Vertical Information Sharing in Distribution Channels

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Abstract

This paper examines the information-sharing behavior of firms in a distribution channel context. While information sharing among firms can occur in a horizontal (among competitors) or vertical (channel members) context, previous attempts at modeling information sharing has primarily been restricted to the horizontal context. For marketers, channel alliances are interesting in view of their growing popularity as witnessed by initiatives like ECR and category management. Such initiatives usually involve the pooling of, often complimentary, information available with manufacturers and retailers. It is argued that such pooling of information should lead to better decision-making and hence it is desirable. However, in practice, category management is often implemented with a somewhat interesting institution of category captain, which appears to be a restricted form of information pooling. It involves the retailer entering into an alliance with only one (of many) supplier in a category, who is accorded the role of category captain.

We first analyze the information sharing incentives of the two industry participants, manufacturer and retailer, in a bilateral monopoly. We find that whether sharing will occur or not is crucially dependent on the baseline quality of information available with the firms and on the degree of complementarity of resources that in turn determine how effective information pooling is. Next, using a model of competing symmetric duopolists selling through a common retailer, we show that information sharing between the alliance partners can sometimes give rise to the emergence of the so-called category captain, i.e., an exclusive alliance. The total channel profits and those of the partners in alliance go up. This increased profit is due to higher average wholesale prices, which can be interpreted as reduction in price promotions, a key goal of the category management initiative. The model generates predictions about when information-sharing alliances are more likely and can also be extended to answer managerially relevant question for retailers, i.e., who to choose as category captain?

Keywords: Distribution Channels, Information Sharing, Decisions Under Uncertainty, Game Theory
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1 Introduction

An important trend in product distribution is the growth of information-intensive channels. Such channels are characterized by channel partners who invest in bundles of sophisticated information technology like telecommunication and satellite linkages, bar coding and electronic scanning systems, database management systems etc. to not only disseminate information within any given organization but also among organizations in a channel by creating interorganizational systems (Stern et al. 1996, Koch 1994). The firms collect and analyze supply side information on inventory and replenishment on one hand and market and demand information (such as store sales, POS data, promotional response etc.) on the other. Major retailers such as Sainsbury and Marks & Spencers in U.K. as well as A&P grocery stores, Super Valu Stores and Von’s supermarket in U.S. have made substantial investments in these technologies and engage in ongoing marketing research. Similarly, leading manufacturers such as Procter and Gamble have responded to the availability of greater information by developing tracking and information systems at the retail store level.

Over the past decade, these trends have given rise to the emergence of some important institutional initiatives between manufacturers and retailers that involve the creation and sharing of store level and market level demand information to improve
the functioning and the coordination of the channel. An important example of these initiatives is Category Management. An early report by A.C. Nielsen (1992) characterizes it as capitalizing on the dramatic increase in market information, advances in technology, and sophisticated software applications. By the middle of 1990s, many industry analysts heralded category management as the future of product distribution in an information-intensive world. While there are several aspects and forms of it, especially after it got co-opted in to the broader Efficient Consumer Response (ECR) movement (Kurt Salmon Associates 1992), Adams (1995) concludes that “the lifeblood of category management is market intelligence ... technological advances ... produce information ... which in turn leads to strategies, tactics and action” (ibid, pg. 182 ). The key idea is to build strategic alliance between retailers and manufacturers and to customize the offerings on a store-by-store basis. This is a collaborative process, in which the increasingly technologically sophisticated retailers pool the local level expertise and information with the regional and national level information and trends available with the manufacturers (Messinger and Narasimhan 1995, Adams 1995, Hill 1999, Pizzico 1999). This enables each party to take appropriate marketing actions and to coordinate to the “... degree possible while meeting its own strategic goals” (A.C. Nielsen 1992, pg. 23). More prominent practitioners of category management include Shaws and Schnuck’s among retailers, and also manufacturers such as Kraft Foods Division of Philip Morris, Anheuser-Busch, Procter & Gamble and Johnson & Johnson. Kraft, for example, practices micro-merchandizing, which involves integrating store-level sales data with market and demographic data to develop detailed understanding of demand and consumer behavior at the level of the retail store.

The above examples each highlight instances of voluntary information sharing among channel partners, which forms the basis for this paper’s analysis. We look at three specific sets of research issues:
• First, we explore the incentives for sharing of private information, for common sense would suggest that keeping information private, - not sharing it - would give a firm the advantage of being able to extract more favorable contract terms. In the context of a channel, when is it optimal for each channel member to agree to join an information sharing alliance? What is the impact of information sharing on channel contracts, in particular, how the wholesale price is affected by such alliances.

• A second issue is on the role of information sharing in channel coordination: i.e., enlarging the profits of the entire channel. In contrast with the first issue, here the focus is on overall channel outcome. Sharing information about market conditions with upstream or downstream partners is possibly beneficial to the channel, as it allows the channel to tailor its actions to the actual market conditions. We investigate the conditions under which this occurs and also whether information sharing coordinates the channel.

• The third set of issue hinges on information sharing in a market with a common monopolistic retailer but upstream competition. Several interesting questions arise in analyzing the incentives of competing manufacturers’ in sharing information with a common retailer. First, are there conditions under which an exclusive information sharing is likely to emerge? In other words, when is it likely that one manufacturer and the retailer would mutually agree to an information sharing alliance to the exclusion of the other manufacturer? Second, what situations are conducive to non-exclusive sharing arrangements? And third, what impact does one manufacturer’s information level have on the other manufacturer’s profits or contracts? Investigating these questions helps us characterize the institutional phenomenon known as category captain.

The category captain is usually a leading manufacturer in the category who pro-
vides the retailer with information and recommendations to help him run the category as a business unit (Adams 1995, Ball 1999). This restricted form of information pooling seems to contradict the idea of information sharing for better decision making. We characterize the theoretical conditions under which a category captain might emerge and also look at the related issues of what information sharing, exclusive or otherwise, does to the contracts and outcomes of the channel. Finally, in this competitive setup, we address the impact of category management type information sharing on manufacturers’ competition. An important objective of the category management movement, as part of the ECR initiatives, was to control the excessive incidence of trade promotions with high variability in demand and related inefficiencies (Stuart 1998). Our model with competing manufacturers allows us to examine how information sharing affects the extent of manufacturer price competition in the channel.

In order to address these questions, we first model the interaction between participants in a bilateral monopoly channel, viz. a manufacturer and a downstream retailer, as a game. The retail demand in the market is uncertain. Information available to a channel member provides it with an imperfect signal of the true demand. However, the better the quality of information, the more reliably can the channel member predict the true level of demand before it takes any action. Information sharing is modeled as a bilateral phenomenon that occurs if and only if both parties agree to it, and it leads to an improvement in the quality of information available with both the firms.

Next, we extend this basic framework to consider competition between two manufacturers to address the information sharing issues in a competitive channel, including the emergence of category captain, (i.e., an exclusive alliance). We model this as a two stage game. In stage 1, the parties decide to share information (or not) and in stage 2, a pricing contract is implemented.
In the bilateral monopoly case we find that sharing information always results in a more coordinated channel outcome by way of increased total channel profits. However, based on individual incentives we find a somewhat surprising result that a retailer with poor quality of information is unlikely to form an information sharing alliance with the manufacturer and the better the quality of the information the more likely the retailer will like information sharing to occur. When there is competition among manufacturers we find that when the quality of the information the manufacturers and retailer posses is somewhat high, asymmetric information sharing occurs. That is, the retailer shares information with one manufacturer who becomes the "captain" of the category. In this case we also find that the wholesale prices are high and the variance in the quantity sold is lower. This is consistent with one of the ECR objectives to manage the category better and gives some credence to category management leading to more stable prices.

We contribute to the existing literature in several ways. At a theoretical level, prior literature has looked at horizontal information sharing (i.e., between competitors), which we extend to the context of vertically related firms, i.e., with upstream or downstream firms in a distribution channel. We develop a metric for the quality of information for this purpose and obtain several key insights on the behavior of the firms in a distribution channel when there is uncertainty about the demand. While in a bilateral monopoly channel profits goes up with the sharing of information, we find somewhat surprisingly that a retailer with less sophisticated information is unlikely to enter into an information sharing alliance where as a more sophisticated one will! Further the manufacturer is more willing to share information in a broader set environment than the retailer. When competition among manufacturers exist we find that even if they have the same information, only one of them might form an alliance with the retailer thus providing an explanation for the emergence of the category captain phenomenon. Finally, from a managerial perspective, we provide guidance
to both manufacturers and retailers contemplating such information-sharing alliances pointing out that such alliances may not always be beneficial for each partner. Thus, potential partners should decide carefully whether to enter into such alliances and in what manner (exclusive or not). They should consider not only the existing quality of information of the firms in the industry in mind but also the impact such an alliance is going to have on each firm’s information quality within the industry.

The rest of this paper is organized as follows. The next section provides a literature review and points out where the present work fits in. Section 3 presents the basic framework and the analysis for information sharing in a simple bilateral monopoly channel. Section 4 extends the analysis to a competitive channel where two competing manufacturers sell through a common retailer. Section 5 briefly presents results from some model extensions, points out certain limitations of the study and concludes the paper. Finally, the Appendix in section 6 provides proofs of certain propositions.

2 Literature Review

The analysis presented in this paper is related with three different streams of literature, which we mention below.

Information Strategies of Firms and Competition:

Li et al. (1987) look at quantity setting competitors’ decision of acquiring information about an uncertain demand parameter through, say, market research, and conclude that more information is always good for a firm though cost consideration may prevent firms from acquiring unlimited amount of information. Several studies have looked at competing firm’s incentives in sharing their private information. Analyzing quantity setting competitors selling directly to consumers, many researchers including Gal-Or (1985) and Shapiro (1986) analyze competitor’s incentives in sharing demand and cost information. Vives (1984) and Gal-Or (1986) each
examine duopolistic competition for both quantity and price setting competitors. Their conclusion suggests that for Bertrand competitors, incentives always exist to share common demand information. The case is usually the opposite for Cournot competitors, but Mauleg and Tsutsui (1996) show that even in a Cournot model, if the demand uncertainty is about a common slope parameter rather than the overall level of demand, competitors may have incentives to share their private information. This paper extends this stream of research analyzing the incentives of competitors in demand information sharing with a distribution channel partner, i.e., vertical information sharing. Another aspect of a firm’s information strategy concerns with information selling (Sarvary and Parker 1997, Iyer and Soberman 2001) but we do not consider that in our model.

**Strategic Alliance Literature and the Distribution Channel Context:**

Carpenter and Coughlan (1998) study the problem of channel partners entering into an alliance for a bilateral monopoly channel. They focus on the importance of hold-up problems in this context even without any uncertainty in the environment. In our work, an alliance is formed only when it is beneficial for both firms, and hence we do not consider the hold-up problems. Stern et al. (1996) point out that information is sometime used to facilitate soft or quasi integration of the entire channel and our analysis also supports a similar outcome. Chu and Messinger (1997) use a bilateral monopoly setup to explore the information acquisition decision of the channel partners. In this paper, our focus is on the information sharing decision. Further, Chu and Messinger allow only the two polar cases; no information vs. perfect information. Using the reliability metric that we develop for measuring the quality of a firm’s information, we are able to model information more generally, allowing for imperfect information as well. Thus, in this work, we analyze information sharing decisions among channel partners both in a bilateral monopoly framework and in a competitive channel.
**Category Management:**

Interest in understanding and implementing category management is very high among executives. As Bucklin and Gupta (1999) report, category management was found to be the most important issue in their study among all issues in the distribution and retail management area. The category management movement has been fairly widespread in frequently purchased packaged goods distributed through grocery stores and similar initiatives were planned in other related businesses in recent years.¹ However, there is also evidence of some disenchantment with the concept, especially among retailers.² By analyzing incentives for both manufacturers and retailers, we investigate the conditions when information sharing is indeed beneficial for each member of the distribution channel. Academic research has provided models to help implement micro marketing (Montgomery 1997) and relevant metrics for evaluating profitability (Chen et al. 1999), but virtually no attempt has been made to explain the emergence of the category captain phenomenon. We model category management as an information sharing phenomenon in competitive channels and also show how information sharing may help mitigate some of the ills associated with excessive upstream competition and trade promotions.

¹Hennessy (1999) reports similar efforts in perishable categories.

²See Thayer (1999) for a report of how retailers routinely complain, often anonymously, about category management, which allegedly helps manufacturers make more money but does not bring a commensurate benefit to the retailers.
3 Information Sharing in a Bilateral Monopoly Channel

3.1 Industry and Demand

We consider a distribution channel consisting of a manufacturer selling to the final consumers through a retailer. Manufacturer and retailer(s) are assumed risk neutral and maximizing expected profits throughout this paper. The marginal cost of production is constant and is normalized to zero without loss of generality. Both firms are risk neutral. Thus, the retailer buys the product from the manufacturer at a wholesale price $w$ and then sets the retail price $P$. The industry demand function from the final consumers is assumed linear and is given by:

$$Q = \alpha - \beta P.$$ 

Industry demand is stochastic and the demand side uncertainty is captured by a two-point (Bernoulli) distribution for the intercept parameter $\alpha$.\(^3\) Let us label the realizations $\alpha_H$ as High ($H$) and $\alpha_L$ as Low ($L$), with the attached probability-masses $\lambda$ and $(1 - \lambda)$ respectively. This “alternate futures” type uncertainty (Courtney et al. 1997) captures the basic notion of uncertainty well in many situations. Also, this description of uncertainty is often used in modeling information sharing (Mauleg and Tsutsui 1996), contracting issues (Butz 1997) or in signaling models (Lariviere and Padmanabhan 1997) by researchers both in economics and in the marketing literature.

\(^3\)If the uncertainty is on the slope parameter $\beta$, the expressions for the solution become more involved, but the sharing incentives are not qualitatively affected in this bilateral monopoly channel.
3.2 Information, the Reliability Metric and Sharing

Information reduces uncertainty by reducing the conditional (on information) variance of the underlying random variable(s) that gives rise to uncertainty. In our setup, any information acquired about the underlying random variable \( \alpha \) updates the probability masses attached to the two possible outcomes \( H \) and \( L \) and thereby affects the conditional variance. Following Blattberg et al. (1994), we find it useful to conceptually distinguish between data and information. They point out that all forms of raw data cannot be called information. Some managerial resources need to be spent before data becomes information, i.e., before it becomes actionable and meaningful to users. We model information as a composite of the underlying data and its processing, and the end result can be thought of as a machine that gives a signal \( \tilde{H} \) or \( \tilde{L} \). The quality of information is captured by a parameter \( R \), which we call reliability, that represents the truth-telling probability. It can be characterized by the following conditional probability:

\[
Pr.(H|\tilde{H}) = Pr.(L|\tilde{L}) = R \quad \text{and} \quad Pr.(L|\tilde{H}) = Pr.(H|\tilde{L}) = (1 - R)
\]  

Note that the above formulation implies that the machine’s truth-telling probability remains the same in both the states of the world. This is, arguably, a desirable property of the machine. However, this type of a machine does not, in general, have some other desirable properties. First, the machine is not “unbiased” in general, where bias means that \( Pr.(H) \neq Pr.(\tilde{H}) \); and \( Pr.(L) \neq Pr.(\tilde{L}) \). It is easily shown that this machine will be unbiased only if \( R = 1 \) and / or if \( \lambda = 1/2 \). Second, we

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4 Throughout the rest of the paper, \( H \) and \( L \) have been used for the true realization of the state of the world, and \( \tilde{H} \) and \( \tilde{L} \) for the signals of a firm, sometimes with subscripts identifying the firm that obtains a signal, e.g., \( \tilde{H}_R \) for a High signal received by the retailer and \( \tilde{L}_M \) for a Low signal received by the manufacturer.

5 To be unbiased, \( Pr.(\tilde{H}) = \lambda \), which requires \( Pr.(H)Pr.(\tilde{H}|H) + Pr.(L)Pr.(\tilde{H}|L) = \lambda \).
would also desire that its signals are meaningful in the following sense: given that the true state is $H$, a machine should have higher probability of giving correct ($\tilde{H}$) signal than incorrect ($\tilde{L}$) signal. Symbolically,

$$Pr.(\tilde{H}|H) > Pr.(\tilde{L}|H),$$

and similarly:

$$Pr.(\tilde{L}|L) > Pr.(\tilde{H}|L).$$

(2)

These two properties require that $R > \lambda$ and $(R + \lambda) > 1$.

Thus, these desirable properties impose certain restrictions on the conditional probability measure that can be used to characterize information quality. We assume $\lambda = 1/2$, i.e., the two states of the world are equally probable, for the rest of this paper without any loss of generality. Recall that in a Bernoulli distribution, this gives the maximum variance for the underlying random variable. We consider the value of the reliability parameter $R$ in the interval $(0.5, 1]$ without any loss of generality and achieve all the desirable properties mentioned above.

Consistent with the institutional practice, we model sharing as pooling of information resources across firms. Some examples of these resources include P.O.S. and loyalty program data from the retailer and national level demand data from the manufacturer, models, forecasting expertise, templates, etc. This is not the same as sharing your information signal with your partner. Thus the signals across the organizations remain mutually independent (conditional on the true state), and the effect of information sharing is reflected in increased reliability of the information. This implies that conditional events ($\tilde{H}_M|H$) and ($\tilde{H}_R|H$) are independent. This, however, does not imply that the unconditional events $\tilde{H}_M$ and $\tilde{H}_R$ are independent as some degree of correlation between the two signals will be built in, being truth-telling representations of the same true state of the world.\footnote{The case of fully correlated signals is uninteresting from an information-sharing standpoint since sharing is meaningless. We expect qualitatively similar results to hold in the case of partially

simplifies to $(1 - 2\lambda)(1 - R) = 0$. This condition can be met only if either $\lambda = 1/2$ or $R = 1$ or both.}
when sharing occurs, the reliability of each players’ information increases by $\sigma (> 0)$ with $\sigma$ taking a higher value, the higher the degree of complementarity of the two independent sources is. Another way of modeling information sharing could be to consider actual pooling of samples by the firms in the distribution channels, like in the competitive sharing literature e.g., Vives (1984). This approach would imply that in addition to an improvement in quality of information available to firms, sharing also perfectly correlates the signals of the firms party to the sharing arrangements. Our way of modeling sharing captures the improvement in information quality while maintaining conditional independence of signals. In our view, this better reflects the institutional reality of strategic independence of the firms in contemporary distribution channels. This approach also largely avoids considering the issue of truthfulness in sharing since our focus in this study is not on analyzing the signaling or screening issues.

3.3 The Information Sharing and Price Setting Game

Both the firms in the present analysis are price setting-firms, and the sequence of moves, after a strategic information sharing stage, is like the manufacturer Stackelberg channel (see Figure 1 for the sequence of moves). We are interested in the interior pure strategy Subgame Perfect Nash Equilibrium (SPNE) for the multistage game of information sharing and pricing. In the information-sharing stage, the manufacturer initiates the offer to form an information-sharing alliance that the retailer can then accept or reject. Thus no firm unilaterally gives away information or forces an information sharing alliance. The key point is that forming an information-sharing correlated signals.

7 It is possible to model the improvement in reliabilities in ways more complicated than as a simple additive parameter. Three such possibilities are mentioned in an extension, and the results are qualitatively unchanged.

8 This sequence of the information sharing is technically similar to the case when both firms simultaneously decide whether to share information and the post-information-sharing payoffs are
alliance is a strategic decision that determines the firms’ quality of information going into the pricing stages of the game. In the discussion below, retailer’s baseline reliability level is labeled as $\rho$ and that of the manufacturer as $\mu$. Both these parameters have the exact properties of the reliability signal $\mathbf{R}$ detailed earlier. If the firms decide to share their information in the first stage, then the reliabilities go up to $(\rho + \sigma)$ and $(\mu + \sigma)$ respectively. Note that information sharing in this simple bilateral monopoly channel occurs only when both parties ex-ante expect to benefit from the sharing arrangement.9

[Figure 1 here]

The solution of the pricing game for any given level of reliabilities of the two firms is sketched out below. In the following discussion, we denote manufacturer’s signal-reliability by $\mu$ and that of the retailer by $\rho$, but the relevant expressions apply to post-information-sharing game also by simple substitution of $(\mu + \sigma)$ for $\mu$ and $(\rho + \sigma)$ for $\rho$. To find the Subgame Perfect Nash Equilibrium (SPNE) of the pricing subgame using backward induction, we start with the retailer’s pricing decision stage. The retailer’s problem (subject to non-negativity constraints) is to choose prices conditional on his own signal to maximize the expected profits given below:

$$
\Pi_R = \sum_{K=L,H} \sum_{\tilde{K}_R=L,R, \tilde{K}_M=L_M,H_M} \Pr(K \tilde{K}_R \tilde{K}_M) (P_{\tilde{K}_R} - w) Q_{K \tilde{K}_R \tilde{K}_M} \quad (3)
$$

In equation (3) above, $K$ is the true state of the world (i.e., intercept could be $\alpha_H$

obtained only if both firms decide to share.

9Notice that the focus in this essay is not on strategic information revelation that has been studied in the disclosure literature(See Okuno-Fujiwara et al. (1990) for an example and references). Fully considering such revelations may result in de-facto sharing under a broader set of conditions.
or $\alpha_L$; $\tilde{K}_R$ is the retailer's signal and $\tilde{K}_M$ is the signals received by manufacturer. The wholesale price charged by manufacturer is given by $w$. The actual quantity demanded by the market depends on the true state of the world, the retailer’s pricing response which is determined by the retailer’s signal and the manufacturer’s signal which determines the wholesale price that the retailer faces. This quantity is given by $Q_{\tilde{K}_R K_M} = \alpha_K - \beta \tilde{K}_R (w_{\tilde{K}_M})$.

As noted before, the retailer’s signal is independent of the manufacturer’s signal, so his own signal does not give him an update on the manufacturer’s signal beyond what is implied by the conditional probabilities. It is assumed that the retailer cannot deduce the manufacturer’s signal just by observing the manufacturer’s choice of wholesale price. Thus the retailer’s pricing response is taken to be conditioned on his own signal only. Of course, his pricing response is a function of the wholesale price $w$ that he faces. We parameterize $\alpha_H$ as $(a + t)$ and $\alpha_L$ as $(a - t)$ in the rest of this section. This parameterization implies that $a$ is the expected value of the parameter and $t$ represents the variability. The retailer’s optimal pricing response is given by:

$$P_R^H(w) = \frac{(a - t + 2\rho t + w\beta)}{(2\beta)}$$
$$P_R^L(w) = \frac{(a + t - 2\rho t + w\beta)}{(2\beta)}$$

(4)

Given these pricing responses of the retailer, the manufacturer now incorporates them in his own optimization problem. The manufacturer optimally chooses the wholesale prices conditional on his signal to maximize expected profit below conditioned on his signal and the pricing response of the retailer given by (4):

\footnote{This is a simplifying assumption that could be justified by other independent uncertainties faced by the manufacturer not explicitly modeled here that may introduce sufficient amount of noise in the wholesale prices. These independent uncertainties (arising, for example, due to supply side or competitive factors) are not crucial to the forces being analyzed here and we ignore them for now.}
\[ \Pi_M = \sum_{K=L,H} \sum_{\tilde{K}_R=L_R,H_R} \sum_{\tilde{K}_M=L_M,H_M} \Pr(K \tilde{K}_R \tilde{K}_M) w_{\tilde{K}_M} Q_{K\tilde{K}_R\tilde{K}_M} \quad (5) \]

Solving the first order conditions \( \frac{\partial \Pi_M}{\partial w_{\tilde{K}_M}} = 0 \) for \( \tilde{K}_M = \tilde{L}_M, \tilde{H}_M \) simultaneously, and checking for the second order conditions, we obtain \( w_{\tilde{L}_M} \) and \( w_{\tilde{H}_M} \) given below:

\[
w_{\tilde{H}_M} = \frac{[a + t(2\mu - 1)(1 + 4\rho - 4\rho^2)]}{(2\beta)} \]
\[
w_{\tilde{L}_M} = \frac{[a - t(2\mu - 1)(1 + 4\rho - 4\rho^2)]}{(2\beta)} \quad (6)
\]

Substituting these values back in the expressions for the prices, quantities and profits we can obtain all the equilibrium quantities, prices and profits for the two firms. Expressions for optimal expected profits for both firms are given below:11

\[
\Pi^*_M = \frac{t^2[(2\mu - 1)^2(4\rho^2 - 4\rho - 1)^2] + a^2}{8\beta} \]
\[
\Pi^*_R = \frac{t^2[(2\mu - 1)^2(4\rho^2 - 4\rho - 1)(4\rho^2 - 4\rho + 3) + 4(2\rho - 1)^2] + a^2}{16\beta} \quad (7)
\]

### 3.4 Individual Incentives of the Firms

In presenting the results of this model, we start with the following lemma about the pricing strategies of the two firms with respect to the reliability levels:

Lemma 1

(a) Wholesale and retail prices increase (decrease) w.r.t. a firm’s own reliability when the signal received is High (Low), i.e., \( \partial w_{\tilde{H}_M} / \partial \mu > 0 \); \( \partial w_{\tilde{L}_M} / \partial \mu < 0 \); \( \partial P_{\tilde{H}_M}(\cdot) / \partial \rho > 0 \);

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11 The solution presented here is the interior solution. Under certain conditions, the interior solution may not exist, but we do not look for the corner solutions in our analysis. A condition for existence of interior solution is: \( a/t \geq (2\mu + 4\rho^2 + (1 - \rho)(8\mu\rho) + 1) \)
0 and $\partial_\rho Pr(\tilde{L}) < 0$.

(b) Wholesale price decreases (increases) w.r.t. retailer’s reliability when manufacturer’s received signal is High (Low), i.e., $\partial w_H \partial_\rho < 0$ and $\partial w_L \partial_\rho > 0$. The retailer’s pricing response is conditional on own signal only and hence it remains unaffected by the manufacturer’s reliability but since the wholesale price enters as an argument of the retail price, the retail prices vary with respect to the manufacturer’s signal as follows:

$$\partial P_{\tilde{H}}(w_H) \partial_\mu > 0; \quad \partial P_{\tilde{H}}(w_L) \partial_\mu < 0; \quad \partial P_{\tilde{L}}(w_H) \partial_\mu > 0; \quad \text{and} \quad \partial P_{\tilde{L}}(w_L) \partial_\mu < 0$$

Proof. See Appendix, section 6  

To see the intuition behind (a), note that in the absence of any reliability ($R = 0.5$), a firm will price according to the expected value of the intercept. This will be too high for the true $L$ state of the world and too low for the true $H$ state of the world. Clearly, as the quality of information improves and a firm’s confidence in its own signal keeps growing, the firm moves its prices towards the “correct” full information optimal prices, which is higher for $\tilde{H}$ signal and lower for $\tilde{L}$ signal.

To understand the reason for optimal $w_H$ being negatively related with $\rho$, let us imagine for a moment that manufacturer’s reliability is $\mu = 1$, while retailer’s reliability is $\rho \in (0.5, 1)$. The manufacturer, when he gets a signal $\tilde{H}$, knows the true state is $H$, but from the first part of the lemma above, he also knows that given $\rho$, the retailer will use a pricing response that marks up the wholesale price somewhere between the markup corresponding to what it should be in expected value and what it should be in a full information case. In this setup, a manufacturer’s optimal response for a lower markup by the retailer is higher wholesale prices. To see this through an example, let us ignore uncertainty for a moment. The intercept is now always $\alpha$, and the retailer’s optimal full information pricing response should be $P = w/2 + \alpha/(2\beta)$,
to which the manufacturer’s response is to set \( w = \alpha/(2\beta) \). However, it can be easily seen that if the manufacturer knows that retailer is going to have a lesser markup than this, for example, if the rule he adopts is going to be \( P = w/2 + \alpha/(4\beta) \), then manufacturer’s optimal response is to set a higher wholesale price \( w = 3\alpha/(4\beta) \). The same strategic force applies in the presence of uncertainty also. Coming back to the case when the true state is high and the manufacturer knows it to be so, the extent of under-pricing by the retailer keeps going down as the retailer’s signal reliability goes up. Therefore, as \( \rho \) increases and retailer’s markup increases towards the full information “correct” value, the manufacturer’s optimal response is to lower the wholesale prices. Similar logic applies when manufacturer’s signal is \( \tilde{L} \) and invoking continuity, the logic can be extended to the general case when the manufacturer’s reliability is less than perfect. For the retail prices with respect to \( \mu \), we can see from equation (2) that the retailer’s price response does not get affected by it except as it affects the argument, \( w \). Thus given all other parameters, the retail prices move with respect to manufacturer’s reliability \( \mu \) in the same direction as the wholesale prices.

(a). Expected profits for both the retailer and manufacturer increase in their own reliability but decrease in the other firm’s reliability. The net effect of an equal increase in both firms’ baseline reliabilities, however, is always positive and hence the total channel profit always goes up as a result of information sharing.

(b). In the information sharing decision stage of the game, firms do not always want to share information with the other channel member. Because sharing is effective only if both firms unilaterally agree to it, information sharing emerges
as the Subgame Perfect Nash Equilibrium of the full game \( i f f \):

\[
(2(\mu + \sigma) - 1)^2(4(\rho + \sigma)^2 - 4(\rho + \sigma) - 1)^2 \geq (2\mu - 1)^2(4\rho^2 - 4\rho - 1)^2
\]

and

\[
(2(\mu + \sigma) - 1)^2(4(\rho + \sigma)^2 - 4(\rho + \sigma) - 1)(4(\rho + \sigma)^2 - 4(\rho + \sigma) + 3) + 4(2(\rho + \sigma) - 1)^2 \geq (2\mu - 1)^2(4\rho^2 - 4\rho - 1)(4\rho^2 - 4\rho + 3) + 4(2\rho - 1)^2
\]

(8)

**Proof.** See below and the Appendix, section 6 ■

The manufacturer’s as well as retailer’s expected profits is given in equation (7). The relevant first derivatives are obtained and signed in the Appendix. The intuition comes from the fact that expected profits are concave functions of the prices and as a firm’s own reliability increases from the no-information case (i.e., \( \rho = \mu = 0.5 \)), pricing decisions are more aligned with the full information outcome; thus an increase in own reliability allows each party to better span the variation in demand. Expected profits thus become an increasing function of reliability since an increase in reliability leads to the capture of a larger part of the variance component. On the other hand, an increase in the reliability of the other firm results in the prices of the focal firm moving in the opposite direction (i.e., away from the correct full information level). This results in a weakening of the variance capturing effect and hence the expected profit moves in the opposite direction. The total channel profit is just the sum of the two firm’s expected profits. The first derivative of the channel profit with respect to the retailer’s and the manufacturer’s reliabilities are obtained in the appendix. Even though individually they don’t have a consistent sign pattern, since sharing of informational resources results in an (equal) increase in the reliability for each firm, we are also interested in what the net effect of a simultaneous increase in the reliability of both players is on the total channel profit. It turns out that the total
or net effect of both the reliability parameters going up by the same small amount \( \sigma \) is always positive. In other words, \( \partial \Pi_{TC} / \partial \mu + \partial \Pi_{TC} / \partial \rho > 0 \).

To understand the sharing decisions of the firms characterized in proposition 1(b), note that information sharing has several effects. First, it expands the total pie, i.e., the total channel profits increase. However, it leads to two opposite forces for each firm in terms of appropriation of the total channel profits. Sharing leads to an increase in own reliability, which is beneficial for a firm. It also increases the other firm’s reliability, which is harmful for the focal firm in terms of appropriation of the total channel profits. Each firm’s willingness to participate in an information sharing arrangement depends on the relative magnitude of \( \Pi_{M}(\mu, \rho) \) Vs. \( \Pi_{M}(\mu + \sigma, \rho + \sigma) \) for the manufacturer and \( \Pi_{R}(\mu, \rho) \) Vs. \( \Pi_{R}(\mu + \sigma, \rho + \sigma) \) for the retailer. Inequalities given by (8) is obtained by simplification of the comparison for the manufacturer and the retailer respectively.

The equilibrium sharing outcome is presented graphically in Figure 2 in the \([\mu - \rho]\) space for a particular set of parameter values. It can be seen that at intermediate levels of base reliabilities, both firms want to share (region B). In this region, the favorable effect of an increase in a firm’s own reliability dominates for both firms. The rest of the space represents a no-sharing outcome because either the manufacturer does not offer such an alliance (region A) or the retailer (region C) prefers not to enter into an information sharing alliance even if the manufacturer proposes it.

Looking at Figure 2, there is an asymmetry in the willingness to enter into strategic information sharing between the two firms. The retailer benefits from sharing only if he has a high level of reliability relative to the manufacturer. The manufacturer, on the other hand, is willing to enter into such alliance in a large part of parameter space except when he already has such high reliability that an added
bump in information quality is less valuable. To see the reason why a relatively low reliability retailer rejects sharing, let us note that keeping the manufacturer’s reliability constant, if the retailer’s reliability comes down then there are two effects. First, the retailer is less confident in his signal and therefore, the retail prices are not going to be as “fine-tuned” for the true state of the world as before. This results in total channel profits being smaller. Second, the retailer’s share of the channel profits will be lower since the manufacturer would anticipate that the retailer is going to price (or mark up) less aggressively, being relatively less sure of the quality of any signal that he receives and therefore, the manufacturer will set a higher wholesale price. Sharing improves the reliability of both parties from their respective baselines, but due to the forces mentioned above, a relatively less sophisticated retailer has less of an incentive to share since the overall channel profit effect is smaller (not as much increase in total pie), and also, the retailer’s share of the total pie is going to be lower.

This probably explains why more sophisticated retailers (like Wal-Mart), who are likely to have higher reliability of information, entered into information sharing arrangements first and continue to do so, but complaints are also voiced in the trade press that the benefits of category management go primarily to the manufacturers and often not to the retailers (Thayer 1999). Probably as the practice became more popular, less sophisticated retailers also got on the bandwagon without fully understanding the implications of sharing.

On the other hand, we have noted that as the retailer’s reliability increases, the manufacturer must incorporate this relatively more aggressive mark-up setting behavior by the retailer in its own wholesale price setting behavior. Looking at equation (6), we can see that as retailer’s reliability ($\rho$) goes higher, the manufacturer compensates for the retailer’s aggressive mark-up by setting relatively lower wholesale price. Also, when $\mu$ is high, the manufacturer causes the maximum double marginalization
problem, and thus the favorable impact of retailer’s higher reliability on total channel profit is somewhat offset when manufacturer has a higher reliability. Thus in region A, where both $\mu$ and $\rho$ are closer to 1, overall channel profits do not go up as much, and also, the manufacturer’s share of the total pie comes down as a result of sharing. On balance, the manufacturer is better off not getting into an information sharing alliance in this region.

3.5 Information Sharing and Channel Outcome

Based on individual incentives of the two firms, sharing is profitable to both firms only when the baseline reliability levels of both the firms are moderate. From an overall channel profit perspective, however, information sharing is always desirable. Thus information sharing can improve channel coordination. It has been shown in literature that without any uncertainty, a two part tariff is sufficient to coordinate the channel (Jeuland and Shugan 1983, Moorthy 1987). However, in the presence of uncertainty, information sharing across vertical firms can achieve directionally similar results for the overall channel. The result is only directional and, typically, the channel profits increase but do not reach the fully coordinated levels. The extent of increase is positively related to (i) the degree of complementarity of resources of the two firms (the parameter $\sigma$ in our model, and (ii) the level of variability in demand (parameter $t$) . Sharing has a higher impact when the degree of complementarity of information resources of the two firms is higher, because the reliabilities of the two firms get a higher boost in such situations resulting in better fine tuned prices to the consumers. Sharing is also more effective in coordinating the channel in high variability of demand situations, since lack of information leads to relatively poorer decisions in such cases, thus, information has more power.

Another related question that can be asked in this context is whether a fixed fee is sufficient to ensure the existence of information sharing arrangements. The
fact that the total channel profits always go up as a result of information sharing alliances between a manufacturer and his retailer implies that it is always true that at least one partner makes a positive gain. Moreover, since the total channel profits go up, the amount of increase in profits for the gaining party is always higher than the amount of decrease in profits by the losing party (if any). Therefore, there is always a possible lump-sum transfer from one player to the other, which will compensate for any losses and make the other party willing to participate in the information sharing arrangement. Our purpose in this paper is not to provide a complete explanation for why that may not happen. However, this clearly requires a more complex contract than the simple wholesale price contract, which may be harder to negotiate in real business situations. Possibly for this reason, in many retail channels, including grocery retailing, a simple wholesale price based contracts are the norm and the paper represents that case fairly well.\footnote{Information selling by one party to the other can be considered a special case of sharing arrangement, where the selling party may be part of the scheme in a passive sense (no effect on its reliability) in exchange for a lump-sum payment. Exploring whether it is always possible to find a fixed fee out of the surplus generated by the active party that will lead to such passive partnerships is also possible in our framework. Such an analysis reveals that it is not always possible to have a selling relationship, but when it is, the retailer is more likely to be the information seller.}

4 Information Sharing in Competitive Channels

4.1 Industry and Demand

In this section, we extend our model to an industry consisting of two price-setting competing manufacturers selling through a common price-setting retailer. The demand faced by the retailer for manufacturer i’s product is:

$$Q_i = \alpha - \gamma P_i + \beta P_j \quad \text{for } i, j = 1, 2 \quad \text{and } i \neq j$$
The two competitors’ product offerings are assumed to be demand substitutes and their own price effect is assumed greater than the cross price effect. These two assumptions are captured by the restrictions $\gamma > \beta > 0$ on the parameters of the model. Also note that the two competitors are symmetric in all respects, i.e., the parameters of the demand functions are same across the two manufacturers. McGuire and Staelin (1983), Choi (1991) and others use similar linear demand functions to study various distribution channel issues. We continue to assume that the marginal cost of production is constant (and symmetric) and is normalized to zero. There are no fixed or variable costs of retailing. All three firms are risk neutral.

Demand uncertainty is captured in this model also by the Bernoulli distribution for the demand intercept parameter $\alpha$ with equal prior probability-masses for the two realizations, that are again labeled as High ($H$) and Low ($L$). Note that the uncertainty is on the common demand parameter implying that the shocks across the two manufacturers are perfectly correlated. Many studies of information sharing referred to in the previous section (e.g., Vives (1984), Gal-Or (1986)) deal with such common-shock induced uncertainty. In the common retailer context such as ours, these common shocks could arise due to some category level factors or due to retailer / retail-trading area specific factors.

4.2 Information Sharing

To focus on vertical information sharing as observed in category management type initiatives in the grocery industry, we allow sharing of informational resources between a manufacturer and the retailer. Thus, the analysis does not cover information sharing between competitors. We do, however, allow flexibility in the type of information-sharing alliance and consider both exclusive and non-exclusive alliances, i.e., either one or both manufacturers entering into sharing arrangements. As in the bilateral monopoly channel, manufacturers move first by independently and si-
multaneously proposing an information-sharing alliance. Thus neither, one or both manufacturers may propose an alliance and the retailer can accept or reject any proposed alliances. If neither manufacturer proposes an alliance, or if the retailer rejects a proposed alliance, then all firms continue to the price setting stage of the game with their respective baseline reliabilities. If just one manufacturer proposes such an alliance and the retailer accepts it, then the two participants in the alliance experience an additive increase (by $\sigma$) in their respective levels of reliabilities. However, since we allow the possibility of a non-exclusive alliance also, we need to specify what happens to the reliabilities if both manufacturers propose an alliance. We assume that in such situations, the retailer gets an increase in reliability equal to $2\sigma$ using a linear increase rule since he has access to two sources of additional informational resources. The results of the analysis do not change qualitatively as long as the increase due to the second additional source is not very close to zero. Even in the non-exclusive alliance case, however, each manufacturer has access to only one extra set of informational resource (that of the retailer), and hence their reliabilities continue to increase by $\sigma$ only.

4.3 The Information Sharing and Price Setting Game

Like the bilateral monopoly channel, we consider an information sharing stage followed by a manufacturer Stackelberg pricing game. The sequence of events in this game is given in Figure 2:

[Figure 2 here]

In solving the full multistage game presented above for an interior subgame perfect equilibrium, first note that the result of the information sharing (the first two) stages of the game is to determine the reliability levels of the three firms going into the pricing stages. The simultaneous information sharing decision of the manufacturers
leads to four possible situations. The resultant reliabilities of the three parties for these possibilities, conditional on the retailer accepting a proposed alliance, are given in the 2X2 matrix in Table 1.

[Table 1 here]

For the analysis in this section, we assume the two manufacturers to be symmetric in terms of the baseline reliability (denoted \( \mu \)) and that the retailer’s reliability is denoted by \( \rho \). Inside each of the four boxes above, we have given the level of reliability for the two manufacturers in parentheses followed by the retailer’s reliability. These reliabilities are conditional on the retailer’s accepting the partnership proposed by the manufacturer(s), if any. Thus, for example, if both manufacturers decide to propose sharing and if the retailer accepts it, then both manufacturers have reliabilities of \((\mu + \sigma)\) and the retailer’s level of reliability is given by \((\rho + 2\sigma)\). Note that if the retailer does not accept the partnership proposal, then no sharing takes place and all firms remain at the baseline level of reliabilities, \( \rho \) and \( \mu \) respectively for the retailer and the two manufacturers. The retailer’s acceptance or rejection of proposed sharing is going to be based on comparing his own expected profits for the proposed exclusive or non-exclusive alliance with his baseline level of expected profits. The manufacturers’ sharing decisions are going to be determined by comparing their expected profits across the four cells of the 2X2 matrix in Table 2, and an equilibrium will be one where neither manufacturer has an incentive to unilaterally deviate. To make these profit comparisons, the pricing stage of the game needs to be solved conditional on each possible combination of reliability obtainable in the information sharing stage. Note that the pricing subgames corresponding to the four cells differ only in terms of the three firms’ reliabilities; therefore we obtain general solutions, labeling the reliabilities of manufacturers as \( \mu_1 \) and \( \mu_2 \) respectively and the retailer’s reliability as \( \rho \). Thereafter, comparing the payoffs to obtain an equilibrium is going to be simply
a matter of substituting these labels with appropriate levels of reliabilities for the three firms as given in the four boxes of Table 2 above.

For \( i = 1,2; j = 3-i \), manufacturer \( i \)'s expected profit function is given by:

\[
\Pi_i = \sum_{K=L,H} \sum_{\tilde{K}_R=L,R} \sum_{\tilde{K}_i=L_i,\tilde{K}_j=L_j,\tilde{H}_j} \Pr(K \tilde{K}_R \tilde{K}_i \tilde{K}_j) \ w_{i\tilde{K}_i} \ Q_{iK\tilde{K}_R\tilde{K}_i\tilde{K}_j} \quad (9)
\]

In equation (9) above, \( K \) is the true state of the world (i.e., intercept could be \( \alpha_H \) or \( \alpha_L \)); \( \tilde{K}_R \) is the retailer’s signal; \( \tilde{K}_i \) and \( \tilde{K}_j \) are respectively the signals received by manufacturers \( i \) and \( j \); and \( w_{i\tilde{K}_i} \) is the wholesale price charged by manufacturer \( i \) when his received signal is \( \tilde{K}_i \). \( Q_{iK\tilde{K}_R\tilde{K}_i\tilde{K}_j} \) in the equation can be derived by plugging the appropriate prices in the linear demand function, and it is given by the equation below. Notice that each manufacturer conditions his wholesale price only on his own signal. Similarly, the retailer’s pricing responses are conditioned on his own signal only. As a result, the retail price for the product of manufacturer \( i \) will be a function of only the retailer’s and manufacturer \( i \)’s signal. In other words \( P_{i\tilde{K}_R\tilde{K}_i\tilde{K}_j} = P_{i\tilde{K}_R\tilde{K}_i\tilde{L}_j} \), and hence retail prices are presented as \( P_{i\tilde{K}_R\tilde{K}_i\tilde{K}_j} \) and \( P_{j\tilde{K}_R\tilde{K}_j} \):

\[
Q_{iK\tilde{K}_R\tilde{K}_i\tilde{K}_j} = \alpha_K - \gamma P_{i\tilde{K}_R\tilde{K}_i\tilde{K}_j} + \beta P_{j\tilde{K}_R\tilde{K}_j} \quad (10)
\]

The retailer maximizes the following expected profit function after observing the two manufacturers’ wholesale prices:

\[
\Pi_R = \sum_{i=1,2} \sum_{K=L,H} \sum_{\tilde{K}_R=L,R} \sum_{\tilde{K}_i=L_i,\tilde{K}_j=L_j,\tilde{H}_j} \Pr(K \tilde{K}_R \tilde{K}_i \tilde{K}_j) \ (P_{i\tilde{K}_R\tilde{K}_i\tilde{K}_j} - w_{i\tilde{K}_i}) Q_{iK\tilde{K}_R\tilde{K}_i\tilde{K}_j} \quad (11)
\]

The retailer needs to maximize the expected profit function above by setting the
two prices conditional on his own low or high signal. For the competitive channel
analysis in the rest of this section, $\gamma$ is taken to be $(\beta + 1)$, and we parameterize
$\alpha_H$ as $(1 + t)$ and $\alpha_L$ as $(1 - t)$. From the first order condition $\frac{\partial \Pi_R}{\partial \tilde{K}_R} = 0$ for $i = 1, 2$ and $\tilde{K}_R = \tilde{L}_R, \tilde{H}_R$, we find the following response functions as equilibrium:

\[ P_{iH} = \frac{1}{2} [w_i + 1 + (2\rho - 1)t] \quad and \quad P_{iL} = \frac{1}{2} [w_i + 1 - (2\rho - 1)t] \quad for \ i = 1, 2. \quad (12) \]

Given this pricing response of the retailer, the manufacturers now incorporate
it into their own maximization problem. Each manufacturer maximizes his own
expected profit (given by equations (9) and (10) above) conditioned on his signal,
on the pricing response of the retailer (given by equation 12) and on the other
manufacturer’s decision. Simultaneously solving the first order conditions of the
relevant maximization routines for the two manufacturers, we obtain the following
response functions in case of symmetric manufacturers ($\mu_1 = \mu_2 = \mu$):\(^{15}\)

\[ w_{iH} = \frac{\left[ (1 + 4\mu - 4\mu^2)\beta + 2 \right] + (1 + 4\rho - 4\rho^2)(2\mu - 1)(\beta + 2)t}{(\beta + 2)[(1 + 4\mu - 4\mu^2)\beta + 2]} \quad and \]
\[ w_{iL} = \frac{\left[ (1 + 4\mu - 4\mu^2)\beta + 2 \right] - (1 + 4\rho - 4\rho^2)(2\mu - 1)(\beta + 2)t}{(\beta + 2)[(1 + 4\mu - 4\mu^2)\beta + 2]} \quad for \ i = 1, 2. \quad (13) \]

The second order sufficiency conditions can be checked with the help of the two

\(^{13}\)Taking more general values (i.e., $\alpha_H = a + t$ and $\alpha_L = a - t$) does not change any of the results,
but the expressions become much more complicated.

\(^{14}\)The Hessian matrix $D^2 \Pi_R(P_{iK_R})$ is found to be negative definite for all relevant ranges of the
parameter values and hence the second order condition is always satisfied.

\(^{15}\)Obtaining the expression for the general asymmetric manufacturers case is straightforward but
the expression itself is tedious and is omitted.
relevant Hessian matrices, which are negative definite for all admissible parameter values. Intuitively, since the pricing responses of the retailer are linear functions of wholesale prices, we expect the profit functions for the manufacturers to be quadratic and globally concave.

4.4 Results for the Competitive Channel Analysis

The solution for the general pricing subgame and the expressions for equilibrium quantities, prices and profits were obtained in closed form and are available in a separate appendix from the first author. The analytical expressions for the profit are too complex to provide intuition on the behavior of firms. We resort to numerical analysis to characterize the solution. The reliability parameters, are bounded between 0.5 and 1, and the $\sigma$ parameter is constrained below 0.5. It turns out that the values of other parameters like $a$, $\beta$, $\gamma$ and $t$, while generally unbounded in the positive region, do not affect the sharing results materially. We conducted dense grid search for a large range of positive values for these parameters and then choose the values $a = 1, \beta = 1, \gamma = 1$ and $t = 0.1$ for most of the figures included in the paper. These represent the typical outcome of the game. Of course, in obtaining the numerical comparisons, we focus only on the range of parameters that satisfies the regularity conditions for an interior solution.

Our goal is to characterize the pricing decisions of the firms, price responsiveness to parameters of interest, profitability and its responsiveness and finally, the information-sharing alliance formation behavior decision of the firms. We start presenting the results of the competitive channel analysis by characterizing the pricing stage of the game.
4.4.1 Implications on Pricing

- For all three firms, two manufacturers and one retailer, prices go up (down) in the firm’s own reliability when a High (Low) signal is received. For both manufacturers, the equilibrium wholesale prices also go up (down) in the competitor’s reliability, when a High (Low) signal is received. The wholesale prices, however, behave in the opposite manner, i.e., go down (up) with respect to the retailer’s reliability when a High (Low) signal is received.

[Figure 4 here, please refer to panel A]

The intuition behind the first part, i.e., the behavior of the prices with respect to a firm’s own reliability, is identical to the intuition in the bilateral monopoly case presented earlier. The reason a manufacturer’s wholesale prices move towards the “correct” prices when the other manufacturer’s reliability increases is not that obvious. In order to get some intuition behind this, imagine that manufacturer $i$ has perfect reliability ($\mu_i = 1$) and is competing against manufacturer $j$, which may have imperfect reliability ($\mu_j < 1$). In this situation, conditional on retailer’s signal $\tilde{K}_R$, only four out of the total eight components of the expected profit (equation 9 above) happen with positive probability; the components correspond to $Q_{iH\tilde{K}_R\tilde{H}_i\tilde{H}_j}$, $Q_{iH\tilde{K}_R\tilde{H}_i\tilde{L}_j}$, $Q_{iL\tilde{K}_R\tilde{L}_i\tilde{H}_j}$ and $Q_{iL\tilde{K}_R\tilde{L}_i\tilde{L}_j}$. Let us first consider the situations where manufacturer $i$ gets a $\tilde{H}$ signal and hence must price $w_{\tilde{H}}$. $Q_{iH\tilde{K}_R\tilde{H}_i\tilde{H}_j}$ is the situation when the true state of the world is $H$ and firm $i$ knows it, but firm $j$ gets the signal $\tilde{L}$ and therefore prices lower than optimal (in a full information sense). Firm $i$ assigns this component a positive probability and therefore responds (optimally) with a slightly lower than optimal price. This is because a competitor’s pricing decision acts as a strategic complement (Bulow et al. 1985, Moorthy 1988) in this setup, and hence the optimal response to an opponent’s lowering his price is to lower your own price. Intuitively,
if one product is priced high, the other product can also afford to price a little bit higher. In the situation \( Q_{iHH_{R},HH_{j}} \), firm \( j \) gets a signal \( H \) but still does not charge a high enough price in the full information sense since its reliability is less than perfect. Therefore, even in this situation, firm \( i \)'s optimal strategy is to charge lower than full information’s “correct” price. As firm \( j \)'s reliability increases, \( Q_{iHH_{R},HH_{j}} \) component gets less and less probability weight in firm \( i \)'s profit function, and the extent of firm \( j \)'s under-pricing for the component \( Q_{iHH_{R},HH_{j}} \) also comes down. Hence, firm \( i \)'s optimal wholesale price increases as \( \mu_{j} \) increases. A continuity argument extends the intuition to the more general case when \( \mu_{i} \) does not equal 1. Similar logic applies to the components when firm \( i \) gets a low signal, and the wholesale price conditional on a low signal goes towards the full information “correct” price (lower) as the competitor’s reliability increases.

4.4.2 Implications on Profits

- Expected Profits for both the manufacturers increase in their own reliability but decrease in the retailer's reliability. Furthermore, expected profits for each manufacturer also increases in the competing manufacturer’s reliability.

[Please refer to Figure 4, Panel B]

The expected profits of the two firms are concave functions of wholesale prices, and taking expectations over the possible realizations of states of the worlds and signals involves quantities weighted by the wholesale prices and not merely by probabilities which are linear. An increase in own and competitor’s reliability leads to an adjustment in the focal manufacturer’s wholesale price towards the correct full information level. Thus, they are able to better span the variation in demand and capture a higher part of the variance component. The impact is similar in direction with respect to both own and competitor’s reliability because the pricing impact
of both is similar in direction, as noted in the earlier result. The intuition behind manufacturer’s profits decreasing in retailer’s reliability is same as in the bilateral monopoly case as discussed after proposition 1. Interestingly, since demand is a linear function of prices, in this symmetric setup, the probabilities of overpricing/underpricing along with the quantity variations across the various possible combinations of realizations of the state and signals of the firms cancel out and the expected quantity turns out to be the same for all values of reliabilities.

4.4.3 Implications on Information-Sharing

- (a). A retailer with relatively high reliability accepts any information sharing proposal from the manufacturers. The retailer’s expected profit ordering for the alliance types in such cases is "Non-exclusive alliance $\succ$ Exclusive Alliance $\succ$ No Alliance." Whether an alliance emerges as equilibrium, therefore, depends on the manufacturers’ expected profits.

- (b). In the region when the retailer accepts any sharing proposal, if the baseline reliability of the manufacturers is very high, the negative effect from retailers’ increase in reliability dominates, and no manufacturer wants to enter into an information sharing alliance with the retailer. At the opposite end, for a lower level of manufacturers’ baseline reliability, Share-Share is the only Nash equilibrium of the full game, and therefore, non-exclusive information sharing alliances may be observed among channel members.

- (c). Finally, when baseline reliability of manufacturers is at intermediate levels, an exclusive information sharing alliance (e.g., category captain) emerges as the equilibrium of the full game. The expected profit of the category captain, the retailer, and the entire channel goes up as a result of this exclusive alliance.
Figure 5 has been drawn with manufacturers’ reliability \( \mu \) (assumed same for both manufacturers) on the horizontal axis and the retailer’s reliability \( \rho \) on the vertical axis. The picture closely resembles that of the information sharing in bilateral monopoly (Figure 2) except for the existence of a region in which exclusive sharing is proposed by one of the manufacturers and accepted by the retailer. The intuition behind the existence of these regions is also similar to that in the bilateral monopoly setup. To further provide some intuition behind exclusive sharing, we present figure 6. In this figure, baseline reliability of all three firms (assumed same, i.e., \( \mu_1 = \mu_2 = \rho \)) is on horizontal axis and the vertical axis represents the degree of complementarity of informational resources of the firms (the parameter \( \sigma \)). In region A where baseline reliability is very large, a manufacturer’s potential gains from increased reliability obtained through an alliance is outweighed by the retailer’s increase in reliability, and hence manufacturers do not propose any alliance. In region B, where exclusive alliance or category captain phenomenon emerges as the equilibrium outcome, the increase in the category captain’s own reliability outweighs the negative impact of the retailer’s increase in reliability. However, in this region only one manufacturer proposes an information-sharing alliance in the alliance stage of the game, i.e., an asymmetric Share-Not Share outcome emerges as the Nash equilibrium of this stage. Essentially, a unilateral deviation to Share-Share is not optimal for the second manufacturer since this would push the retailer’s reliability even further up, thereby hurting his own profits. For the rest of the parameter space (region C), the positive impacts from one’s own reliability increase as well as from a competing manufacturer’s reliability increase are enough to offset the negative impact of a disproportionately higher bump in the retailer’s signal reliability.

This result characterizes the kind of alliances likely to emerge due to the infor-
information sharing considerations. Point (c), in particular, points to the situation when a category captain-like exclusive alliance might emerge. The profits of the category captain are larger than that of the other manufacturer left out of the alliance, and that might explain why, if the retailers are in a better bargaining situation, they may be able to extract a category captain fee (Merrefield 1996) from the partner.

Analysis of quantity sold also shows that expected quantity sold across all realizations of states of the world and signals of players is independent of information reliability. Thus all the profit gains reported above for manufacturer(s) are due to higher effective average wholesale prices. Also, the variations in quantity sold for both manufacturers’ products come down as a result of any alliance compared to the baseline level of no alliance. This is because a retailer is able to price better in line with the actual state of demand. Thus, a higher price is charged when the true state is high, and a lower price is charged when the true state is low. This has the effect of smoothing out the extremes from quantity sold. These two features of higher wholesale prices and reduced fluctuations in quantity sold can be interpreted as a reduction in trade promotions, which was one of the key objectives of category management, as part of the ECR initiatives.

To summarize, many forces similar to bilateral monopoly are still operating. However, we have also put forward an explanation for an exclusive information sharing alliance by explicitly considering multiple manufacturers in the category. Also, one of the major objectives of category management movement, i.e., the reduction of trade promotions and realizing higher effective wholesale prices, can be achieved by information sharing to a certain extent.

5 Some Extensions and Conclusions

In this paper we investigated distribution channel members’ incentives to form information sharing alliances with upstream or downstream channel partners. We
analyzed a bilateral monopoly and competing manufacturers selling through a common intermediary. While the total channel profit goes up as a result of information sharing, the existence of two usually countervailing forces affects the distribution channel partner’s ability to appropriate a larger share of the total profits. In general, the quality of one’s own information affects one’s ability to appropriate profits positively, while a channel partner’s quality of information affects this ability negatively. Whether channel members want to enter into such alliances depends on the net effect of these forces. In competitive channels, the strategic interaction of these two forces can lead to the endogenous emergence of an asymmetric equilibrium where only one of the firms forms an alliance with the retailer. We put this idea forward as one possible explanation of the category captain phenomenon observed in the recent adoption of category management practices by the food retailing industry. Also, such information sharing alliances increase the average wholesale prices and reduce the variance in quantity sold, which can be interpreted as a reduction in trade promotion, which has been a major goal of initiatives like category management in this industry.

5.1 Extensions

5.1.1 Different Sharing Rules

In section 3, we conceptualized information sharing as resulting in an equal additive increase in the base reliability of the firms in a bilateral monopoly channel. There are other, slightly more complicated, but quite plausible ways of modeling the result of sharing for the two partner firms. Three such rules that we investigated corresponded to the following:

(a). Sharing results in an increase in reliability of the firms proportional to their baseline level of reliability. This is operationalized as post-sharing reliability for a firm increasing to \([R(1 + \sigma)]\) from a baseline of \(R\). This is plausible in situations where the primary reason for the baseline reliability differential
across firms is their ability to process and make sense of the data available to them. As firms open access to their unique data sources to their partners, a firm with higher ability is likely to benefit more in this situation.

(b). Sharing results in an increase in reliability of the firms in inverse proportion to their baseline level of reliability. This is operationalized as post-sharing reliability for a firm increasing to \([R + (1 - R)\sigma]\) from a baseline of \(R\). This implies that a firm with lower baseline reliability benefits more by sharing as the returns to having access to more data and other information resources may be concave.

(c). Sharing results in an increase in reliability of the firms in proportion to the baseline level of reliability of the other firm. This is operationalized as post-sharing reliability for a manufacturer increasing to \([\mu + \rho\sigma]\) from a baseline of \(\mu\) and that for a retailer increasing to \([\rho + \mu\sigma]\) from a baseline of \(\rho\). This formulation explicitly captures the idea that the benefit from sharing informational resources may be proportional to the quality of the "new" resources, which should be reflected in the other firm's baseline reliability.

Our analysis of these three rules reveals that the forces identified in the base model are robust to these alternate formulations and the sharing results remain qualitatively unchanged. In particular, even under these rules, retailers typically do not find it optimal to enter in information-sharing alliances in larger portions of parameter space while the manufacturers typically found information sharing to be beneficial under a broader set of conditions.

5.1.2 Asymmetric Manufacturers

The competitive analysis presented in section 4 considers ex-ante completely symmetric manufacturers. In order to get more interesting insights about the man-
ufacturers’ or retailers’ incentives in the face of more realistic situations, we may consider asymmetries between manufacturers. We can consider many types of asymmetries with very minimal modifications of our model. This helps us in answering two broad type of questions. First, which manufacturer has a larger incentive in entering into an information-sharing alliance with the retailer? Second, assuming there are institutional constraints (like prohibitive costs or privacy concerns) that rule out non-exclusive alliance, and the retailer gets to choose which of the two manufacturer to enter into an alliance with, then “who to choose as category captain” (Trypus 1998, Ball 1999)? The four asymmetries that we consider relate to the following:

(a). Manufacturers may be asymmetric with respect to the potential demand. This situation can be captured by the following formulation for the demand intercept for the two products: let $\alpha_H$ for manufacturer 1’s product be $a(1 + t)$ and $\alpha_L$ be $a(1 - t)$, while keeping $\alpha_H$ for manufacturer 2’s product as $(1 + t)$ and $\alpha_L$ as $(1 - t)$. In this way, we keep the demand variability (coefficient of variation) of the two products constant but the expected potential demand across the two products can be varied.

(b). Manufacturers may be asymmetric with respect to the demand variability. This situation can be captured by the following formulation for the demand intercept for the two products: let $\alpha_H$ for manufacturer 1’s product be $(1 + t_1)$ and $\alpha_L$ be $(1 - t_1)$, while for manufacturer 2’s product keeping $\alpha_H$ as $(1 + t_2)$ and $\alpha_L$ as $(1 - t_2)$. In this way, we keep the average demand potential of the two products constant but the demand variability across the two products can be varied.

(c). Manufacturers may be asymmetric with respect to the baseline level of reliability. This situation can be handled in the present solution approach very easily since the general solutions have already been obtained assuming reliabilities of the two manufacturers being $\mu_1$ and $\mu_2$. Thus, it is merely a matter of
numerically comparing the incentives of the firms.

(d). Manufacturers may be asymmetric with respect to the degree of complementarity of information resources. Again, this situation can be very easily accommodated in our present approach by considering the two increases in reliability as $\sigma_1$ and $\sigma_2$ while doing numerical comparison.

A brief numerical analysis of these asymmetric situations was undertaken and we have the following results. In answering the first set of questions posed earlier regarding manufacturer’s incentive to offer a sharing arrangement, we analyze one asymmetry at a time and find that, the bigger brand manufacturer, the manufacturer with a higher product demand variability, the manufacturer with a lower base reliability and the manufacturer with a higher degree of complementarity of informational resources with the retailer has bigger incentive to get into an information-sharing alliance with the retailer. To answer the second question regarding who to choose as category captain, the alliance formation stages of the game are modified appropriately and this time comparing retailer’s expected profits across the four sharing outcomes, it is found that other things being equal, the retailer should choose the smaller brand manufacturer, the manufacturer with a smaller product demand variability, the manufacturer with a larger base reliability and the manufacturer with a higher degree of complementarity of information resources as his exclusive alliance partner or category captain.

5.2 Limitations and Research Directions

One limitation of the modeling approach in this study has been ignoring signaling and screening considerations in the analysis. Another related issue is the incentives of firms to distort information. These are potentially interesting but probably very complicated issues to consider in this setup. We have also not considered information selling in detail, either by the firms themselves or by third party vendors.
Other possible avenues of future research include the study of information sharing strategies in the presence of private demand shocks for the manufacturers, especially since very different incentives have been found for private vs. common shock uncertainties in horizontal information sharing context (Vives 1984). Research on explicitly modeling the nature of institutional constraints or possibly other forces that make a retailer choose an exclusive or non-exclusive alliance in retailer-led channels may also be fruitful to fully understand the phenomenon of category captain. Finally, empirically testing some of the propositions developed in the paper could help validate the model and its results.
6 Appendix : Proof of Bilateral Monopoly Results

6.1 Proof of Lemma 1

\( w_{HM} \) and \( w_{HL} \) as given in expression (6) of the text are:

\[
\begin{align*}
    w_{HM} &= \frac{a + t(2\mu - 1)(1 + 4\rho - 4\rho^2)}{2\beta} \\
    w_{HL} &= \frac{a - t(2\mu - 1)(1 + 4\rho - 4\rho^2)}{2\beta}
\end{align*}
\]

Plugging these in the retailer’s price functions (given by (4) in the main text), the expressions for optimal prices, \( P_{HR}(w_{KM}) \) can be readily obtained as below:

\[
\begin{align*}
    P_{HR}(w_{HM}) &= \frac{1}{4\beta}[3(a - t) + 2t(\mu + 2\rho^2) + 8\mu t(1 - \rho)] \\
    P_{HR}(w_{LM}) &= \frac{1}{4\beta}[3a - t(1 + 2\mu) + 4\rho t(2 - \rho) + 8\mu t(\rho - 1)] \\
    P_{LR}(w_{HM}) &= \frac{1}{4\beta}[3a + t(1 + 2\mu) + 4\rho t(\rho - 2) + 8\mu t(1 - \rho)] \\
    P_{LR}(w_{LM}) &= \frac{1}{4\beta}[3(a + t) - 2t(\mu + 2\rho^2) + 8\mu t(\rho - 1)]
\end{align*}
\]

From these simple expressions for wholesale and retail prices, obtaining and determining the signs of the derivatives with respect to \( \rho \) and \( \mu \) is immediate to get the results stated in the lemma.

6.2 Proof of Proposition 1

The optimal expected profit expressions for the two firms are given in section 3 as expression (7). The signs for the four derivatives required for the comparative statics in the first part of proposition 1(a) are derived below:
\[
\frac{\partial \Pi_M}{\partial \mu} = t^2/2\beta[(2\mu - 1)(4\rho^2 - 4\rho - 1)^2]
\]
\[
\frac{\partial \Pi_M}{\partial \rho} = t^2/\beta[(2\mu - 1)^2(4\rho^2 - 4\rho - 1)(2\rho - 1)]
\]
\[
\frac{\partial \Pi_R}{\partial \mu} = t^2/4\beta[(2\mu - 1)(4\rho^2 - 4\rho - 1)(4\rho^2 - 4\rho + 3)]
\]
\[
\frac{\partial \Pi_R}{\partial \rho} = t^2/2\beta[(2\mu - 1)^2(2\rho - 1)^2 + 2)(2\rho - 1)]
\]

Given that \(\rho\) and \(\mu\) both take values only between 0.5 and 1, and both \(t\) and \(\beta\) are strictly positive, determining the sign for these expressions is relatively simple and can easily be checked to be respectively positive, negative, negative and positive as claimed in the proposition.

Let the total channel profits be \(\Pi_{TC} = \Pi_M + \Pi_R\). Plugging the values of the manufacturer’s and retailer’s profits and differentiating, after some simplification, we obtain,

\[
\frac{\partial \Pi_{TC}}{\partial \mu} = t^2/4\beta * [(2\mu - 1)(4\rho^2 - 4\rho - 1)(12\rho^2 - 12\rho + 1)]
\]
\[
\frac{\partial \Pi_{TC}}{\partial \rho} = t^2/2\beta(2\rho - 1) * [(12\rho^2 - 12\rho + 1) + 48\mu\rho(1 - \rho)(1 - \mu) + 4\mu(1 - \mu)]
\]

It can be seen that the two derivatives do not have a consistent sign pattern in the relevant range of values for \(\mu\) and \(\rho\). However, the sum of the two derivatives, which is relevant in the information sharing context, is strictly positive, i.e., \(\frac{\partial \Pi_{TC}}{\partial \mu} + \frac{\partial \Pi_{TC}}{\partial \rho} > 0\).
Bibliography


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Manufacturers’ reliabilities given inside and the retailer’s reliability given outside the parenthesis. Reliabilities are conditional on the retailer accepting any proposed sharing.

Table 1: Reliability of Players After Information Sharing Stage in Competitive Channel
Manufacturer decides whether to offer to form an information-sharing alliance

Retailer decides to accept or reject the offer, if one is made

Manufacturer sets a wholesale price $w$ conditional on own signal

Retailer sets the retail price $P$ conditional on own signal and observed wholesale price

Figure 1: Game Sequence in Bilateral Monopoly
Figure 2: Equilibrium Sharing Outcome in Bilateral Monopoly

\[ \alpha_L = 0.9, \ \alpha_H = 1.1, \ \beta = 1, \ \sigma = 0.1 \]
Stage 1: Both manufacturers simultaneously decide whether to propose information sharing.

Stage 2: If proposed, the retailer accepts or rejects the proposed alliance(s).

Stage 3: Both manufacturers set the wholesale prices simultaneously based on their own signal.

Stage 4: Retailer observes the wholesale prices and sets the two retail prices based on his own signal.

Figure 3: Game Sequence in Competitive Channel
Figure 4: Panel A - prices

Wholesale price of i
With respect to i’s reliability

Wholesale price of i
With respect to j’s reliability

Retail price of i
With respect to retailer’s reliability

Figure 4: Panel B - Profits

Manufacturer i’s profits
w.r.t i’s reliability
w.r.t j’s reliability

Manufacturer (i or j)’s profits

Manufacturer profits and manufacturer reliability

Manufacturer profits and retailer reliability
Baseline Reliability of Manufacturers

\[ \alpha_L = 0.9, \quad \alpha_H = 1.1, \quad \gamma = 2, \quad \beta = 1, \quad \sigma = 0.05 \]

Figure 5: Equilibrium Sharing Outcome in Competitive Channel (I)
Non-Exclusive Alliance
No Sharing

Proposed

Category Captain: Exclusive Sharing

Baseline Reliability of Firms (R)

Increase in Reliability (σ)

\( \alpha_L = 0.9, \alpha_H = 1.1, \gamma = 2, \beta = 1, \mu_1 = \mu_2 = \rho = R \)

Figure 6: Equilibrium Sharing Outcome in Competitive Channel (II)