

# Manufacturer Marketing Initiatives and Retailer Information

Sharing<sup>1</sup>

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## **Abstract**

This research examines a retailer's incentive to share information with its supplier when the supplier can also undertake initiatives to increase retail demand. It is well known that a retailer is averse to sharing market information with a manufacturer due to concern for a manufacturer's strategic use of such information. This research shows that despite such strategic exploitation of market information, a retailer may want to establish information sharing channels with its supplier. Information sharing essentially shifts power upstream which, in turn, enhances the manufacturer's incentive to bear costs to boost retail demand. This real effect of information sharing can make it such that the retailer benefits from information sharing *ex ante* despite the costly *ex post* exploitation by the manufacturer. In fact, due to the investment effect, information sharing can lead to gains for the retailer, manufacturer, and consumers alike.

**Keywords:** Information sharing, supply chain management, disclosure, marketing investment

# 1 Introduction

Recent years have seen an economic environment increasingly characterized by substantial uncertainty and rapidly changing consumer preferences. The inherent volatility in demand and market conditions has given rise to an economy in which access to information is paramount. Highly volatile demand markets such as fashion apparel are a case in point, wherein retailers have increasingly deployed information technologies to gain market knowledge to better adjust retail pricing decisions to meet market demand conditions (Fisher et al. 1994). At the same time, the volume and the quality of customer and market data accessible to retailers has been exploding due to advances in data collection technologies such as scanner systems and online data processing.

The increasing importance of and access to information at the retail level makes the issue of information sharing in supply chains particularly relevant. Further, better informed retailers can now share market information with their suppliers more easily thanks to electronic data interchange relationships (Srinivasan et al. 1994, Wang and Seidmann 1995). Theoretically, such shared information can help better manage an upstream manufacturer's tasks, thereby boosting efficiency at all levels of the supply chain (Cachon and Fisher 2000, Gavirneni et al. 1999, Lee et al. 2000). For example, sales forecast data shared by a retailer enables a manufacturer to reduce inventory costs by lowering inventory holdings and streamlining logistics processes. Despite the potential advantages of information sharing, extant research has been quick to point out that the strategic use of such information by a manufacturer at the expense of the retailer may preclude a retailer from fully "opening its books" to its suppliers (e.g., Li 2002, He et al. 2008, Guo and Iyer 2008, Guo 2009). For example, most U.S. automotive vendors are concerned that if they share their information with manufacturers, the Big Three auto manufacturers will use that information to squeeze the vendors' margins (Narayanan and Raman 2004).

Despite the warning that information can be used against them, retailers have been increasingly willing to communicate their retail information with suppliers. For example, according to the Grocery Manufacturers Association, most U.S. grocery retailers and mass merchandisers with more than \$5 billion in annual sales are sharing weekly and even daily store sales and other data directly

with their suppliers at no cost (*Supermarket News* July 2009). In this paper, we seek to provide one explanation for the gap between the prevalence of information sharing in practice and the seemingly unequivocal theoretical result that retailers should maintain their information advantage over their suppliers. In particular, we suggest that one reason for the growing pattern of supply chain information interlinkages may be that information sharing provides a manufacturer with an incentive to allocate more resources to enhancing consumer demand. Since the retailer is one beneficiary of such greater demand, the retailer is, in turn, more willing to share information with a manufacturer despite the concomitant strategic downsides.

In short, this paper's analysis notes that the propriety of a retailer providing information to a supplier hinges on the importance of supplier investments in demand. In this vein, we note that such supplier investments are commonplace in practice. When a manufacturer introduces a new product or fashion item to the marketplace, it often offers several different marketing support activities such as local advertising and promotion, financial support to properly equip and furnish the retail outlet to suit the new product,<sup>1</sup> sales training for retail managers and employees, and equipment for servicing and repair (Besanko and Perry 1993). As an example, manufacturers of over-the-counter pharmaceuticals routinely undertake widespread brand advertising to boost demand for their products. Of course, local retailers of these products are one beneficiary of such advertising. Also, manufacturers often expend substantial resources to create point-of-purchase (POP) advertising and displays for in-store use to help retailers increase demand. Even when advertising is undertaken and paid for exclusively at the local retail level, manufacturers often willingly undertake co-op advertising, whereby they share the cost of local advertising undertaken by downstream channel members (Bergen and John 1997, Coughlan et al. 2001). It is the prevalence of such manufacturer investment in retail demand that forms the crux of the current paper's premise.

To elaborate on our setting, we revisit the standard vertical information sharing model wherein a distribution channel consists of one manufacturer and one retailer. The manufacturer sets a (unit)

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<sup>1</sup>For example, VF Corporation, a major manufacturer of clothing and lingerie, with a compliance from the retailer, developed a supply chain information system (Sender 1998). The core of the system is the analysis of market data (consumer information, point-of-sale data, and so forth) at the level of a retail store in a given location. This retail information allows VF to develop a recommended optimal in-store display and a floor-space plan to maximize the local sales by accommodating its local preferences (*Discount Store News*, 1998).

wholesale price at which it will provide products to the retailer. The retailer, in turn, decides how many units to procure and provide to final market consumers. As a benchmark case, we confirm the result in extant work that in the absence of (endogenous) demand-enhancing investment by the manufacturer, the retailer does not have incentive to share its private information with its upstream supplier. In this case, the provision of information allows the manufacturer to tailor its wholesale price to the particulars of retail demand. Though the responsive wholesale price benefits the retailer in the event of low demand (due to a lower wholesale price), it is costly in the event of high demand (due to a higher wholesale price). Since potential profits are greatest when demand is high, the cost of information sharing is more pronounced than the benefit from an ex ante sense (as in Li 2002).

Next, we incorporate the distinct aspect of our analysis – demand-enhancing investment undertaken by the manufacturer. In doing so, we consider a circumstance in which investment by the manufacturer must be made up front, i.e., prior to the retailer’s observation of its private information. This reflects the practical aspect that manufacturer investment such as brand advertising is often undertaken prior to fully understanding the extent of demand (e.g., advertising is typically greatest at the product launch stage). This formulation also serves to "stack the deck" against finding an investment-related benefit to information sharing since it precludes the manufacturer from conditioning its investment on the realized market information. In other words, under this "ex ante investment" case, one may wonder how unrealized demand information can affect the manufacturer’s investment decision. Surprisingly, the result shows that when a retailer agrees to share information, the manufacturer makes a higher investment in demand-enhancing marketing activity even without learning the actual realization of demand information. Though the information is not directly helpful to the manufacturer investment choice, its impending release ensures the manufacturer a greater marginal benefit from such investment due to the prospect of demand-contingent wholesale pricing. In effect, the supply chain suffers from both (1) double-marginalization due to strategic wholesale pricing and retail procurement and (2) a hold-up problem due to unilateral manufacturer investment. By permitting environment-contingent wholesale pricing, information

sharing gives the manufacturer a leg up in terms of the double-marginalization problem which, in turn, helps alleviate the manufacturer hold-up problem. Our results indicate that as long as the potential gain of investment is sufficiently large relative to the extent of private information, the ability to increase demand-enhancing manufacturer investment compels the retailer to share its information. Further, since information sharing can alleviate attendant supply chain inefficiencies, information sharing can also achieve Pareto gains among supply chain parties.

The remainder of this paper proceeds as follows. In Section 2, we relate our paper to the existing literature in marketing and supply chain. Section 3 represents the model and section 4 shows a benchmark case. Section 5 examines a retailer's disclosure decision in the presence of a manufacturer's demand enhancing investment. Section 6 concludes this paper.

## 2 Literature Review

The results of this paper fit into the broader literature on information sharing in imperfect markets. There have been a large number of papers on the effect of information disclosure on horizontal markets. Gal-Or (1985, 1986) and Li (1985) demonstrate that a firm would be better off by committing to disclosure when demand (cost) information is available in Bertrand (Cournot) competition while they should commit to no disclosure when cost (demand) information is available. As in the previous papers, our paper shows the effect of disclosure in an imperfect product market but instead focuses on vertical information sharing. In this vein, there are many papers which have investigated the direct effect of information sharing between channel members (e.g., Gavirneni et al. 1999, Cachon and Fisher 2000, Lee et al. 2000, and Raghunathan 2001). These papers ostensibly examine the effect of information sharing on operational efficiency such as inventory management and improved order function in the absence of strategic tensions among supply chain partners.

Most germane to the present paper is the stream of research examining the strategic effect of a retailer's information disclosure on a manufacturer's wholesale pricing and market competition. Li (2002) examines an information leakage effect in a vertical relationship in the presence of horizontal competition. He shows that in the presence of Cournot retail competition a retailer shares cost

information with a manufacturer but does not share demand information due to the potential for information leakage to horizontal competitors. In that setting, while the strategic wholesale price effect of information sharing is uniformly detrimental to the retailer, it can be offset by demand-side effects on competition. In a related vein, Guo (2009) shows that a monopolist retailer's disclosure of demand information lowers both a retailer's expected profit and a supply chain efficiency. In contrast to Li (2002) and Guo (2009), our paper shows that a monopolist retailer is not always unwilling to share information in the distribution channel when a manufacturer's demand enhancing activity is considered. The manufacturer's demand enhancing activity benefits a retailer by boosting market demand and, therefore, the manufacturer's investment can work as a countervailing incentive to induce a retailer to disclose its information in the supply chain.

In a recent paper, Li and Zhang (2008) examine the effect of confidentiality on information sharing in a supply chain when there exists Bertrand competition in a retail market. They show that higher confidentiality leads to a lower wholesale price and confidentiality induces truth telling and coordinates the supply chain. In this case, strategic wholesale pricing again serves to undercut information sharing incentives, while market competition can provide an offsetting incentive for information sharing. In contrast, the current paper focuses on the interplay between a retailer's information disclosure and a manufacturer's demand enhancing investment and shows the conditions under which a retailer shares its information, thereby achieving Pareto gain in the channel. While the emphasis herein is on retailer information sharing, other work has also examined circumstances wherein manufacturers gain information advantage (Gal-Or et al. 2008, Guo and Iyer 2009).

There are also several papers which examine the relationship between information acquisition and its disclosure. Shavell (1994) examines information acquisition incentive before sale in the relationship between a seller and a buyer. He shows that mandatory disclosure mitigates a seller's excessive information acquisition incentive but eliminates a buyer's information acquisition incentive. Jansen (2008) studies the effect of information acquisition on strategic disclosure in Oligopoly setting and shows that the imperfect information acquisition allows a firm strategically to withhold unfavorable information from rival firm. That is, when the likelihood that a firm receives informa-

tion is endogenously decided by its own information acquisition investment, the firm can selectively disclose information and thereby improve its profit. Similarly, Guo (2009) shows that a retailer can conceal information from a manufacturer when the information acquisition is not observable. Unlike the previous papers focusing on the interaction between information acquisition and information disclosure, the current paper focuses on the effect of an informed party (a retailer)'s disclosure on an uninformed party (a manufacturer)'s investment incentive and shows that the informed retailer's disclosure can enhance the uninformed manufacturer's investment incentive.

Since manufacturer investment represents the distinguishing aspect of our analysis vis a vis the information sharing literature, it is worth noting there are several papers which investigate the effect of manufacturer investment on supply chain efficiency. Besanko and Perry (1993) examine the relationship between a manufacturer's demand enhancing activity and exclusive dealing. They show that exclusive dealing induces more investment from a manufacturer by eliminating interbrand demand externality but in ex post the more efficient investment may intensify market competition. Chu and Desai (1995) examine a manufacturer's investment assistance to improve customer satisfaction, thereby enhancing future demand. They find that such manufacturer's investment is more useful when dealing with a long-term oriented retailer. Gerstner and Hess (1995) analyze the effect of a manufacturer's pull promotions on channel coordination. They show that the enhanced price coordination based on the manufacturer's targeted promotion improves supply chain efficiency. Gupta and Loulou (1998) show that channel structure affects a manufacturer's investment incentive and lack of channel coordination results in a manufacturer's lower investment for process innovation. Hess and Lucas (2004) examine a manufacturer's resource allocation problem between market information acquisition and production capability and they emphasize the importance of a manufacturer's effort to acquire market information. Compared to these papers, our research investigates a manufacturer's demand enhancing investment in the context of information sharing and suggests that an impending manufacturer investment choice may be the linchpin for a retailer's information sharing.



### 3 Model

Consider a model in which a manufacturer produces a product and sells it to a retailer who, in turn, provides it to end users. Demand in the retail market is captured through the following demand function:

$$q = \alpha(1 + I) - p. \quad (1)$$

In the demand function,  $\alpha$ , denotes the underlying consumer demand,  $p$  is the retail price charged by the retailer, and  $q$  is the quantity of the end product demanded in the market. Consumer demand  $\alpha$  is uncertain and distributed on the interval  $[\underline{\alpha}, \bar{\alpha}]$ , according to the density function  $G(\alpha)$ , with mean  $\mu$  and variance  $\sigma^2 > 0$ .<sup>2</sup> Also, the manufacturer has the opportunity to undertake investment which increases demand. For example, the manufacturer can undertake a brand-level marketing campaign, make investments in point-of-purchase (POP) advertising and displays for in-store use to help retailers increase the demand, modify its product to meet a specific local market preference, or undertake an investment in technology to enhance product quality. When the manufacturer invests in these demand-enhancing marketing activities, it increases the baseline consumer demand. This effect is reflected in the demand function by  $I$ . The investment cost necessary to increase the demand intercept to  $\alpha(1 + I)$  is  $C(I)$  and, to ensure interior investment levels in equilibrium, we assume  $C(I)$  is twice differentiable,  $C(0) = C'(0) = 0$ , and  $C''(I)$  for  $I > 0$  is sufficiently large that second-order conditions are satisfied throughout (hereafter, we will refer to  $I$  as the investment level). For simplicity, we normalize the unit production cost of the manufacturer to be zero. Given this formulation, the profit functions for the retailer and the upstream manufacturer, respectively, are:

$$\Pi_R = (p - w)q; \quad \Pi_M = wq - C(I), \quad (2)$$

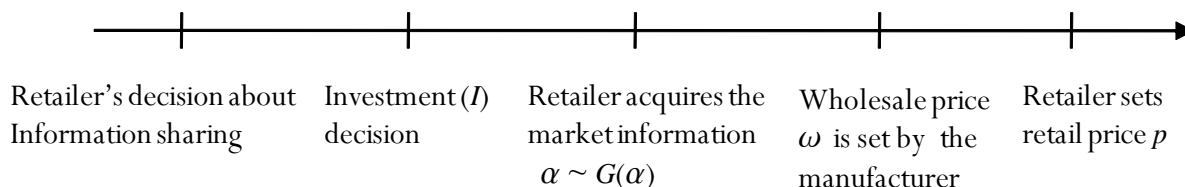
where  $w$  is the (unit) wholesale price charged by the manufacturer. Under this basic structure, the sequence of events is as follows. First, the retailer decides whether to establish a formal information

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<sup>2</sup>As is standard, we assume  $\underline{\alpha}$  is sufficiently large that the first-order approach provides positive equilibrium prices and quantities throughout.

sharing channel with the manufacturer. Following the stream of literature (Gal-or 1985, Li 1985, 2002, Cachon and Fisher 2000), it is presumed that the retailer can pre-commit to this disclosure decision and any disclosures are necessarily truthful (i.e., subject to third-party audit). Next, the manufacturer decides its investment level for activities which can enhance the ultimate demand for the product. Third, the retailer privately observes  $\alpha$ , the critical information about market demand, and discloses (or not) according to its information sharing arrangement. Fourth, the manufacturer decides its wholesale price reflecting the manufacturer’s information about the market and its investment level. Finally, the retailer sets its optimal retail price based on the market demand and wholesale price. We use the Subgame Perfect Equilibrium (SPE) as our solution concept and throughout the paper, backward induction is employed to examine the equilibrium behavior of the retailer and the manufacturer. Figure 1 summarizes the sequence of events.

Figure 1: Sequence of the Game



## 4 Benchmark: Exogenous Investment

Before we analyze our main model, we investigate the benchmark case in which the manufacturer’s investment is exogenously given so that the manufacturer does not have an option to change its investment level in demand-enhancing activities. This benchmark case will highlight the role of the manufacturer’s endogenous investment decision on a retailer’s information sharing incentive, which will be examined in next sections.

This benchmark case can be easily seen by setting an exogenous level of  $I$  in our model. Consider first the outcome when the retailer opts to disclose its information. Using backward induction, the

retailer's chosen retail price maximizes profit given the manufacturer's chosen wholesale price, the exogenous investment level, and realized consumer demand, as in (3):

$$\underset{p}{Max} \Pi_R \Leftrightarrow \underset{p}{Max} [p - w][\alpha(1 + I) - p]. \quad (3)$$

The unique solution to (3) yields the retailer's optimal pricing choice,  $p^*(w, I, \alpha) = [\alpha(1 + I) + w]/2$ . Given this optimal retail price, the manufacturer chooses a wholesale price to maximize its profit given the exogenous investment level and disclosed consumer demand, as in (4):

$$\underset{w}{Max} \Pi_M \Leftrightarrow \underset{w}{Max} w[\alpha(1 + I) - p^*(w, I, \alpha)] - C(I). \quad (4)$$

The first order condition of (4) reveals that the manufacturer's optimal wholesale price is  $w^*(I, \alpha) = \alpha(1 + I)/2$ . From the wholesale price, one consequence of information sharing is immediate. When consumer demand is high (low), the wholesale price, too, is high (low). As such, the state-contingent nature of the wholesale price helps protect the retailer when demand is low but also serves to dilute its profits when demand is high. Taking investment level as given, the expected profits of the retailer and the manufacturer under disclosure (reflected by the  $D$  superscript) are, respectively,

$$\begin{aligned} \Pi_R^D(I) &= E_\alpha\{[p^*(w^*(I, \alpha), I, \alpha) - w^*(I, \alpha)][\alpha(1 + I) - p^*(w^*(I, \alpha), I, \alpha)]\} \\ &= \frac{[\mu^2 + \sigma^2][1 + I]^2}{16}, \end{aligned} \quad (5)$$

$$\begin{aligned} \Pi_M^D(I) &= E_\alpha\{w^*(I, \alpha)[\alpha(1 + I) - p^*(w^*(I, \alpha), I, \alpha)] - C(I)\} \\ &= \frac{[\mu^2 + \sigma^2][1 + I]^2}{8} - C(I). \end{aligned} \quad (6)$$

On the other hand, if the retailer does not disclose its information, the manufacturer must choose its wholesale price based on its expectation of market demand. In this case, the wholesale

price is chosen to solve (7):

$$\underset{w}{Max} E_{\alpha}\{\Pi_M\} \Leftrightarrow \underset{w}{Max} E_{\alpha}\{w[\alpha(1+I) - p^*(w, I, \alpha)] - C(I)\}. \quad (7)$$

As might be expected, the solution to (7) yields a wholesale price of  $w^*(I) = E_{\alpha}\{w^*(I, \alpha)\} = \mu(1+I)/2$ . In this case, wholesale price reflects expected consumer demand. The expected profits for the retailer and the manufacturer, respectively, under no disclosure (reflected by the  $N$  superscript) are:

$$\begin{aligned} \Pi_R^N(I) &= E_{\alpha}\{p^*(w^*(I), I, \alpha) - w^*(I)[\alpha(1+I) - p^*(w^*(I), I, \alpha)]\} \\ &= \frac{[\mu^2 + 4\sigma^2][1+I]^2}{16}, \end{aligned} \quad (8)$$

$$\begin{aligned} \Pi_M^N(I) &= E_{\alpha}\{w^*(I)[\alpha(1+I) - p^*(w^*(I), I, \alpha)] - C(I)\} \\ &= \frac{\mu^2[1+I]^2}{8} - C(I). \end{aligned} \quad (9)$$

A comparison of the retailer's expected profits under disclosure and no disclosure leads to the following lemma.

**Lemma 1** *In the absence of endogenous manufacturer investment, the retailer prefers not to share market information:  $\Pi_R^D(I) < \Pi_R^N(I)$  for any  $I$ .*<sup>3</sup>

The lemma implies that in the absence of an investment effect of information disclosure, the retailer's net benefit of information sharing is negative. Further, it is readily confirmed that the net benefit of withholding information is increasing in the extent of the retailer's information advantage (as reflected in  $\sigma^2$ ). Intuitively, since the retailer's profit is convex in consumer demand, the loss from disclosure realized when demand is high exceeds the potential gain from information sharing realized when demand is low. As a result, the retailer is always better off by not sharing information with a manufacturer. This result conforms to analogous findings in the previous literature (e.g., Li 2002 and Guo 2009).

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<sup>3</sup>Note that even under the extreme case of  $I = 0$ , where the manufacturer does not invest in demand-enhancing activities at all, the lemma holds – implying that the retailer is better off by not sharing information with a manufacturer.

## 5 Manufacturer Investment in Retail Demand

In this section, the consequences of a manufacturer's investment in retail demand on a retailer's disclosure incentive is analyzed. In practice, there are various types of manufacturer activity that can enhance market demand: training of a retailer's employees, advertising, investment in a retailer's chain stores, increasing quality control, and so on. In light of the ubiquity of manufacturer investment, the ensuing results examine how it can be a tool to elicit a retailer's information sharing.

### 5.1 Endogenizing the Investment Choice

Given the result of the lemma in the previous section, one may wonder how considering investment could change the desirability of disclosure since (i) any disclosure happens after investment and thus the manufacturer's investment choice cannot be influenced by the realized demand information, and (ii) the retailer prefers not to share information regardless of the investment level. As we will show, surprisingly, the manufacturer makes higher investment even without realization of demand information. The retailer's commitment to information sharing ensures the arrival of information to a manufacturer and the anticipation of information arrival makes the manufacturer increase the investment level. To see this, we first consider the outcome under no disclosure.

#### 5.1.1 No Disclosure

As in previous sections, we solve this game using backward induction. Under no disclosure, the manufacturer's chosen wholesale price and ensuing expected profit for a given investment level are  $w^*(I)$  and  $\Pi_M^N(I)$ , as derived previously. Given this, the manufacturer chooses investment to solve:

$$\text{Max}_I \Pi_M^N(I) \Leftrightarrow \text{Max}_I \frac{\mu^2[1+I]^2}{8} - C(I). \quad (10)$$

The first-order condition for (10) yields the manufacturer's investment level under no disclosure, denoted  $I^N$ .

$$\frac{4C'(I^N)}{1+I^N} = \mu^2. \quad (11)$$

Using the first-order condition for investment level in the wholesale price, retail price, and profit expressions, the equilibrium outcomes under no disclosure are presented in Lemma 2.

**Lemma 2** *With endogenous investment, the equilibrium outcomes under no disclosure are as follows:*

- (i) Investment level,  $I^N$ , solves  $\frac{4C'(I^N)}{1+I^N} = \mu^2$ .
- (ii) Wholesale price is  $w^*(I^N) = \mu[1 + I^N]/2$ .
- (iii) Retail price is  $p^*(w^*(I^N), I^N, \alpha) = [2\alpha + \mu][1 + I^N]/4$ .
- (iv) Expected Retailer profit is  $\Pi_R^N(I^N) = \frac{[\mu^2 + 4\sigma^2][1 + I^N]^2}{16}$ .
- (v) Expected Manufacturer profit is  $\Pi_M^N(I^N) = \frac{\mu^2[1 + I^N]^2}{8} - C(I^N)$ .

### 5.1.2 Disclosure

If the retailer opts to share information, the manufacturer investment choice changes. This occurs despite the fact that information does not arrive prior to the investment choice. To elaborate, the manufacturer's chosen wholesale price and ensuing expected profit for a given investment level are  $w^*(I, \alpha)$  and  $\Pi_M^D(I)$ , as derived previously. Given this, the manufacturer chooses investment to solve:

$$\underset{I}{Max} \Pi_M^D(I) \Leftrightarrow \underset{I}{Max} \frac{[\mu^2 + \sigma^2][1 + I]^2}{8} - C(I). \quad (12)$$

The first-order condition for (12) yields the manufacturer's investment level under disclosure, denoted  $I^D$ .

$$\frac{4C'(I^D)}{1 + I^D} = \mu^2 + \sigma^2. \quad (13)$$

Given this and the expressions for wholesale price, retail price, and each party's profits, the equilibrium outcomes under disclosure are presented in Lemma 3.

**Lemma 3** *With endogenous investment, the equilibrium outcomes under disclosure are as follows:*

- (i) Investment level,  $I^D$ , solves  $\frac{4C'(I^D)}{1+I^D} = \mu^2 + \sigma^2$ .
- (ii) Wholesale price is  $w^*(I^D, \alpha) = \alpha(1 + I^D)/2$ .
- (iii) Retail price is  $p^*(w^*(I^D, \alpha), I^D, \alpha) = 3\alpha[1 + I^D]/4$ .

(iv) Expected Retailer profit is  $\Pi_R^D(I^D) = \frac{[\mu^2 + \sigma^2][1 + I^D]^2}{16}$ .

(v) Expected Manufacturer profit is  $\Pi_M^D(I^D) = \frac{[\mu^2 + \sigma^2][1 + I^D]^2}{8} - C(I^D)$ .

Given these equilibrium outcomes, we now compare the disclosure and no disclosure regimes to determine if and how manufacturer investment can alter the retailer's disclosure choice.

### 5.1.3 Disclosure vs. No disclosure

In comparing disclosure regimes, we first examine the consequence of information disclosure on manufacturer investment. From Lemma 3, the manufacturer's investment under disclosure solves

$\frac{4C'(I^D)}{1 + I^D} = \mu^2 + \sigma^2$ . Differentiation of the first-order condition with respect to  $\sigma^2$  yields:

$$\begin{aligned} \frac{4C''(I^D) \frac{\partial I^D}{\partial \sigma^2}}{1 + I^D} - \frac{4C'(I^D) \frac{\partial I^D}{\partial \sigma^2}}{(1 + I^D)^2} &= 1 \\ \Leftrightarrow \frac{\frac{\partial I^D}{\partial \sigma^2} [4C''(I^D) - \mu^2 - \sigma^2]}{1 + I^D} &= 1. \end{aligned} \tag{14}$$

From the second-order condition of (12), we know that  $[4C''(I^D) - \mu^2 - \sigma^2] > 0$ . Hence, from (14), we can see that  $\frac{\partial I^D}{\partial \sigma^2} > 0$ . In other words, when information is shared with the manufacturer, the greater the "information content" (i.e., demand uncertainty  $\sigma^2$  is high), the greater the investment level. Intuitively, when information is shared, uncertainty introduces opportunity for the manufacturer. When demand is at its peak, the manufacturer can utilize demand-contingent wholesale pricing to take advantage of such a circumstance. Further, when demand is low, the manufacturer can tailor its wholesale price to better respond to consumer (and thus retailer) demand. Since investment essentially intensifies the degree to which these fluctuations can be exploited by the manufacturer, greater information content translates into greater investment. Further, since, the investment level under no disclosure corresponds to that under disclosure with  $\sigma^2 = 0$ , the subsequent proposition follows.

#### Proposition 1

(i) The manufacturer's investment is higher under information sharing, i.e.,  $I^D > I^N$ .

(ii) *The incremental investment under information sharing increases as information content increases, i.e.,  $I^D - I^N$  is increasing in  $\sigma^2$ .*

Proposition 1 confirms that the retailer's establishment of an information sharing arrangement encourages the manufacturer to more aggressively invest in enhancing market demand. In other words, the information transparency due to the retailer's disclosure motivates a manufacturer to prepare for the upcoming high demand by making a higher investment. Without an information sharing arrangement, the manufacturer can only charge its wholesale price based on its prior and then ex post gains from its investment in demand enhancing activities cannot be fully captured. Therefore, the retailer's commitment to share its market information alleviates the manufacturer's hold-up concern which causes underinvestment in demand enhancing marketing activities up-front. Moreover, this effect becomes more pronounced as the demand uncertainty becomes higher. The higher the demand uncertainty, the greater the manufacturer's concern for hold-up problem. Hence, the incremental investment from the information sharing increases as "information content" increases (i.e., demand uncertainty  $\sigma^2$  becomes high).

This enhanced investment effect can change the retailer's information sharing incentive despite the fact that concern for a manufacturer's opportunistic wholesale pricing remains. From the retailer's perspective, there exists a trade-off between investment efficiency and an exploitative wholesale price. The retailer weighs the net benefit of disclosure by considering the advantage from the enhanced investment efficiency and the disadvantage from the higher wholesale price. A comparison of  $\Pi_R^D(I^D)$  and  $\Pi_R^N(I^N)$  leads to the retailer's decision rule stated in the following proposition.

**Proposition 2** *In the presence of an endogenous manufacturer's demand enhancing investment, the retailer prefers to disclose its market information if and only if*

$$\left[ \frac{1 + I^D}{1 + I^N} \right]^2 > \frac{\mu^2 + 4\sigma^2}{\mu^2 + \sigma^2}.$$



Proposition 2 indicates that a retailer prefers to disclose the information when the incremental investment from disclosure is greater than the incremental wholesale price effect. Intuitively, the greater the left-hand side of the condition ( $\frac{1+I^D}{1+I^N}$ ), the greater the new benefits of information sharing to the retailer of enhanced manufacturer investment (i.e., reduction of the hold-up problem). On the other hand, the greater the right-hand side ( $\frac{\mu^2+4\sigma^2}{\mu^2+\sigma^2}$ ), the greater the loss to the retailer of sharing its information with the manufacturer. Recall, this loss arises because by sharing demand-specific information with the supplier, the retailer effectively grants the supplier pricing power when demand is high (precisely when the retailer wishes not to give such pricing power).

Another interesting question is how information sharing affects supply chain efficiency. After all, in the exogenous investment case, it is readily confirmed that supply chain profit is lower under disclosure. In effect, the potential gain in efficiency from information sharing is dwarfed by the expansion of the double-marginalization problem it engenders. However, just as the investment effect can benefit the retailer, it can also benefit the supply chain as a whole. Consider the expected manufacturer profit from disclosure. In particular, note that  $\Pi_M^D(I^N) - \Pi_M^N(I^N) = \frac{\sigma^2[1+I^N]^2}{8} > 0$ . And, since  $\Pi_M^D(I^D) > \Pi_M^D(I^N)$  by the derivation of  $I^D$ , it follows that

$$\Pi_M^D(I^D) > \Pi_M^N(I^N). \quad (15)$$

Hence, the manufacturer always benefits from information sharing.

Finally, consider the consequence of information sharing on consumer surplus. In order to calculate the consumer surplus from the inverse linear demand function ( $q = \alpha(1 + I) - p$ ) used here, we follow Singh and Vives (1984) and consider a representative consumer in the market with the utility function,  $u(q) = \alpha(1+I)q - \frac{q^2}{2} - pq$ . That is, the first-order condition of the utility function with regard to  $q$  yields the same linear demand function,  $q = \alpha(1 + I) - p$  we are considering. Given this, the consumer surplus ( $CS$ ) is derived by substituting  $p = \alpha(1 + I) - q$  ( $\Leftrightarrow q = \alpha(1 + I) - p$ )

into the utility function as follows:

$$\begin{aligned} u(q) &= CS = \alpha(1+I)q - \frac{q^2}{2} - (\alpha(1+I) - q)q \\ &= \frac{q^2}{2} = \frac{[\alpha(1+I) - p]^2}{2}. \end{aligned} \tag{16}$$

Using equilibrium retail prices from Lemmas 2 and 3 and taking expectations yields expected consumer surplus for the no disclosure ( $CS^N(I^N)$ ) and disclosure ( $CS^D(I^D)$ ) cases, respectively:

$$CS^N(I^N) = E_\alpha\{[\alpha(1+I^N) - p^*(w^*(I^N), I^N, \alpha)]^2/2\} = \frac{[\mu^2 + 4\sigma^2][1 + I^N]^2}{32}, \tag{17}$$

$$CS^D(I^D) = E_\alpha\{[\alpha(1+I^D) - p^*(w^*(I^D), \alpha), I^D, \alpha)]^2/2\} = \frac{[\mu^2 + \sigma^2][1 + I^D]^2}{32}. \tag{18}$$

One immediate implication of (17) and (18) is that for exogenous manufacturer investment (i.e.,  $I^N = I^D$ ), expected consumer surplus is higher under no information sharing. Intuitively, just as the retailer benefits more from high demand when the manufacturer is unable to exploit such demand with higher wholesale prices, so too do consumers. After all, the underlying source of the retailer's preference for no disclosure is that disclosure intensifies the effects of double-marginalization. Like the retailer, consumers are also willing to overlook such strategic wholesale pricing if disclosure permits sufficient additional investment by the manufacturer. In fact, comparison of (17) and (18) confirms that the consumers' condition for a preference for disclosure is precisely that of the retailer found in Proposition 2. Hence, the next proposition follows.

**Proposition 3** *When the retailer chooses to disclose its information, such disclosure also benefits the manufacturer and consumers, and, thus, yields Pareto gains.*

While the above results indicate how consideration of manufacturer investments can alter the prevailing views about retailer information sharing in a relatively general setting, the general nature of the formulation prevents closed form solutions for investment levels. Next, we consider a particular (and commonly examined) class of investment cost functions to derive closed form results and, in the process, better highlight the intuition.

## 5.2 Quadratic Cost Function

Consider the analysis above under a quadratic cost function ( $C(I) = \frac{kI^2}{2}$ ), which represents a simple formulation that also satisfies the property of the general cost function  $C(I)$ .<sup>4</sup> Using this cost function, we now revisit the manufacturer's endogenous investment and the ensuing equilibrium outcomes under disclosure and no disclosure cases. The closed form of equilibrium outcomes using the function will provide us with a better understanding about the effect of investment on the retailer's information sharing incentive.

We first find the optimal ex ante investment levels under the quadratic cost function in the following Lemma 4 .

**Lemma 4** *Under the quadratic cost function,  $C(I) = \frac{kI^2}{2}$ , the optimal investment levels under each regime is as follows:  $I^N = \frac{\mu^2}{4k - \mu^2}$  and  $I^D = \frac{\mu^2 + \sigma^2}{4k - (\mu^2 + \sigma^2)}$ .*

Lemma 4 confirms the previous result that the investment level is higher under disclosure. Moreover, it shows more explicitly that the investment level under disclosure increases in uncertainty ( $\sigma^2$ ) while it is not affected by uncertainty under no disclosure. Using the investment levels in the lemma, we can then derive the expected profits of both the retailer and the manufacturer as follows:

$$\begin{aligned} \Pi_R^N(I^N) &= \frac{k^2[\mu^2 + 4\sigma^2]}{[4k - \mu^2]^2} ; \Pi_M^N(I^N) = \frac{k\mu^2}{2[4k - \mu^2]} ; \\ \Pi_R^D(I^D) &= \frac{k^2[\mu^2 + \sigma^2]}{[4k - \mu^2 - \sigma^2]^2} ; \Pi_M^D(I^D) = \frac{k[\mu^2 + \sigma^2]}{2[4k - \mu^2 - \sigma^2]} . \end{aligned} \quad (19)$$

Comparing the retailer's expected profit under disclosure with that under no disclosure, the result in Proposition 4 is obtained.

**Proposition 4** *Under a quadratic cost function,  $C(I) = \frac{kI^2}{2}$ , the retailer prefers to disclose its market information if and only if*

$$k < k^R = \frac{1}{12} \left[ 4(\mu^2 + \sigma^2) + \sqrt{(\mu^2 + \sigma^2)(\mu^2 + 4\sigma^2)} \right] .$$

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<sup>4</sup>The sufficient condition to guarantee that investment levels are positive is  $k > \frac{\mu^2 + \sigma^2}{4}$ .

Proposition 4 suggests that a retailer discloses its market information if investment cost is not so high ( $k < k^R$ ). As  $k$  becomes higher, the manufacturer's investment is more costly and then its investment level will be lower at given market profitability. Therefore, when  $k$  is smaller than  $k^R$ , the investment efficiency is high enough to convince the retailer of disclosing his information, thereby increasing its profit. Further, the limiting case of  $k \rightarrow \infty$  represents the traditional analysis of information disclosure without consideration of manufacturer investment.

One may expect that as uncertainty increases, private information becomes more valuable and thus the informed retailer may be less willing to share the information. However, as demonstrated previously, greater uncertainty also increases the wedge in manufacturer investment levels under disclosure and no disclosure. Which effect is more pronounced in this case can be gleaned from inspection of  $k^R$  which is increasing in  $\sigma^2$ . We investigate this in the following Corollary.

**Corollary 1** *Under quadratic investment cost,  $C(I) = \frac{kI^2}{2}$ , information sharing is more attractive the greater the information content of disclosure, i.e.,  $k^R$  is increasing in  $\sigma^2$ .*

**Proof.** From the first-order condition of  $k^R$ ,  $\frac{\partial k^R}{\partial \sigma^2} = \frac{1}{12} \left( 8\sigma + \frac{5\mu^2\sigma + 8\sigma^3}{\sqrt{(\mu^2 + \sigma^2)(\mu^2 + 4\sigma^2)}} \right) > 0$ , which implies that  $k^R$  increases as uncertainty ( $\sigma^2$ ) increases. ■

Further, as derived in the general investment cost function, when the retailer benefits from disclosure, so too do the manufacturer and consumers. One question that may arise is since disclosure by the retailer benefits others, how does the retailer's preference match up with total welfare. In particular, even when the retailer prefers not to disclose, is there a welfare benefit from such disclosure? Such a question may be relevant in circumstances where mandatory disclosure regulations are under consideration.<sup>4</sup>

It is readily confirmed that in the benchmark case of exogenous investment, welfare considerations and retailer considerations are perfectly aligned – disclosure is always harmful to welfare. This equivalence, however, does not carry forward to the case of endogenous investment.

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<sup>4</sup>For instance, the regulatory reporting requirement, Statement of Financial Accounting Standards No. 131 mandates disclosure of firms' segment performance and the disclosure naturally reveals a retailer's market information to a manufacturer even if the retailer does not prefer to share the information. Extant research in accounting (e.g., Arya et al. 2009, Botosan and Stanford 2005, and Street et al. 2000) examines the effect of mandatory segment disclosure on market competition, information sharing, and a firm's disclosure behavior in a capital market.

Using the expressions in Lemmas 2, 3, and 4, the expected welfare under information disclosure ( $W^D$ ) and non-disclosure ( $W^N$ ) are as follows:

$$W^D = \Pi_M^D(I^D) + \Pi_R^D(I^D) + \lambda CS^D(I^D) = \frac{k[\mu^2 + \sigma^2][(6 + \lambda)k - \mu^2 - \sigma^2]}{2[4k - \mu^2 - \sigma^2]^2}, \quad (20)$$

$$W^N = \Pi_M^N(I^N) + \Pi_R^N(I^N) + \lambda CS^N(I^N) = \frac{k[(6 + \lambda)k\mu^2 - \mu^4 + 4k(2 + \lambda)\sigma^2]}{2[4k - \mu^2]^2}. \quad (21)$$

In Equations (20) and (21),  $\lambda \geq 0$  represents the relative importance of consumer surplus in evaluating overall welfare (see, e.g., Baron 1988; Shapiro 1986). Comparing the welfare in the two cases yields the following corollary.

**Corollary 2** *Under quadratic investment costs,  $C(I) = \frac{kI^2}{2}$ , disclosure increases expected welfare if and only if  $k < k^W$ , where*

$$k^W = \frac{1}{8 + 12\lambda} \left[ 4(1 + \lambda)\mu^2 + (6 + 4\lambda)\sigma^2 + \sqrt{(2 + \lambda)^2\mu^4 + 5(2 + \lambda)^2\mu^2\sigma^2 + 4(5 + 4\lambda + \lambda^2)\sigma^4} \right].$$

The result in Corollary 2 indicates that, unlike in the benchmark case of exogenous manufacturer investment, the preference for disclosure from a welfare perspective diverges from that of the retailer. In particular, while the retailer prefers disclosure if and only if  $k < k^R$ , welfare is enhanced by disclosure if and only if  $k < k^W$ . Importantly, an algebraic comparison reveals that  $k^W > k^R$  indicating that disclosure is more attractive to the economy as a whole than it is to the retailer. Taken together, these results imply the following proposition.

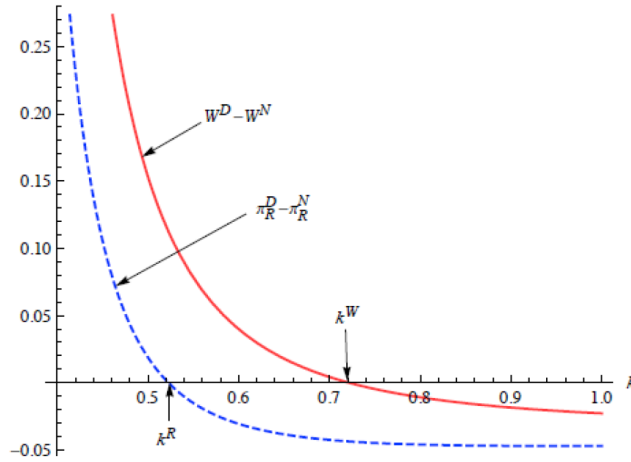
**Proposition 5** *The relationship between the retailer's disclosure choice and welfare maximization is as follows:*

- (i) *If  $k \geq k^W$ , the retailer does not disclose and no disclosure also maximizes total welfare;*
- (ii) *If  $k^R \leq k < k^W$ , the retailer does not disclose although disclosure maximizes total welfare;*
- (iii) *If  $k < k^R$ , the retailer discloses and disclosure also maximizes total welfare.*

As  $k$  increases, the manufacturer's incentive to invest in demand-enhancing activities decreases because of a higher investment cost. Therefore, when the investment cost is extremely large

( $k \geq k^W$ ), the endogenous investment effect is minimal and the usual no disclosure result applies: withholding information is better for both the retailer and overall welfare. For intermediate values of  $k$  (between  $k^R$  and  $k^W$ ), the ability for disclosure to increase manufacturer investment outweighs the double-marginalization effect in terms of overall welfare. Yet, since only part of those benefits (and a preponderance of the cost) is borne by the retailer, the retailer is unwilling to share its information. This range introduces a role for mandatory disclosure regulations that compel the retailer to provide information it would otherwise be unwilling to for the sake of overall welfare. Finally, when  $k < k^R$ , the benefit from the increased demand through the manufacturer's investment dominates the double-marginalization cost, both economy-wide and retailer-specific. In this case, the retailer's voluntary information sharing always improves the manufacturer's expected profit and consumer surplus. Hence, a Pareto gain is obtained in the supply chain when  $k < k^R$ .

Figure 2: A Retailer's Disclosure Decision and Total Welfare



To highlight the results about a retailer's disclosure decision and welfare consequences of disclosure, Figure 2 plots each under disclosure and no disclosure when  $\mu = 1$ ,  $\sigma^2 = 0.2$ , and  $\lambda = 1$ . The graph demonstrates that the retailer decides to share its demand information if  $k \leq k^R = 0.522$  and total welfare is greater under information sharing when  $k \leq k^W = 0.721$ . Thus, when the retailer decides to share its market information (i.e.,  $k \leq 0.522$ ), the welfare also increases. On the other

hand, when  $k$  is between 0.522 and 0.721, welfare is enhanced under disclosure but the retailer does not disclose because the concern for the higher wholesale price dominates the benefit from the incremental investment under disclosure.

## 6 Conclusion

This research examines a retailer's information sharing incentive in the presence of investment by suppliers that can enhance product demand (e.g., advertising, quality control, etc.). A large number of previous papers have investigated retailer disclosure incentives in various contexts. While much of the previous work has focused on the strategic consequence of information sharing on wholesale pricing choices, the prevalence of manufacturer investments that can affect retail demand motivated our revisitation of such analyses. We find that information sharing naturally has an impact on a manufacturer's investment decision in that the impending ability to condition wholesale prices on retailer information boosts the manufacturer's incentive to invest in demand in the first place. Our analysis shows that the real (investment) effect of information can change a retailer's information sharing incentive and, as a result of investment efficiencies, such information sharing can be welcomed by all economic participants.

More precisely, this paper first examines a baseline case wherein a manufacturer's investment in demand is taken as exogenously given. This benchmark is largely consistent with existing results in this realm (e.g. Li 2002). We show that absent investment incentives, the retailer opts to withhold information from the manufacturer since such information is ostensibly used by the manufacturer to fine-tune wholesale prices to the detriment of the retailer. The primary contribution of the present analysis is to introduce manufacturer investment to the set of strategic manufacturer decisions. We demonstrate that, while the manufacturer does tailor wholesale prices in response to retailer information sharing, such additional "pricing power" serves to boost the manufacturer's investment. If these investment effects are more pronounced than the pricing effects, the retailer may actually voluntarily share its information despite the obvious downsides.

In practice, there has been a growing trend that a manufacturer makes various investments to

enhance market demand. However, there is a paucity of evidence as to how a retailer can induce more such investment by the manufacturer. In this vein, the present paper suggests that information sharing can be a tool through which the retailer can establish such mutually beneficial investment behavior. As a result, information sharing may benefit not only supply chain participants but also the ultimate consumers of such products.



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