required managerial processes and infrastructure has been set up [3], research has showed that category management by an external captain generates positive results.

In this paper, we explain why and how the retailer (he) induces the supplier (her) into subsidizing the retailer’s investment costs related to the implementation of category captainship with her. We show how the supplier can protect her rent and prevent or mitigate the former’s opportunistic behaviour. On the other hand, being always suspected of favouring her own brands at the expense of the other suppliers within the category [3, 10], we show how the retailer can reduce ex ante the possibility of the captain opportunistically clawing back some rent during her category

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1 CM is one type of collaboration effort involving relationship specific investments between supplier and retailer [3].
captainship tenure. We model both types of opportunistic behaviour and analyze the consequences in terms of supply chain efficiency. We provide justification for the retailer’s and supplier’s attitudes of information retention to defend against possible opportunistic behaviour prior to the signing of the category captainship contract.

The model makes both a contribution to the contracting literature, reversing the roles of information sharing and RSA order, as well as offering empirically testable hypotheses for the supply chain management literature. The anchoring in the information economics literature provides natural extensions and adaptations to new situations, generalizing beyond the stylized settings in the current model.

The paper presents, in the following section, some elements of related literature on the subject. The third section describes the model. In it, the first subsection presents the evaluation of the full information scenario as benchmark. The second sub-section presents the case of asymmetric information and the third and last one the retaliation possibilities open to the supplier. A numeric example in Section 4 illustrates the asymmetric information scenario and provides some insights. We conclude in Section 5.

2. Literature review. Category management in literature largely turns around the advantage that category captainship brings to the supplier which allows her to increase sales to the detriment of both other suppliers in the category as well as the retailers.

[25, 34, 46] and sources therein investigate the anticompetitive practices of category captains relative to the other suppliers in the category. [47] is one of the first papers to provide a model-based rationale for the behaviour of the retailer and manufacturer in non-price-related demand enhancing activities. In the process minimizing the potential opportunistic behaviour, [28, 33] provide proof of the rent generated for the dyad by the effort deployed by the category captain during her tenure. These papers further circumscribe the ability of the category captain to behave opportunistically. We contend here that even potential possibilities for opportunistic behavior between retailer and manufacturer will hamper supply chain efficiency.

When those investments are the subject of contracts, game or bargaining then contract theory is often used to explain the interactions. The starting point for our modelling exercise is the standard contracting model with complete but unverifiable information in a single-period framework [38, 39]. Often, the partners will not arrive at a maximizing arrangement as explained by [48] presenting strong arguments on the mechanisms which move away the players from optimal contracting arrangements. One is the cognitive limitations of human agents or organizations as well as information processing costs (information seeking is costly), another is the completeness of contracts (too much information may induce rent seeking), a third is the ex-post incentive mis-alignment which induces sub-optimal welfare or costly opportunism. The implications drawn in that paper apply here as well: designing covenants for all possible outcomes of a contract is costly. If, additionally, one partner fears being held up, he may well wish that no information about relationship-specific investment costs be included.

Although the model is related to the classical question of relationship-specific assets (RSA) and strategic incentives to invest in such assets [12, 14], our research angle is different. Most previous work in this area consider models where the
downstream buyer is exploiting RSA upstream by undermining margins (Stackelberg leadership) or opportunistically renegotiating contracts after the contract has been signed \[8, 7\]. The set-up of these models is seemingly intuitive: the buyer enjoys all bargaining power, supply markets are competitive and the investments are undertaken upstream (whereas in our paper, both parties enjoy strong bargaining power and the investment is undertaken downstream). The policy findings from these models point at the need for contractual commitments over longer periods, relational effects through reputation and trust-building through joint ventures and cost-sharing.

The setting we present here is a single-period game version of the sequential bargaining or renegotiation of rental price with one buyer under asymmetric information about his willingness-to-pay presented originally in \[18\]. \[18\] characterize the set of equilibria of two-period bargaining games when the seller and buyer each have two potential types (two-sided incomplete information), when the seller makes the offers and when the players alternate making offers. The single-buyer interpretation of this problem when the buyer is willing to trade and profitable mutual interaction is given has been looked into by \[17\] which demonstrate that a perfect Bayesian equilibrium exists.

The case of the alternative supplier has been looked into in \[22\]: a partner has private information about the value of trading with some alternative partner in which case, when the alternative is more lucrative or when a penalty may be levied on his profit, this buyer will defect and trade with the alternative supplier\(^2\).

We consider that the supplier is a Bayesian rational player in the sense that he separates his beliefs from his preferences by quantifying the former with a subjective probability measure and the latter with a utility function and seeks to maximize his expected utility \[45\].

A large part of the costs and investments incurred to engage in close collaborations is “soft” in the sense of verifiability, involving training, development and documentation of internal resources and routines as well as declining other work and options for the time and resources involved. As opposed to the textbook scenario of the “custom mold” that is fully relationship-specific, yet conveniently observable, our RSA are less specific and highly intangible (eg, the implementation of Category Management in Carrefour France, \[9\]).

3. Model. Consider a supplier (she) offering to become category captain to a retailer (he), serving demand in a product category. The corresponding service is limited to one period (generation\(^3\)). Managing a product category requires a specific investment on the retailer’s side to be effective. This investment corresponds to the significant resources that need to be dedicated to understanding the consumer response to the assortment, pricing and shelf placement decisions of products within a category and communicating the pertinent information to the supplier through \textit{ad hoc} information systems and procedures \[9\]. This specific investment is labeled \(\alpha \geq 0\). Included in this investment by the retailer is the required knowhow and information systems which will enable the retailer to monitor the supplier’s performance in providing the resources, time and service required to correctly and

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\(^2\)This is the case of the retailer naming another supplier as category captain. Note that this alternative is here a non-strategic player because he has been sidelined by the retailer when the latter chose to negotiate with the supplier.

\(^3\)In retail, the length of the category management contract can extend from one to three years and can be renewed or not.
efficiently provide the category captainship services expected. Incrementing the capacity to monitor brings to the retailer the required information necessary to detect opportunistic behaviour on the part of the supplier [10]. The value $\alpha$ represents the amount above the minimum or basic investment required to make the contract work (i.e., the information systems, data collection process, and coordination with the retailer or with an alternative retailer). If $\alpha = 0$, the retailer invests just this minimum and will forego monitoring the supplier’s opportunistic behaviour. If $\alpha = 1$, the retailer develops a complete monitoring system enabling him to detect supplier category management maximization effort and that this effort is not to the detriment of other suppliers of this category. Limiting the upper bound of $\alpha$ to 1 is without loss of generality.

The supplier is maximizing her expected profit $\Pi_s$ for the category under management by both increasing sales and reducing the costs involved (asset usage, inventory holding, procurement, investment in RSA), [27]. The net sales revenue $S_1$ of a period is known as $S_1$.

In the case when the contract with the retailer is rejected, the supplier turns to a non-strategic second best retailer, leaving the first retailer to manage the category alone and receive a lower revenue $R_2$. In such a case, the focal retailer still has to invest into relationship-specific assets including the relationship specific investment cost required to set up the information systems with a non-strategic second-best supplier (for simplicity, this cost is considered to be standardized to 0). The net revenue of the category $S_2$ will be smaller than $S_1$.

The net revenue $S_2$ is privately known by the supplier and cannot be observed by the retailer.

Denote by $w$ the contribution which the retailer asks the supplier to pay to be able to perform the category captainship services for him [29, 30]. It may include various forms of service remunerations like slotting allowances, listing or shelf space allocation. They can take the form of wholesale price reductions or outright upfront access fees [25, 35].

The supplier is maximizing the expected profit contribution $\Pi_s$ from managing a category and registering higher sales $S_1$. The reservation profit for the supplier is defined as $S_2 > 0$ from linking up with another retailer for category captain services. Costs are standardized to 0 without loss of generality.

In time (see Figure 1), the sequence of events is the following: the retailer organizes a tender for the category captainship among suppliers with potential interest in becoming category captain. The retailer ranks the offers in terms of expected profit taking into account the required investment in RSA and retains the best. He offers each of the retained suppliers a contract to be accepted or rejected. One supplier accepts. A contract is agreed upon and the retailer invests in the required specific assets. The retailer communicates the sales data and other relevant information to the supplier. Taking advantage of the retailer’s investment, the supplier provides suggestions and advice for category sales enhancement which yields additional sales to the retailer. The retailer observes the performance of the supplier. In this paper, we are not interested in how the value of the category is enhanced.

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4 The net revenue is the selling revenue net of all other direct costs which have been standardized to 0. We assume that the net revenues from the products are sufficiently high to always exceed the costs for this specific category and that those costs are the same whatever the retailer.

5 If the retailer is managing the category himself, he is less knowledgeable about this particular category than the supplier. If another supplier becomes category captain, she is the second-best in terms of category management know-how and expected performance enhancement.
Figure 1. Timeline of events when retailer and supplier agree on a contract for category captain. If the supplier refuses, the timeline is stopped on this disagreement (not represented here).

[28] or the captain’s impact on it [33]. Payout takes place. The game is over. The retailer can then organize a new tender and use the information gathered to favor the incumbent or, on the contrary, exclude her from taking part as retaliation for detected opportunistic behaviour or competitive exclusion tactics [15, 20, 25, 46].

If the supplier rejects the offer from the first retailer, both turn to outside options: the retailer manages the category himself or signs with the second-best supplier and obtains sales $R_2$. The supplier turns to her other retailer clients and obtains a reduced profit $S_2$ (this branch of the alternative is not represented in Figure 1).

The decision model is simple, the supplier makes a binary decision $\delta_s$ about the contract: 1 if she accepts to pay the retailer’s fee, 0 otherwise. This decision is a function of the fee $w$ she has to pay. We present all the notation in Table 1.

Supplier’s problem:

$$\max_{\delta_s} \Pi_s = (S_1 - w)\delta_s(w) + (1 - \delta_s(w))S_2.$$  \hfill (1)

The profit-maximizing decision rule for the supplier becomes

$$\delta_s(w) = \begin{cases} 1 & \text{if } S_1 - w \geq S_2, \\ 0 & \text{else}. \end{cases} \quad \text{PC1} \hfill (2)$$

Retailer’s problem:

$$\max_w \Pi_r = \delta_s(w)(R_1 - \alpha + w) + (1 - \delta_s(w))(R_2),$$ \hfill (3)

under the participation constraint

$$R_2 \leq R_1 - \alpha + w \quad \text{PC2}. $$
Given the position of the retailer, we assume that he acts as a Stackelberg leader in the game-theoretic sense, maximizing his profit with respect to anticipated responses from the supplier. Following [43] for bargaining under asymmetric information, we limit the model to one final offer that the supplier either accepts or rejects.

3.1. Pricing under full information. As a benchmark for our results, we consider the case where the retailer has full information on the costs and options for the supplier. In this case, the retailer may extract all interaction profit (information rent) from the supplier by exploiting the participation constraint PC1 presented in (2): the contractual fee $w_1$ will be set as

$$ w_1 = S_1 - S_2 $$

The contract $w_1$ will be proposed as long as the retailer’s participation constraint PC2 is met.

The intuition for a non-integrated supply chain is straightforward: a fully informed retailer prices his fee so as to capture all the potential extra revenue from the supplier, given the investment costs. The latter’s profit becomes, in this case,

$$ \Pi_s = S_2. $$

As the supplier’s profit no longer depends upon category captainship with the retailer, it is clear that her optimal strategy is to minimize her effort and the coordination effort with the retailer during the game or generation (not included in our model). As a result, because of potential opportunistic behavior by the retailer, when information about investment costs and potential sales are available to the retailer, the supplier will reduce her effort as she will not be able to oppose the potential opportunistic behavior of the retailer, thus affecting supply chain efficiency.

We now consider the results taking into account the case of information asymmetry.
3.2. **Pricing under asymmetric information.** The expected sales that the supplier can obtain if she is not category captain are difficult to evaluate because of two impacts. The supplier is then one among other suppliers in the category depending upon the effort by a captain for the sales registered with this retailer. Because this second captain brings less value, it is difficult for the retailer to assess the difference \( S_1 \) and \( S_2 \). The second impact stems from the possibility that the supplier becomes captain for the same category to another retailer. In this case, due to competition between retailers, the sales of the whole category may potentially be lower than initially thought.

In the case of asymmetric information about net revenues \( S_1 \) and \( S_2 \), the retailer must use an expected value approach to determine his offer. As seen from the benchmark contract presented in (4), all relevant parameters are private information. Hence, he must form a Bayesian belief of the supplier’s benefit of interaction, \( z = S_1 - S_2 \). He assumes that this economic quantity is a random variable from a probability distribution \( F_Z(Z) = P(z < Z) \) with first moment \( \mu \) and second moment \( \sigma \). He must estimate a value \( Z \) for the contract offer which maximizes his expected profit.

**Remark 1.** If the retailer ignores the distribution of \( z \) (complete uncertainty), his rational option is to offer \( w_2 = R_2 + \alpha - R_1 \) his indifference level. This provides the supplier a rent equal to \( S_1 - R_2 - \alpha + R_1 \).

The estimated distribution of \( Z \) follows a density function \( f_Z(.) \) and a cumulative density function \( F_Z(Z) \) over a domain \([Z, \overline{Z}]\) which we shall assume to be IFR (increasing failure rate) as defined in [4]. The density functions which enjoy this IFR characteristic include quite a large variety of classical statistical distributions such as the continuous uniform, the gamma, the Weibull, the modified extreme value, the truncated normal and the exponential for most types of common parameter sets as characterized in [4]. Without loss of generality, we consider a domain \([Z, \overline{Z}]\) such that \( 0 < Z \leq R_2 \leq \overline{Z} \).

The acceptance function of the contract at a level \( w_3 = Z \) is \( \delta_s(Z) = P(z \geq Z) = 1 - F_Z(Z) \). For notational convenience, denote the complementary cumulative density function \( 1 - F_Z(Z) = F_{Z}(Z) \).

The retailer now solves the following stochastic problem:

\[
\max_Z E (\Pi_r (Z)) = (R_1 + Z - \alpha) F_Z(Z) + R_2 F_Z(Z). \tag{6}
\]

If the retailer’s belief distribution function is IFR, then there exist a unique contractual threshold value which maximizes his expected profit (6) from the offer he presents to the supplier [7, the proof is available in][bru17]. The unique contract offer \( Z^* \) maximizing the supplier’s profit is the solution to

\[
Z^* - \frac{F_Z(Z^*)}{f_Z(Z^*)} = R_2 + \alpha - R_1. \tag{7}
\]

The retailer then offers a contract such that \( w_3 = Z^* \). This contract also meets PC1. To be acceptable to the supplier, \( Z^* \leq z \). Hence, the accepted contract is

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6Note that in an IFR distribution \( F_Z(Z) \neq 0 \) which leads to the notion that \( F_Z(\overline{Z}) < 1 \) but it can be defined such that it is arbitrarily close to 1.

7The case where \( R_2 > \overline{Z} \) is trivial: the retailer’s reservation sales are higher, there is no incentive to trade with the supplier. If \( R_2 < \overline{Z} \), \( R_2 \) is replaced by \( \overline{Z} \) in (7).
such that

\[ R_2 + \alpha - R_1 \leq Z^* \leq S_1 - S_2. \]  

(8)

Compare the contract with the full information benchmark contract presented in (4) in terms of rent allocation. In the full information benchmark, the supplier has no expected rent and will limit her coordination effort. For the asymmetric information case, an accepted contract leaves the supplier the rent

\[ V = z - Z^*. \]  

(9)

This rent \( V \) is positive or null for all \( Z^* \) for the supplier to accept.

The link between the result observed in the full information benchmark and the solution above are due to the accuracy and precision of the information available to the retailer. The accuracy of the information can be modeled as the mean of the distribution function that the retailer must build and which represents his belief. If the supplier conveys information to the retailer such that the latter forms a belief with a \( \mu \) very different from the true \( z \), the ensuing \( Z^* \) based upon the distribution function \( F_Z \) (built with \( \mu \)) will also be very different from a \( Z^* \) based upon the true \( z \).

In the same way, the precision of the information can be modeled as the variance of the distribution of the belief \( Z \): increasing information precision lowers the variance. In this way, when information becomes perfect (ie, \( \mu \rightarrow z \) and \( \sigma \rightarrow 0 \), \( Z^* \) tends to \( S_1 - S_2 \) from below. In other words, the retailer captures the rent of the supplier when fully informed.

We now place ourselves in the position of the supplier to evaluate the rent she can retain by virtue of the information she withholds from the retailer. Along the timeline presented in Figure 1, this point is placed before the retailer’s offer: she is in a position to influence the retailer’s belief about \( z \) (eg, by the information provided in the tender, or, after having been accepted on technical grounds, by providing information on the necessary information technology investments required). She does not know the retailer’s ensuing distribution \( f_Z \), investment cost in RSA \( \alpha \), nor his reservation sales \( R_2 \) resulting from the retailer turning to his outside option. So, under strict logic, we should assume that the supplier forms a belief about the distribution of the retailer’s belief and reservation profit plus investment in RSA. However, since she “guides” the retailer about the \( \mu \) and \( \sigma \), she “informs” him of a value \( \mu \) with a precision \( \sigma \) for the distribution of \( z \). In this way, she structures the construction by the retailer of \( f_Z \). However, this is not enough for the supplier to determine the future offer \( w_3 \). She must in turn also form a Bayesian belief about \( R_2 + \alpha \) supported by a distribution function \( G_r \) (she is better aware of \( R_1 \) resulting from using her services as category captain). This belief has \( \mu_r \) as mean.

So as to simplify the model, we take \( F_Z \) as a proxy of the supplier’s distribution of the retailer’s belief about \( z \). Based upon this belief and the parameters \( \mu \) and \( \sigma \), the supplier can now estimate the retailer’s optimal threshold \( Z^* \) which will maximize the retailer’s profit. The supplier’s information rent can then be stated as a function of his belief about \( R_2 + \alpha \) and the relatively better known information parameters, \( R_1 \), \( \mu \), and \( \sigma \):

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8The result and attending conclusions still hold when selecting a different distribution.
\[ E[V(\mu, \sigma, \mu_r)] = E[\Pi_s (w_3)] - \Pi_s (z) \]
\[ = S_1 - \alpha - Z^* - (S_1 - \alpha - z) \]
\[ = z - Z^* \]  
(10)

We then use the result provided in (7), which can also be written as

\[ Z^* = R_2 + \alpha - R_1 + \frac{F(Z^*)}{f(Z^*)}. \]

We then replace \( Z^* \) in the second step of (10) to obtain

\[ E[V(\mu, \sigma, \mu_r)] = z - R_2 - \alpha + R_1 - \frac{F(Z^*)}{f(Z^*)}. \]  
(11)

We use the definition of \( z = S_1 - S_2 \) and replace the belief held by the supplier \( \mu_r \) by its underlying value \( R_2 + \alpha \) to obtain

\[ E[V(\mu, \sigma, \mu_r)] = S_1 - S_2 + R_1 - \mu_r - \frac{F(Z^*, \mu, \sigma)}{f(Z^*, \mu, \sigma)}. \]  
(12)

For an illustration of this result, the reader is referred to Figure 5 presented in the numerical illustration.

We can now state one of the results of the model.

**Theorem 3.1.** The information rent that the supplier can extract from his interaction with the retailer is a function of the accuracy and precision of the information provided by the supplier about her net benefit from interaction: \( \mu \) and \( \sigma \) as the first and second moments of the belief distribution that the retailer has to evaluate. This information rent \( V \) can be expressed as a function of \( \mu, \sigma \) and the supplier’s estimate \( \mu_r \) of the retailer alternative revenue and investment cost in RSA:

\[ E[V(\mu, \sigma, \mu_r)] = S_1 - S_2 - (R_1 - \mu_r + \frac{F(Z^*, \mu, \sigma)}{f(Z^*, \mu, \sigma)}), \]  
(13)

where \( Z^* \) is solution to (7).

**Corollary 1.** The lower the retailer supposes \( S_1 - S_2 \) to be, the lower \( Z^* \) will be and the higher the retained rent for the supplier. The supplier must present an exaggerated value of the alternative opportunities to the retailer and downplay the expected revenues from him.

The intuition of this theorem is strong: the supplier can expect better contractual conditions the less aware the retailer is about the extra revenue she will make from working as category captain to the retailer above what she could make from working with a second best retailer. This result stems in part from her technological capability and knowhow about category-level assortment planning, shelf design, shelf-space allocation, stocking policy and demand forecasting. But it also stems from the investment in RSA done by the retailer to enhance the profit from category management in his stores. This effect has been reported in Finland in [36]: the larger suppliers have a stronger role in collaboration with retailers and are in a better position to influence category management than weaker or smaller suppliers. [5] reports that small retailers in Germany feel that the benefits of Efficient Customer Response (ECR) efforts do not accrue to them but to the large suppliers.

Note that this rent depends entirely on the distribution of the retailer’s belief and hence of the supplier’s guidance of such belief. For given values of \( z \), the higher
$\mu$ is respective to $z$, the lower the difference between $z$ and $Z^*$ will be (tending to 0). When $\mu > z$, the expected information rent for the supplier $V = 0$: the supplier rejects the offer and turns to her outside option. If $\mu$ tends to $z$ from below and if $\sigma$ tends to 0 (full information case), then $E[V(\mu, \sigma)]$ tends to 0. Finally, when $\mu \to 0$, $Z^*$ tends to $\mu_r$. This last result can be spelt out in the following way.

**Theorem 3.2.** In a single-period game, under asymmetric information, the supplier’s dominant strategy is to distort the information conveyed to the retailer about the expected revenues and investment costs, influencing the retailer into building a belief distribution $F_Z$ such that $Z = 0$, $\mu = 0$ and $\sigma = 0$. In this case the expected information rent to the supplier is

$$E[V(0, 0, \mu_r)] = z - R_1 + \mu_r,$$

so $Z^* = 0$, $\mu_r = R_2 + \alpha$ and $E[\Pi_s] = S_1$.

This result is to be compared to the complete uncertainty scenario seen in Remark 1. It yields the maximum information rent but not the rent obtained when the retailer is completely ignorant of the outside options available to the supplier. It is the case where the supplier influences the retailer into believing that she expects to obtain the same revenue from being category captain to the retailer as she would from some alternative retailer; ie,

$$S_1 - S_2 = 0 \Rightarrow \mu = 0, \Rightarrow Z^* = w_3 = 0.$$

The translation of this theorem in actual practice is as follows. The supplier ensures asymmetry of information by multiple means: through the organization of the supply chain, non-investment in information exchange technology, retention of innovation information (see the opportunistic mechanisms at work which curtail information exchange in networks in [2]). The supplier then presents the retailer with minimal extra revenue prospects. The retailer can either incur extra information discovery costs [16, 41] and call his bluff or make a trust-building statement by accepting the information at face value and consequently letting the supplier reap an information rent. This situation is clearly similar to the one described in [13] about French retailers’ policies regarding category management.

To illustrate our point, when using the values given in the numerical illustration, we obtain $Z^* = -0.036$ for $\mu = 0.1$ and $\sigma = 0.15$, ie, not only does the retailer invest $\alpha$, but he pays the supplier to be category captain!

However, when implementing category management, the retailer’s rent and bargaining position can be protected by deploying controls and setting joint targets [16]. After signing a contract, the retailer needs to oversee and control the supplier to prevent opportunistic behaviour during the life of the category management contract [41]. As is apparent from our numerical illustration, this rent protection is costly to the supply chain, in $F_Z(Z^*)$ % of the cases the proposed contract is rejected and both the retailer and supplier resort to second-best solutions. Indeed, part of the returns from innovation and development from suppliers lies in the leverage it offers in terms of bargaining position towards the retailers. It suits them to retain information about these from the latter.

The challenge for managers in category management is then to create contractual commitment beyond the single-generation setting so as to create additional rents through repeated win-win agreements. Part of that challenge can be met through trust as reported by [41]. Note that [41] did not find strong correlation between
the retailer’s ability to monitor or punish the focal supplier and that supplier’s perceived opportunistic behaviour.

We now turn to the information needed to enhance the retaliatory capability of the retailer.

3.3. Retaliatory threat by the retailer. In our model, the ability to monitor the actual opportunistic behaviour of the category captain during the life of the contract is given by the investment in relationship specific monitoring capability \( \alpha \). As defined, the retailer chooses the level he wishes. This investment provides him with the ability to screen the recommendations about the brands to carry, where to locate each brand on the shelf, how to display the products, how much space to allocate to each brand, what effect the marketing recommendations have on sales and consumer experience, etc. As mentioned in [30], “practices vary depending on the retailer, resulting in a continuum of practices. At one end of the spectrum, some retailers implement the category captains recommendations as they are; at the other end, some retailers filter the recommendations provided by the category captain and verify their appropriateness before deciding on the implementation”. The ability to evaluate and verify the appropriateness in question depends upon the monitoring capability of the retailer’s organization (managerial knowhow, store managers’ reporting, monitoring work processes, . . .). Such effort and managerial tools require an important investment \( \alpha \) by the retailer. [14] observed that, contrary to their initial hypothesis, as the retailer’s monitoring capabilities increase, so the economic performance of the category captain decreases.

When the retailer has developed ample category management monitoring ability, the practice has been reported to increase sales for both partners (e.g., Carrefour and Colgate have reported that both benefited from implementing category management in oral care, as mentioned in [30]). This insight has also been comforted by [36] who, based upon a survey, found that the two largest retail chains in Finland, representing 70% of fast moving consumer goods sold in the country, reported satisfactory results from category management with large suppliers.

But a high investment \( \alpha \) by the retailer can have a second type of outcome: it can result in retaliatory action by the retailer in the period following the end of the contract, when he excludes the opportunistic supplier from participating in the next tender for category captainship as punishment. So we must now look to what can potentially happen in the next period. From now on, we tweak the model and its results to account for this.

In a two-period setting, how can he signal to the supplier that he has, or will have, the ability to monitor the appropriateness of her recommendations without giving away too much information?

We contend that the retailer can signal \textit{ab initio} the existence and size of \( \alpha \). In the single period game presented earlier, from \textbf{Theorem 3.2} his best strategy is to maintain \( R_1, R_2, \) and \( \alpha \) secret. In a two-period setting this result no longer holds. Since \( \alpha \) enters the evaluation of \( \mu_r \) by the supplier, the retailer must be very plain and truthful about the elements that will enter the composition of the supplier’s belief. A higher \( \alpha \) suggests a higher \( R_1 \) (because of the retailer’s participation constraint), promising extra managerial capabilities on the retailer’s side. So that the supplier can tease out the impact of \( \alpha \) on \( w \), the retailer must make plainer those different elements.

As the retailer is bound to communicate sales data to the supplier during the course of the contract, the latter will know the level of sales \( R_1 \). So as to foster
trust in their relationship and give credence to the information given, the retailer could announce \textit{ex ante} (for example, these values could be included as forecasts in the tender documents) the anticipated $R_1$ and past sales $R_2$. In this way, he guides the supplier’s belief about $\alpha$ and hence about $\mu_r$. The remaining unknown for the supplier would turn on $\alpha$.

In the following, we consider that the retailer knows that the supplier will not accept a contract if she considers that the contract fee $w$ overvalues the true value of $\alpha$ (ie, he believes that the supplier will call his bluff). Assume without loss of generality that $R_1 - R_2 = 1$ (remember that $0 \leq \alpha \leq 1$). The retailer must influence the supplier into believing that:

\begin{equation}
0 \leq \alpha = R_1 - R_2. \tag{16}
\end{equation}

The upper bound is given by the fact that above it the retailer would be investing in monitoring capability more than the expected sales anticipated from working with the supplier, generating a loss for the contract, hence violating the retailer’s participation constraint. The lower bound is supposed to be 0 inferring that the monitoring cost to the retailer is equal whether or not a category captain is chosen.

The retailer knows that the supplier will form a Bayesian belief about $\alpha$. The supplier will assume that this economic quantity is a random variable from a probability distribution with $F_Y(Y) = P(y \leq Y)$ with first moment $\mu_{retal}$ and second moment $\sigma_{retal}$. As in subsection 3.2, she must estimate $Y$ so that she can decide whether to accept the contract fee $w$ or not. In effect, because of PC1, she is led to assume that

\begin{equation}
w_4 = R_1 - R_2 + Y^* \Rightarrow 0 \leq w_4 \leq 2. \tag{17}
\end{equation}

The acceptance function of the contract at a level

\begin{equation}
w_4 = R_1 - R_2 + Y^*, \text{is } \delta_r(Y) = P(\alpha \geq Y) = 1 - F_Y(Y). \tag{18}
\end{equation}

The stochastic problem which the supplier must solve stems from (6):

\begin{equation}
\max_Y E[\Pi_s(Y)] = (S_1 - Y)F_Y(Y) + S_2F_Y(Y). \tag{19}
\end{equation}

In the same way and for the same reasons as earlier, there exists one and only one value $Y^*$ which maximizes the supplier’s profit function and it is solution to

\begin{equation}
Y^* - \frac{F_Y(Y^*)}{f_Y(Y^*)} = S_2 - S_1. \tag{20}
\end{equation}

Hence, an \textit{accepted} contract leaves the supplier a different rent than the one that came from the fully asymmetric information scenario in (9):

\begin{equation}
V = S_1 - S_2 - Y^* \tag{21}
\end{equation}

Note that in this instance also, the value $Y^*$ is influenced by the \textit{accuracy} and \textit{precision} of the information conveyed by the retailer to the supplier about $\alpha$ but also by the faith that the supplier puts into the numbers $R_1$ and $R_2$ provided. In fact,

\begin{equation}
E[V(\mu_{retal}, \sigma_{retal})] = S_1 - S_2 - Y^* = 2(S_1 - S_2) - \frac{F_Y(Y^*, \mu_{retal}, \sigma_{retal})}{f_Y(Y^*, \mu_{retal}, \sigma_{retal})}. \tag{22}
\end{equation}

Note that the information rent in (22) and (12) are not comparable: one stems from the retailer’s belief about $S_1 - S_2$, while the other stems from the supplier’s belief about $\alpha$. 
The retailer’s optimal policy when information is asymmetric and the supplier can potentially behave opportunistically during the contract can now be phrased as the following:

**Theorem 3.3.** In a two-period setting, under information asymmetry and potential opportunistic behaviour by the supplier, the retailer must convey truthful information about $R_1$ and $R_2$ but guide her belief so that the cost of the RSA is the highest possible. He protects his rent from interaction by minimizing the supplier’s information rent

\[
E[V(\mu_{\text{retal}}, \sigma_{\text{retal}})] = 2(S_1 - S_2) - \frac{\bar{F}_Y(Y^*, \mu_{\text{retal}}, \sigma_{\text{retal}})}{\bar{f}_Y(Y^*, \mu_{\text{retal}}, \sigma_{\text{retal}})},
\]  

where $Y^*$ solves (20).

To recapitulate, we find that the retailer offers different contracts according to the information in his possession and the information he can manage to convey credibly to the supplier. Both supplier and retailer have some incentive into misleading the other about such important information as the investment cost in RSA by the retailer or the difference between sales that can be registered by the supplier if working with the retailer as opposed to working with a third party.

To get a better grasp of the link between the estimate of the unknown quantities and the rent that the supplier keeps, we present a numerical illustration.

4. **Numerical illustration.** We illustrate the findings from the model with a simple numerical instance. Suppose that a retailer and a supplier have the option to work together in a specific product category. Let the true parameters for each partner be

\[
\begin{align*}
\alpha &= 0.5, \\
S_1 &= 2, & S_2 &= 1, \\
R_1 &= 3, & R_2 &= 2.
\end{align*}
\]  

4.1. **Full information benchmark.** In this first scenario, the retailer is informed of the supplier’s alternative third party outside opportunity $S_2$. The retailer offers the contract in equation (4),

\[
w_1 = S_1 - S_2 = 1.
\]

This contract is accepted by the supplier and results in a profit for her of $\Pi_s = 1$, making her indifferent with the option of turning to her alternative retailer. The retailer’s profit is $\Pi_r(w_1) = R_1 - \alpha + w = 3.5$. The retailer’s profit is better than her reservation profit $R_2 = 2.5$. However, the relevant bound here is naturally the joint profit contribution from the interaction, $\Pi_r + \Pi_s = 3.5$. The results are presented together in Table 2.

4.2. **Complete ignorance.** When the retailer is totally uninformed about the supplier’s relevant information, from Remark 1, he can only offer $w_2 = R_2 + \alpha - R_1 = -0.5$, ie, he pays the supplier for the benefit of her knowhow in category management. The profits are $\Pi_r(w_2) = R_1 - \alpha + w_2 = 2$. The supplier’s profit is $\Pi_s(w_2) = S_1 - w_2 = 2.5$. The joint profit for the supply chain is now 4.5.

The difference between both contractual offers represents the price of information to the retailer.
4.3. **Asymmetric information.** Now consider that alternative $S_2$ is the supplier’s private information. Assume that the retailer’s Bayesian belief of $Z$ is normally distributed $N(\mu, \sigma)$ truncated at 0. Using the result in equation (7), the retailer calculates an optimal contract $w_3$ such that

$$w_3 - \frac{F_Z(w_3)}{f_Z(w_3)} = R_2 + \alpha - R_1. \quad (25)$$

Numerically, we obtain $w_3 = 1.697$ for the instance when $\mu = 0.5$ and $\sigma = .15$. Thus, for the instance given above, the profits are

$$\Pi_r (w_3) = R_1 - \alpha + w_3 = 3 - 0.5 + 1.697 = 4.197 > \Pi_r (w_1) = 2,$$

whereas

$$\Pi_s (w_3) = S_1 - w_3 = 0.303 < \Pi_s (w_1) = 2.5.$$

We observe an increase of almost 60% in profit level for the retailer through the asymmetric information. The supplier accepts the offer and still comes out ahead as compared to turning to her outside option.

The optimal contracts $w_3$ based upon $Z^*$ vary according to $\mu$, the mean of the distribution of $Z$, from which the given parameters above are just one of possible outcomes. For $\mu > 1.25$, the supplier would reject the contract since she would be better off by turning to her other option (see Figure 2).

Thus, overestimating the supplier’s advantage in working with the retailer can lead to the retailer being turned down (a high $\mu$). Underestimating this advantage reduces the retailer’s profit (Cf. Figure 2 when $\mu = 0.1$, $\sigma = 0.15$, $w_3 = 0.04$ and $\Pi_r = 2.504$).
We now turn to an evaluation of the impact of the precision of the information held by the retailer about the supplier’s private information on the contract that he will offer.

To do so, we vary the degree of information precision available to the retailer represented as the standard deviation of the distribution function $\sigma$ that the retailer builds to embody his belief. When $\sigma = 0$, the retailer has a precise notion of $\mu$ (which does not guarantee that he knows $z$, merely that he is certain about the true value of $\mu$). We present in Figure 3 the change of $Z^*$ when the standard deviation of the distribution of $Z$, truncated normal, varies from 0 to 1.5. As can be seen, when it goes from 0.25 to 0, $Z^*$ approaches $z = R_2 - R_1 + \alpha$ from below.

Another interesting observation which can be made from this Figure is the way that $Z^*$ also increases when the standard deviation $\sigma$ increases over 0.25. The reason is mathematical in nature: the distribution of $Z^*$ is truncated at 0.

Table 2 lists the outcomes for retailer and supplier when information is common or asymmetric and compare it to the case where both turn to their alternative options. According to the initial estimate formulated by the supplier, the cost or profit varies. In all cases, it can be seen that the asymmetric information scenario enables the supplier to keep part of the profit contribution which the retailer strives to capture.

To illustrate Theorem 3.1, we present in Figure 5 the evolution of the difference in rent which the supplier keeps according to the mean of the retailer’s distribution of belief and for two different standard deviation values and in Figure 4 when the standard deviation varies. A low standard deviation ($\sigma \rightarrow 0$) yields a null information rent when the retailer also knows that $\mu = z$ (here, this means that $\mu = 1$). Clearly, the supplier must try to guide the retailer towards low estimates.
of \( z \) and obfuscate the information in such a way that the retailer will have the vaguest idea of the true \( z \) (tantamount to influencing him into increasing \( \sigma \)).

5. **Conclusion.** In this paper, we have studied the precontractual arrangements between a supplier and a retailer wishing to enter into a category management collaborative contract. Considering that retailers often enjoy considerably more power than the suppliers of fast moving consumer goods [35], it is of interest to research the possibilities open to either of them to protect their share of the supply chain rent and to influence the other party into relinquishing some of his or her rent. [50] model the category captainship as an alliance which increases profit for both to the disadvantage of other suppliers to the same category. As shown here, both players want to protect this additional rent from encroachment by the other party.

We show how, in a single period game with full information, a retailer can extract a rent from a supplier. We show how the rent extracted is proportional to the retailer’s knowledge of the upstream partner’s outside options and why the latter
will hide or mis-represent such opportunity. We also show that the supplier will want to gauge the amount invested by the retailer in relationship-specific assets and that it is in the interest of the retailer to mis-represent such cost by inflating it. This situation is typical of adversarial relationships between suppliers and retailers. Even though the benefits of category management have been proven, given that both parties have substantial investment in management and information systems at stake, in the initial reunions to determine the contract and the outlays to be made, the ground will be tested by staff from both parties so as to measure intent and capabilities. In spite of the advertised frankness and trust façade, representatives of the retailer and of the supplier will disguise their true costs, opportunities and monitoring capabilities. Any opportunity for rent encroachment will fade if both players have sophisticated information management tools/practices and extensive knowledge of outside opportunities.

Retailers will over-represent their costs of setting up the necessary tools of category management and undervalue the expected extra revenues generated. The retailer’s optimal strategy is to argue that the extra revenue barely covers the extra investment in RSA. As in the case of the small retailers in [36], if the supplier has a deep knowledge of the managerial and informational outlay costs and of the retailer’s revenue opportunities and alternatives, the former will under-invest in RSA and in supply chain collaboration independently from the perceived fee. This underinvestment results in a lower overall supply chain rent.

It is noticeable that these investments and eventual rent escape the metrics that are in place to monitor the captain’s performance such as target category profits or sales as well as the retailer’s evaluation of the recommendations provided [32]. They are also different from the research costs that a retailer would have to make if he wanted to manage a category himself. Our results complement those presented by
Kurtuluş and Toktay in their numerous publications in that they mainly concerned themselves with modeling the behaviours of the players after the negotiation of the captainship contract.

We show in a two-period setting how the retailer may protect himself against opportunistic behaviour during the category management contract. To do so, we find that he must influence the category captain into believing that he invests in extra monitoring capability on top of the optimal relationship specific assets. The supposition by the supplier of the existence of such capability motivates her into accepting a less than optimal contract offer and refrain from opportunistic behaviour during the contract in an attempt to be eligible as category captain in future rounds. During her captainship tenure, she will deepen her knowledge of the retailer’s capabilities so that, if given the opportunity in future, she may be able to refine her belief about $\alpha$ and hence be able to argue with the retailer for a lower contract price. This observation and information gathering is a natural result given the necessary managerial interaction with the retailer. To limit this effect, the retailer may obtain better results if he rotates the captainship of all categories at every renewal of the corresponding contracts.

Further research may explore how the current findings can be extended in multi-period settings and multi-sourcing scenarios, e.g., when a retailer invests in relationship specific assets (or general management capability) and several suppliers as category captains and swaps them around on a regular basis. There might also be interesting conclusions to be drawn by modeling the effects presented above and those from competition among the suppliers induced by the retailer as presented in [47].

The results presented here can be extended, mutatis mutandis, to other cases where a buyer has to invest in some relationship-specific assets to work with a particular supplier. It is the case when firms buy an ERP software, services from a law or accounting firm or a machine that involves modifying work processes. This model and attending results complement and extend research in pre-contractual situations in supply chain management collaboration and coordination. They contradict some of the recent results in supply chain management literature which tend to consider that supplier and retailer are always better when sharing information and collaborating extensively (see the extensive literature review in [11]). Such results can explain the observed non-financial factors which, according to [42], affect the performance of buyer-supplier exchanges and justify the lack of openness in firms within the same supply chain, especially as regards the exact extent of relationship-specific investments in connection with their upstream partners.

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