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Who Wants Consumers to Be Informed? Facilitating Information Disclosure in a Distribution Channel

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Abstract. We investigate a retailer's and a supplier's incentive to facilitate information disclosure, i.e., consumer learning of their true product valuation, under two popular supply chain contracts, i.e., the agency pricing model and the wholesale pricing model. Our results show that when a product has medium or high dispersion in its consumers' true valuation distribution and the degree of information disclosure before facilitation is moderate, two parties might have opposing interests as to more information disclosure. Specifically, in the agency pricing model, the revenue sharing mechanism leads the supplier to benefit, but the retailer to suffer, from more information disclosure. In the wholesale model, potential misalignment of interests as to more information disclosure disappears if the demand is linear. Double marginalization absorbs influence of two parties' marginal cost discrepancy and eventually tunes the two parties' margin proportional to each other. If the demand is log-concave and derived from common valuation distributions such as normal or logistic distributions, misalignment reappears in the wholesale model, but interestingly, the retailer benefits and the supplier suffers from more disclosure, which is opposite to the misalignment result in the agency model under the same log-concave demand. Our results suggest that information disclosure facilitation has a different interplay with the revenue sharing mechanism in the agency model than with double marginalization in the wholesale model.

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Keywords: information disclosure • supply chain contract • agency pricing • double marginalization • revenue sharing

1. Introduction

Online retailing has experienced remarkable growth during the last decade in the United States. A recent report from U.S. Census Bureau shows that annual online sales across the United States surpassed $330 billion in 2015, a three-fold increase compared to 2006 (U.S. Department of Commerce 2016). This number is expected to reach $523 billion in 2020, and by then more than 200 million people in the United States will shop online (Mulpuru et al. 2016). One salient feature of online retailing is that consumers have different true valuations of a product yet each consumer is uncertain about her own valuation due to lack of full information about the product's characteristics before purchase (Hong and Pavlou 2014). For example, an online shopper may be unsure about whether a pair of shoes or a garment fits her idiosyncratic preference without discovering all its attributes through a hands-on examination. This lack of product information causes shoppers with true high valuations to underestimate their willingness to pay and those with true low valuations to overestimate their willingness to pay (Lewis and Sappington 1994). In response, sellers can undertake a set of practices to facilitate disclosure of product information, for example, issuing free product samples, providing enhanced online product description, and facilitating consumer-generated content (Cheng and Liu 2012, Niculescu and Wu 2014, Kwark et al. 2014), all of which help consumers better discover their true valuations. Past research has identified the market conditions under which such facilitation benefits a seller (Chen and Xie 2008). It has shown that when consumers are sufficiently differentiated by their true product valuation, it is crucial for the seller to attain excellent disclosure, not only because it better segments a market such that he can fully capitalize on consumers with true high valuation, but more important because mediocre disclosure could be detrimental to his profit compared to full disclosure and no disclosure (Johnson and Myatt 2006).

The question of the market conditions under which sellers may facilitate information disclosure becomes more perplexing when it takes a distribution channel perspective and examines upstream suppliers' and downstream retailers' interests in facilitation. It is also important to understand whether their interests in

disclosure are conflicted in a market condition because suppliers or retailers can disclose more information to consumers, though sometimes information disclosure is a joint effort (Sun 2015). For example, in the Seller Central program launched for third-party sellers to sell their products on Amazon, Amazon.com, by default, does not hold any inventory of sellers' products and does not oversee the product description provided by sellers. Hence, a seller (i.e., the supplier) can choose to hinder information disclosure by withholding detailed product information in the product description section, or facilitate disclosure by revealing information. Amazon.com (i.e., the retailer) can facilitate information disclosure by maintaining a highly effective consumer review section, for example, highlighting the most informative consumer reviews, or it can hinder information disclosure by not doing so or by restricting the length of the product description that the seller can draft. Recent studies have shown that facilitating information disclosure could intensify upstream competition in a distribution channel, and that which party will be the beneficiary depends highly on the channel's supply chain contract (Kwark et al. 2014, 2017). In summary, different supply chain contracts dictate different timing for suppliers' and retailers' decisions, use different mechanisms to allocate channel revenues (Cachon and Lariviere 2005), and hence may lead to different incentive alignments among firms in terms of facilitating information disclosure.

While the wholesale pricing model has been a popular choice of supply chain contracts for decades, a new type of supply chain contract, i.e., agency pricing model, is gaining popularity. Under the agency pricing model, which started in the e-book industry, a retailer must delegate the retail price decision to her supplier (Hao and Fan 2014, Abhishek et al. 2015, Hao et al. 2017). The supplier passes a certain percentage of his total revenue to the retailer. This new type of supply chain contract mitigates the retailer's cost of managing retail prices as such cost can be significant if the retailer is working with many individual suppliers. Giant online retail platforms such as Amazon.com have started to offer third-party sellers the option to choose between the wholesale pricing model where they sell through the retailer's platform, and the agency pricing model where they sell on it (Hartman 2016).

How does facilitating information disclosure in this new agency pricing model differ from the wholesale pricing model? To shed light on this question, we investigate a supplier's and a retailer's incentive to hinder or facilitate information disclosure under two pricing models in the absence of competition. Specifically, we ask the following research questions: Under what conditions does the supplier benefit from more information disclosure such that he wants to facilitate that disclosure? Under what conditions does the retailer benefit such that she wants to facilitate it? Are their interests in more disclosure always aligned? If not, which party, the retailer or the supplier, benefits from more disclosure? Most important, how do the answers to these questions depend on the choice between the agency pricing model and the wholesale pricing model?

We build a game-theoretical model to answer these questions. Based on previous works on this topic (Johnson and Myatt 2006, Chen and Xie 2008), we characterize a market condition mainly by three relevant factors, i.e., (i) firms' marginal cost, (ii) dispersion of consumers' true valuation distribution, i.e., whether consumers are more differentiated or less differentiated by their true product valuation, and (iii) the degree of informativness of product information without facilitation, i.e., the baseline for "more information disclosure," which can be attributed to extraneous sources of product information such as consumers reviews. For simplicity, hereafter we refer to a product with a high dispersion of consumers' true valuation distribution as a product with high dispersion, and the opposite as a product with low dispersion. We assume that the retailer's marginal cost is sufficiently low relative to the supplier's. We have developed several key insights: In the agency pricing model, the supplier and the retailer will benefit from more information disclosure regardless of other factors such as dispersion when the supplier's marginal cost is sufficiently high. The same conclusion applies to the wholesale pricing model when its channel marginal cost is sufficiently high. In the wholesale or the agency pricing model with other marginal costs, the supplier and the retailer benefit from more information disclosure when they are selling a product with high dispersion and prefacilitation information is highly informative, whereas both suffer from more information disclosure when they are selling a product with low dispersion and prefacilitation is less informative. When the product has medium or high dispersion and prefacilitation information is moderately informative, the two parties might have opposing interests in terms of facilitating information disclosure; still, the manner of misalignment depends on the supply chain contract. In the agency pricing model, the supplier benefits from more disclosure while the retailer suffers. In the wholesale pricing model, if the demand is linear, two parties have identical interests in more disclosure. If the demand belongs to a category of commonly seen log-concave demands (e.g., those derived from common product valuation distributions such as normal or logistic distribution), the retailer benefits from more disclosure while the supplier suffers. This is the opposite of misalignment compared to the case in the agency pricing model under the same log-concave demand.

Essentially, our results show that facilitating information disclosure has significantly different interplay

with the wholesale pricing model compared to the agency pricing model. Note that, in our model setting, there is only one supplier and one retailer. Hence more information disclosure always produces the same amount of demand change for both firms. In the agency pricing model, the revenue sharing mechanism gives the supplier a higher percentage increase in margin than the retailer when the retailer has a sufficiently low marginal cost. Therefore, more disclosure benefits the supplier and hurts the retailer whenever their interests in disclosure are misaligned. In the wholesale pricing model, double marginalization largely absorbs the influence of the retailer's low marginal cost during facilitation. When the demand is linear, this absorbing effect results in the same percentage change in the two parties' margin, thus giving them identical interests in more disclosure. More generally, double marginalization turns the supplier's escalation in wholesale price, i.e., the supplier's own response to more inelastic demand led by more information disclosure, into the retailer's additional marginal cost. Hence, to regain the equality between marginal revenue and marginal cost after facilitation, the retailer must raise the retail price not only to account for her own response to the more inelastic demand but also to compensate for such additional marginal cost passed from the supplier. How much the retailer must raise the price depends highly on the curvature of the demand. If the demand is linear (i.e., zero curvature), the retailer's rise in the retail price will result in same percentage increase in two parties' margin. If the demand is log-concave with positive curvature increasing in price, the retailer must raise the retail price significantly to achieve such equality, which makes the percentage increase in the retailer's margin higher than the supplier's. Hence, more disclosure benefits the retailer while hurting the supplier whenever the two parties' interests in disclosure are misaligned.

In addition, we demonstrate the impact of the fourth factor, product quality, on two parties' facilitation decisions. While facilitation rotates a product's inverse demand curve clockwise, a higher (lower) product quality shifts out (in) such a curve. We show that our qualitative findings still hold when product quality is below a certain threshold. When product quality is above a certain threshold and the supplier's and the retailer's marginal costs are at the low end, the retailer in the agency pricing model and the retailer and the supplier in the wholesale pricing model will not facilitate regardless of dispersion and the informativeness of prefacilitation information. This is because a very high product quality significantly shifts out the inverse demand curve, pushing the market into a significant low-valuation-consumer-overload condition together with two parties' low marginal costs. Such a significant low-valuation-consumer-overload condition will outweigh other factors to make the retailer in the agency pricing model and both parties in the wholesale pricing model lose profits after facilitation.

The rest of this paper is organized as follows. In the next section, we present a literature review. Then we construct our model and analyze the supplier's and the retailer's incentive for more information disclosure in the agency pricing model and the wholesale pricing model, respectively. We then compare the outcomes from two pricing models and explain the similarities and differences. Several key insights are discussed in the model results section. We then discuss the impact of product quality on the two parties' incentives for information disclosure. We conclude with a summary of our findings and potential avenues for future research.

2. Literature Review

Our study is at the intersection of two streams of literatures, i.e., product information disclosure and pricing models in a distribution channel. Over the past decades, a vast amount of work has been dedicated to the topic of product information disclosure. The central issue examined by the extant literature is under what conditions a seller should disclose product information. The general unraveling theory established by Grossman (1981) and Milgrom (1981) demonstrates that all sellers would choose to disclose their product quality because the goal of the highest quality type in any pooling equilibrium is to differentiate itself from all others in the pool. The subsequent studies extend this line of work by examining sellers' optimal strategies on information disclosure under different market settings. For example, Guo (2009) analyzes the disclosure decision in a distribution channel with bilateral monopolies. He compares two disclosure formats, i.e., a supplier directly discloses to consumers or through a retailer. He shows that more information will be provided if the supplier discloses through a retailer. Kuksov and Lin (2010) investigate two competing firms' optimal disclosure strategies when consumers are uncertain about product quality as well as their preferences for quality. They find that the firm selling a high quality product always has an incentive to disclose information on that product. Lewis and Sappington (1994) show that a firm's profit could be U-shaped with respect to the degree of fit information disclosure. Sun (2011) analyzes a case where the product has multiple horizontal attributes and shows that the results from unraveling theory may not hold after accounting for firm's incentive to disclose fit information. Chen and Xie (2008) study when and to what extent a firm should facilitate fit information disclosure in response to consumer reviews. They demonstrate that consumer reviews can complement or be a substitute for the firm's incentive to facilitate. Gu and Xie (2013) examine two competing firms' decisions

on facilitating fit information disclosure, showing that whether a firm wants to facilitate disclosure depends on the quality value of its product. Our paper extends this stream of literature by investigating the issue of facilitating disclosure in the presence of a newly emerged supply chain contract, i.e., the agency pricing model, and comparing the disclosure result under the agency pricing model with that under the wholesale model.

Our study is also related to the literature on supply chain contracts in a distribution channel, especially the wholesale pricing model and the agency pricing model. Spengler (1950) shows that the wholesale pricing model will lead to double marginalization. Bresnahan and Reiss (1985) demonstrate that under this same model, there is a proportional relationship between the supplier's margin and the retailer's margin in equilibrium. Lariviere and Porteus (2001) investigate the properties of a wholesale pricing model under a stochastic demand. Cachon and Lariviere (2005) compare wholesale pricing contracts and revenue sharing contracts with respect to performance on channel coordination. Hagiu and Wright (2014) compare the wholesale pricing model with the agency pricing model when the supplier may have more information about the demand than the retailer in a distribution channel. For the agency pricing model, Abhishek et al. (2015) examine a dual channel structure where e-tailers can choose whether to use agency pricing models or wholesale pricing models to manage upstream suppliers. They show that an e-tailer will choose the agency pricing model if the electronic channel cannibalizes the demand in the traditional channel, but will choose the wholesale pricing model if the electronic channel stimulates the demand in the traditional channel. Hao and Fan (2014) study the agency pricing model in the electronic book market and show that the complementary consumption of e-readers and e-books may lead to a lower publisher's profit in the agency pricing model compared to the wholesale pricing model. Tan et al. (2015) study the agency pricing model in a distribution channel with one supplier and two competing retailers. They identify a Pareto improving condition in which the supplier and the retailers prefer the agency pricing model to the wholesale pricing model. Johnson (2013) investigates the agency pricing model in which a retailer has the capability to lock in consumers. He shows that switching from the wholesale pricing model to the agency pricing model will boost retail prices and may increase rival retailers' profits. The general issue of price delegation has also been studied in a broader setting in marketing literature. Bhardwaj (2001) analyzes the impact of competition on a firm's decision whether to delegate retail pricing directly to its salesforce. Mishra and Prasad (2004) study how information asymmetry between a firm and its salesforce affects the firm's decision on price delegation. Mishra and Prasad (2005) extend Mishra and Prasad (2004) to a competitive setting and demonstrate how information asymmetry affects two competing firms' choices on price delegation.

Our paper is most closely related to the burgeoning stream of literature on the interplay between supply chain contracts and product information disclosure. Kwark et al. (2014) study information disclosure in a channel setting where a retailer and two competing suppliers are managed under a wholesale pricing model. They demonstrate how quality information disclosure and fit information disclosure, respectively, affect the retailer's and two competing suppliers' profit. Kwark et al. (2017) compare the effects of fit information disclosure across the agency pricing model and the wholesale pricing model, based on a similar channel structure. They show that if the two suppliers are selling experience goods, fit information disclosure softens competition between the two, thus hurting the retailer under the wholesale pricing model yet benefitting the retailer under the agency pricing model. Sun (2015) compares the effects of fit information disclosure across two distribution scenarios: In one scenario the supplier sells through a monopolistic retailer and in the other the supplier sells through two competing retailers. Results show that selling through one retailer reduces the supplier's incentive to disclose fit information, while selling through two competitive retailers, under certain circumstances, can increase the supplier's incentive to disclose. In summary, previous literature often considers competition as a mediator between information disclosure and firms' profits: They first study how information disclosure affects upstream or downstream competition, and then let supply chain contracts moderate the impact of intensified or softened competition on firms' profits. Sun (2015) has incorporated downstream competition among retailers as a mediator. Kwark et al. (2014 and 2017) have incorporated upstream competition among suppliers. Our study, instead of having a mediator, focuses on how supply chain contracts directly moderate the impact of information disclosure on firms' profits in a distribution channel. To our knowledge, this is the first paper to investigate this direct interaction. We show that, even if there is no competition, the wholesale pricing model and the agency pricing model interact with information disclosure in fundamentally distinct ways.

On a more theoretical front, the seminal paper by Johnson and Myatt (2006) demonstrates how information disclosure facilitation affects the elasticity of demand, known as the first-order derivative property of demand. Here , we extend the discussion by showing how information disclosure facilitation affects the curvature of demand, known as the second-order derivative property of demand. Last, note that our study is

not restricted to any specific form of information disclosure facilitation such as free trials or online virtual showrooming (Cheng and Liu 2012; Niculescu and Wu 2014; Gu and Tayi 2015, 2016; Gao and Su 2017).

3. The Model

We consider a supplier who sells one product to a mass of consumers through a retailer. Each consumer has a unit demand and the market size is normalized to 1. Consumers are heterogeneous in terms of their true valuation of the supplier's product. We assume they are uniformly distributed[1] between $[(q-t)/2, (q+t)/2]$ where $q > 0$ and $0 \le t \le q$. For simplicity, hereafter we call this the true valuation distribution. Without loss of generality, we normalize $q = 1$. Hence the mean of the true valuation distribution is $1/2$ and t indicates the degree of dispersion of the true valuation distribution. A low (high) t suggests that consumers have similar (differentiated) true valuations of the product.

Each consumer is uncertain about her true valuation v before purchasing the product. To decide whether to purchase the product, she estimates her true valuation v based on information available on the market. In line with previous literature (Kwark et al. 2014), a consumer receives a private signal θ which, with probability β, equals her true valuation v (i.e., $\Pr(\theta = x \mid v = x) = \beta$), and, with probability $(1-\beta)$ is completely uninformative (i.e., $\Pr(\theta \neq x \mid v = x) = 1-\beta$) and follows the true valuation distribution. For example, if $\beta = 1$, a consumer with v being equal to x will always receive a signal that indicates x, i.e., the information is perfectly informative. If $\beta = 0$, a consumer with v being equal to x will never receive a signal that indicates x, i.e., the information is completely uninformative. If $0 < \beta < 1$, the information partially reveals a consumer's valuation but does not achieve perfect disclosure. Parameter β essentially characterizes the degree of informativeness of information with respect to revealing consumers' true valuation *prior* to purchase. Denote a consumer's expected (gross) valuation by $\hat{v}$. Based on Bayesian updating, we derive

$$\hat{v} = \beta \cdot x + (1-\beta)/2.$$

Note that x follows the same distribution of v. Suppose the product's retail price is p. A consumer will make the purchase when her expected net utility is non-negative, i.e., $\hat{v} - p \ge 0$.

3.1. Effect of Facilitating Information Disclosure

The effect of facilitating information disclosure is to increase β, making each consumer more informed about her true valuation before purchase. Let the subscript NF denote "without facilitation" and F denote "with facilitation." We assume that without facilitation consumers are less than perfectly informed, i.e., $\beta = \beta_{NF} = b$ $(0 < b < 1)$. With facilitation, each consumer can fully discover her true valuation before purchase, i.e., β improves from β_{NF} to β_F where[2] $\beta_F = 1$. Thus, the market demands of the product without facilitation and with facilitation are

$$D_{NF} = \begin{cases} 0 & p > \dfrac{1+bt}{2} \\ \dfrac{1}{2} + \dfrac{1-2p}{2bt} & \dfrac{1-bt}{2} < p \le \dfrac{1+bt}{2} \\ 1 & 0 \le p \le \dfrac{1-bt}{2} \end{cases} \quad \text{and}$$

$$D_F = \begin{cases} 0 & p > \dfrac{1+t}{2} \\ \dfrac{1}{2} + \dfrac{1-2p}{2t} & \dfrac{1-t}{2} < p \le \dfrac{1+t}{2} \\ 1 & 0 \le p \le \dfrac{1-t}{2} \end{cases}.$$

Next, we model the supply side. Denote the supplier's marginal cost of the product by c_S and the retailer's by c_R. The supplier's marginal cost may include the cost of production. The retailer's marginal cost may include the cost of selling. Denote the channel marginal cost by c_C where $c_C = c_S + c_R$.

3.2. Agency Pricing Model

In the agency pricing model, the supplier sets retail price $p = p_i^A$ $(i \in \{F, NF\})$. Meanwhile, the supplier agrees to send s share of his revenue $(0 < s < 1)$ to the retailer. Denote the supplier's margin in the agency pricing model by $m_i^{S,A}$ where $m_i^{S,A} = p_i^A(1-s) - c_S$, and the retailer's margin in the agency pricing model by $m_i^{R,A}$ where $m_i^{R,A} = p_i^A s - c_R$. Denote the supplier's profit by $\pi_i^{S,A}$ where

$$\pi_i^{S,A} = m_i^{S,A} \cdot D_i.$$

Denote the retailer's profit by $\pi_i^{R,A}$ where $\pi_i^{R,A} = m_i^{R,A} \cdot D_i$.

3.3. Wholesale Pricing Model

In the wholesale pricing model, the retailer sets retail price $p = p_i^W$ $(i \in \{F, NF\})$. For each unit sold, the retailer agrees to pay wholesale price $w = w_i^W$ to the supplier. Wholesale price w_i^W is determined by the supplier. Denote the supplier's margin in the wholesale pricing model by $m_i^{S,W}$ where $m_i^{S,W} = w_i^W - c_S$, and the retailer's margin in the wholesale pricing model by $m_i^{R,W}$ where $m_i^{R,W} = p_i^W - w_i^W - c_R$. Denote the supplier's profit by $\pi_i^{S,W}$ where

$$\pi_i^{S,W} = m_i^{S,W} \cdot D_i.$$

Denote the retailer's profit by $\pi_i^{R,W}$ where $\pi_i^{R,W} = m_i^{R,W} \cdot D_i$.

3.4. Facilitation Decisions

In this paper, we study two facilitation scenarios, i.e., (i) the *S-driven* scenario in which the supplier dictates whether to facilitate information disclosure, and (ii) the *R-driven* scenario in which the retailer dictates whether to facilitate. The facilitation decision made by the dictating party cannot be overturned by the other party. Either scenario can be combined with either pricing model. In the agency pricing model, denote the optimal retail price with facilitation as $p_F^{A^*}$ and that without facilitation as $p_{NF}^{A^*}$. Under the *R*-driven scenario, the retailer will choose to facilitate if and only if facilitation improves her profit (i.e., $\pi_F^{R,A}(p_F^{A^*}) > \pi_{NF}^{R,A}(p_{NF}^{A^*})$). Similarly, under the *S*-driven scenario, the supplier will choose to facilitate if and only if facilitation improves his profit (i.e., $\pi_F^{S,A}(p_F^{A^*}) > \pi_{NF}^{S,A}(p_{NF}^{A^*})$). In the wholesale pricing model, denote the optimal retail price with facilitation as p_F^{W*} and that without facilitation as p_{NF}^{W*}. Denote the optimal wholesale price with facilitation as w_F^{W*} and that without facilitation is w_{NF}^{W*}. Under the *R*-driven scenario, the retailer will choose to facilitate if and only if $\pi_F^{R,W}(p_F^{W*}, w_F^{W*}) > \pi_{NF}^{R,W}(p_{NF}^{W*}, w_{NF}^{W*})$. Similarly, under the *S*-driven scenario, the supplier will choose to facilitate if and only if $\pi_F^{S,W}(p_F^{W*}, w_F^{W*}) > \pi_{NF}^{S,W}(p_{NF}^{W*}, w_{NF}^{W*})$.

Because there is no retailer's facilitation decision in the *S*-driven scenario, for ease of presentation, we use "retailer's facilitation decision" to refer to "retailer's facilitation decision in the *R*-driven scenario" in the later part of the paper. Similarly, we use "supplier's facilitation decision" to refer to "supplier's facilitation decision in the *S*-driven scenario." We create the *S*-driven and the *R*-driven scenario to help us compare two parties' incentive to facilitate in identical market conditions. Two parties are said to have aligned (misaligned) interests in facilitation when the supplier's facilitation decision to facilitate or not is the same as (or different from) the retailer's facilitation decision for a given market condition.

3.5. Timing of the Game

The timing of the game in the agency pricing model is as follows: At the beginning, the party who dictates the facilitation decision chooses whether to facilitate information disclosure. Based on whether facilitation is chosen (e.g., $\beta = 1$ if chosen and $\beta = b$ if not chosen), the supplier adjusts the retail price accordingly. Then each consumer decides whether to make a purchase. The timing of the game in the wholesale pricing model is similar to that of the agency pricing model except for price determination. After the facilitation decision is made, the supplier, instead of setting the retail price, only sets the wholesale price; then the retailer sets the retail price in the wholesale price model. Important notations are summarized in Table 1.

Note that we forgo any market condition that leads to the uninteresting boundary solution where the market is already fully covered or zero covered without facilitation, or will be fully covered or zero covered with facilitation. In the agency pricing model, we assume that $c_S < (1-s)$, a necessary condition for the supplier's individual rationality (IR) condition to hold in the agency pricing model. We assume that the supplier's marginal cost is not excessively low, i.e., $c_S > (1-s)/3$, in which case the influence of supplier's marginal cost on his facilitation decision does not always dominate the influence of dispersion. Furthermore, we assume that the retailer's marginal cost is sufficiently low, i.e., $c_R < (s/2)\cdot(1/3 + c_S/(1-s))$, which at the same time guarantees the retailer's IR condition. In the wholesale pricing model, for similar reasons, we assume that $c_S + c_R < 1$. Detailed proof of lemmas, propositions and corollaries are provided in the online appendix.

Table 1. Model Parameters and Variables

Parameters	
b	Degree of informativeness of information without facilitation
t	Degree of dispersion of consumers' true product valuation distribution
s	Retailer's revenue sharing percentage
c_S	Supplier's marginal cost of product
c_R	Retailer's marginal cost of product
Variables	
p	Product's retail price
w	Product's wholesale price
β	Degree of informativeness of information
m	Firm's margin
D	Product demand
π^S	Supplier's profit
π^R	Retailer's profit

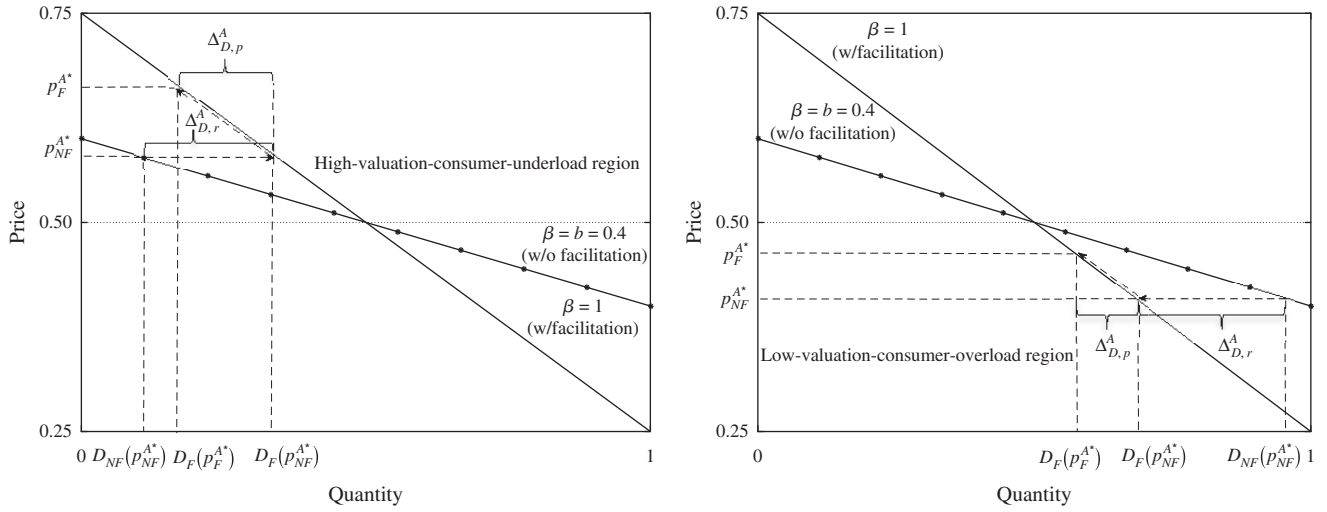
4. Model Results

4.1. Agency Pricing Model

Lemma 1 (Impact of Facilitation on Retail Prices and Product Demands in the Agency Pricing Model). *The supplier's optimal choice of the retail price is higher with facilitation compared to that without facilitation, i.e.,* $p_F^{A^*} > p_{NF}^{A^*}$. *The demand is lower* (*higher*) *with facilitation than without facilitation if the supplier's marginal cost is less* (*greater*) *than a threshold, i.e.,* $D_F(p_F^{A^*}) < D_{NF}(p_{NF}^{A*})$ *if* $c_S < c_{S1}^A$ *and* $D_F(p_F^{A*}) > D_{NF}(p_{NF}^{A^*})$ *if* $c_S > c_{S1}^A$. *The marginal cost threshold* $c_{S1}^A = (1-s)/2$.

Without facilitation, consumers who have true high and true low valuation will only perceive average values from the product. Facilitation updates consumers' willingness to pay from those average values back to their own true high or true low valuation. Therefore, the supplier can no longer set a medium price to exploit the overestimated willingness to pay from low valuation consumers but wants to increase the price to exploit the improved willingness to pay from high valuation ones.

Figure 1. Facilitating Information Disclosure Causes an Inverse Demand Curve to Rotate Clockwise



To explain how supplier's marginal cost c_S affects the equilibrium demand change, note that facilitation rotates the inverse demand curve clockwise, from D_{NF} to D_F, around a fixed point 1/2, which is the mean of the true valuation distribution (shown in Figure 1). The total equilibrium demand change consists of the changes from two stages: (i) the first-stage change led by the demand curve rotation only while holding the retail price as constant, i.e., $\Delta^A_{D,r} = D_F(p^{A^*}_{NF}) - D_{NF}(p^{A*}_{NF})$, and (ii) the second-stage change led by the upward price adjustment from $p^{A^*}_{NF}$ to $p^{A^*}_F$, i.e., $\Delta^A_{D,p} = D_F(p^{A*}_F) - D_F(p^{A*}_{NF})$. For the first-stage change $\Delta^A_{D,r}$, we refer to a market condition before facilitation as *low-valuation-consumer-overload* when and only when the prefacilitation equilibrium retail price is less than the mean of the true valuation distribution (i.e., $p^{A^*}_{NF} < 1/2$). In such a case, $p^{A^*}_{NF}$ captures low valuation consumers who would not purchase at p^{A*}_{NF} if they knew their true valuation. Therefore, the first-stage demand change will be negative (i.e., $\Delta^A_{D,r} < 0$) because a fraction of similar low valuation consumers will no longer purchase at $p^{A^*}_{NF}$ after facilitation. The lower $p^{A^*}_{NF}$ is, the more significant low-valuation-consumer-overload condition the market is in, the more negative the first-stage demand change will be. On the other hand, we refer to a market condition before facilitation as *high-valuation-consumer-underload* when the prefacilitation equilibrium retail price is greater than the mean (i.e., $p^{A^*}_{NF} > 1/2$). In such a case, p^{A*}_{NF} rules out high valuation consumers who would purchase the product at p^{A*}_{NF} if they knew their true valuation. Therefore, the first-stage demand change will be positive (i.e., $\Delta^A_{D,r} > 0$) because a fraction of similar high valuation consumers restore their true high willingness to pay and hence add back to the demand after facilitation. The higher $p^{A^*}_{NF}$ is, the more significant high-valuation-consumer-underload condition the market is in, the more positive the first-stage demand change will be.

A higher supplier's marginal cost c_S, through inducing a higher retail price before facilitation, leads the market to a less significant low-valuation-consumer-overload condition that mitigates the first-stage demand reduction, or a more significant high-valuation-consumer-underload condition that amplifies the first-stage demand augmentation. In the meantime, the second-stage demand change (i.e., $\Delta^A_{D,p}$), although always negative, does not depend on c_S (i.e., $d\Delta^A_{D,p}/dc_S = 0$) when the demand is linear.[3] Higher p^{A*}_{NF} sets a higher starting point for the upward price adjustment and thus does not provide enough space for greater second-stage demand reduction. Eventually, when the supplier's marginal cost reaches beyond a certain threshold (i.e., $c_S > c^A_{S1}$), the high-valuation-consumer-underload condition becomes so significant that the first-stage demand augmentation overcomes the second-stage demand reduction, leading the equilibrium demand to increase after facilitation.

According to Lemma 1, neither the equilibrium demand nor the equilibrium retail price will decrease after facilitation when the supplier's marginal cost is sufficiently high (i.e., $c_S \geq c^A_{S1}$). Hence, the supplier and the retailer will choose to facilitate information disclosure when $c_S \geq c^A_{S1}$. In rest of Section 4.1, we focus on the case wherein $c_S < c^A_{S1}$ unless otherwise noted.

Lemma 2 (Supplier's Facilitation Decision in the Agency Pricing Model). *When $c_S < c^A_{S1}$, the supplier will choose to facilitate when* (i) *the product is high dispersion (i.e., $t_2^{S,A} < t < 1$), or* (ii) *the product is medium dispersion and the prefacilitation information is highly informative (i.e., $t_1^{S,A} < t < t_2^{S,A}$ and $b_1^{S,A} < b < 1$). In any other market condition, the*

supplier will not choose to facilitate. The above thresholds are

$$t_1^{S,A} = 1 - \frac{2c_S}{1-s}, \quad t_2^{S,A} = 3\left(1 - \frac{2c_S}{1-s}\right) \quad \textit{and}$$
$$b_1^{S,A} = \frac{(2c_S + s - 1)^2}{t^2(1-s)^2}.$$

When $c_S < c_{S1}^A$, the equilibrium retail price will still increase but the equilibrium demand will drop. The deciding factors then shift from the supply-side factor marginal cost to two demand-side factors, i.e., dispersion of the true valuation distribution (i.e., t) and the degree of informativeness of prefacilitation information (i.e., b).

Holding all other factors constant, the supplier will adopt a more margin-driven strategy and thus set a higher retail price before facilitation for a product with higher dispersion. Such higher $p_{NF}^{A^*}$ alleviates the low-valuation-consumer-overload condition and thus lessens the first-stage demand reduction when it is less than the mean of the true valuation distribution (i.e., $p_{NF}^{A^*} < 1/2$), or intensifies the high-valuation-consumer-underload condition and thus amplifies the first-stage demand augmentation when it is greater than the mean (i.e., $p_{NF}^{A^*} > 1/2$). Note that the supplier's *profit* always increases during the second-stage upward price adjustment. Hence, he will choose to facilitate when the first-stage demand reduction is lessened to a degree such that the resulting profit reduction in the first stage countervails the profit augmentation in the second stage. As we find $d\Delta_{D,r}^A/dt > 0$, dispersion must reach a sufficiently high level (i.e., $t_2^{S,A} < t < 1$).

On the other hand, for a product with sufficiently low dispersion (i.e., $t < t_1^{S,A}$), $p_{NF}^{A^*}$ can be well below the mean of the true valuation distribution. This causes a significant low-valuation-consumer-overload condition that leads to significant first-stage demand reduction. The supplier's equilibrium profit eventually drops and thus he chooses not to facilitate. When the dispersion is sufficient but not high (i.e., $t_1^{S,A} < t < t_2^{S,A}$), whether the supplier will choose to facilitate now depends on the degree of informativeness of prefacilitation information (i.e., b). Lemma 1 shows that highly informative prefacilitation information induces the supplier to facilitate. Chen and Xie (2008) have documented the conditions for such a complementary relationship between prefacilitation information and a firm's incentive to facilitate. We have found that an additional condition for such a complementary relationship exists for a supplier in a distribution channel, albeit only for products with medium dispersion in their consumers' true valuation distributions. Sufficiently low (or high) dispersion leads to a significant low-valuation-consumer-overload or a significant high-valuation-consumer-underload condition, which outweighs the complement effect from prefacilitation information.

Proposition 1 (Comparison of Two Parties' Facilitation Decisions in the Agency Pricing Model). *When $c_S < c_{S1}^A$, the supplier and the retailer will make identical facilitation decisions, facilitating or not facilitating,* except when *the product is medium or high dispersion and the prefacilitation information is moderately informative. In such a case, the supplier will facilitate while the retailer will not. The exact condition for this misalignment case in terms of b and t is as follows*:

(1) *When* (i) $c_S < 2(1-s)/5$, *or* (ii) $2(1-s)/5 < c_S < 13(1-s)/27$ *and* $c_R > (5c_S + 2s - 2)s/(1-s)$, *it requires* $t_1^{S,A} < t < t_1^{R,A}$ *and* $b_1^{S,A} < b < 1$, *or* $t_1^{R,A} < t < t_2^{S,A}$ *and* $b_1^{S,A} < b < b_1^{R,A}$, *or* $t_2^{S,A} < t < 1$ *and* $b < b_1^{R,A}$.

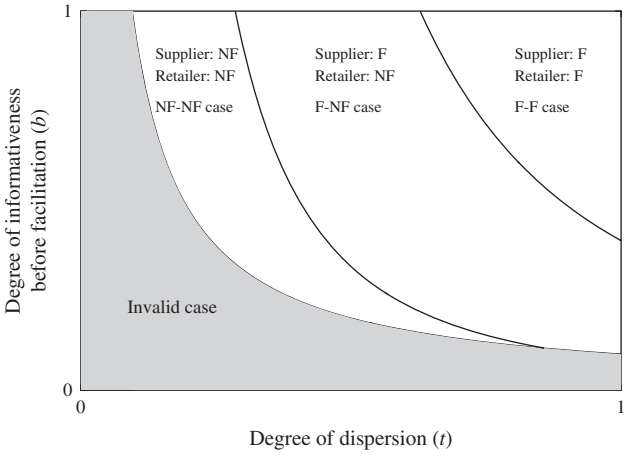
(2) *When* (i) $2(1-s)/5 < c_S < 13(1-s)/27$ *and* $c_R < (5c_S + 2s - 2)s/(1-s)$, *or* (ii) $13(1-s)/27 < c_S < c_{S1}^A$, *it requires* $t_1^{S,A} < t < t_2^{S,A}$ *and* $b_1^{S,A} < b < 1$, *or* $t_2^{S,A} < t < t_1^{R,A}$, *or* $t_1^{R,A} < t < 1$ *and* $b < b_1^{R,A}$.

The above undefined thresholds are

$$t_1^{R,A} = \frac{\sqrt{s(1-s-2c_S)(s(1-s+2c_S) - 4(1-s)c_R)}}{s(1-s)} \quad \textit{and}$$
$$b_1^{R,A} = \frac{(1-s-2c_S)(s(1-s+2c_S) - 4(1-s)c_R)}{st^2(1-s)^2}.$$

Note that the invalid case in Figure 2 represents a group of parameter (b, t) values that will lead the market to be fully covered or have zero coverage before facilitation. Proposition 1 shows that the retailer's facilitation decision is still the same as the supplier's on two ends of the (b, t) spectrum: The retailer will also choose to facilitate products with high dispersion and highly informative prefacilitation information (i.e., the F-F case in Figure 2), and choose not to facilitate products with low dispersion and low informative prefacilitation information (i.e., the NF-NF case in Figure 2). According to Lemma 2, a higher dispersion will amplify the first-stage demand augmentation and thus lessen the equilibrium demand reduction. For a

Figure 2. The Supplier's and the Retailer's Incentive to Facilitate Under the Agency Pricing Model



product with sufficiently high dispersion, the equilibrium demand reduction will be lessened to a degree such that it will be outweighed by the augmentation in both parties' equilibrium margin, leading both parties' profit to increase after facilitation. On the other hand, a sufficiently low dispersion will worsen the first-stage demand reduction to an extent that makes equilibrium demand reduction outweigh the augmentation in both parties' equilibrium margin. In such a case, both parties are worse off with facilitation. However, when the dispersion is medium or high and prefacilitation information is moderately informative, the two parties' facilitation decisions are set apart, and the supplier chooses to facilitate while the retailer chooses not to (i.e., F-NF case in Figure 2). To explain this result, we present the following special case.

Corollary 1 (Condition for Identical Facilitation Decisions in the Agency Pricing Model). *When $c_S < c_{S1}^A$, the retailer's facilitation decision, i.e., to facilitate or not, is identical to the supplier's for products with all different levels of dispersion and informativeness of prefacilitation information when and only when $c_R/s = c_S/(1-s)$.*

When $c_R/s = c_S/(1-s)$, the retailer's margin $m_i^{R,A}$ is proportional to the supplier's $m_i^{S,A}$at a constant rate (i.e., $m_i^{R,A}/m_i^{S,A} = (1-s)/s$) for *any* level of dispersion at *any* retail price, the distribution channel is essentially coordinated by this condition (Cachon and Lariviere 2005). Any upward price adjustment will lead to the same amount of percentage change in the supplier's margin as in the retailer's margin. Hence, their facilitation decisions are identical.

Nonetheless, the special case $c_R/s = c_S/(1-s)$, i.e., $s = (1-s)c_R/c_S$, in Corollary 1 rarely holds for a profit-maximizing monopolistic retailer. The reason is that the retailer cannot capitalize on a relatively low marginal cost if she settles with $s = s^{CO} = (1-s)c_R/c_S$. Note that s^{CO} increases in the retailer's marginal cost c_R (i.e., $ds^{CO}/dc_R > 0$). Hence, if $s = s^{CO}$, the lower marginal cost the retailer has, the fewer revenue shares she will take from the channel profit. In an extreme case where the retailer's marginal cost is zero (i.e., where $c_R = 0$)), the retailer will make zero revenue. Therefore, $s > s^{CO}$is more plausible than any other possibilities, i.e., $c_R < s \cdot c_S/(1-s)$.

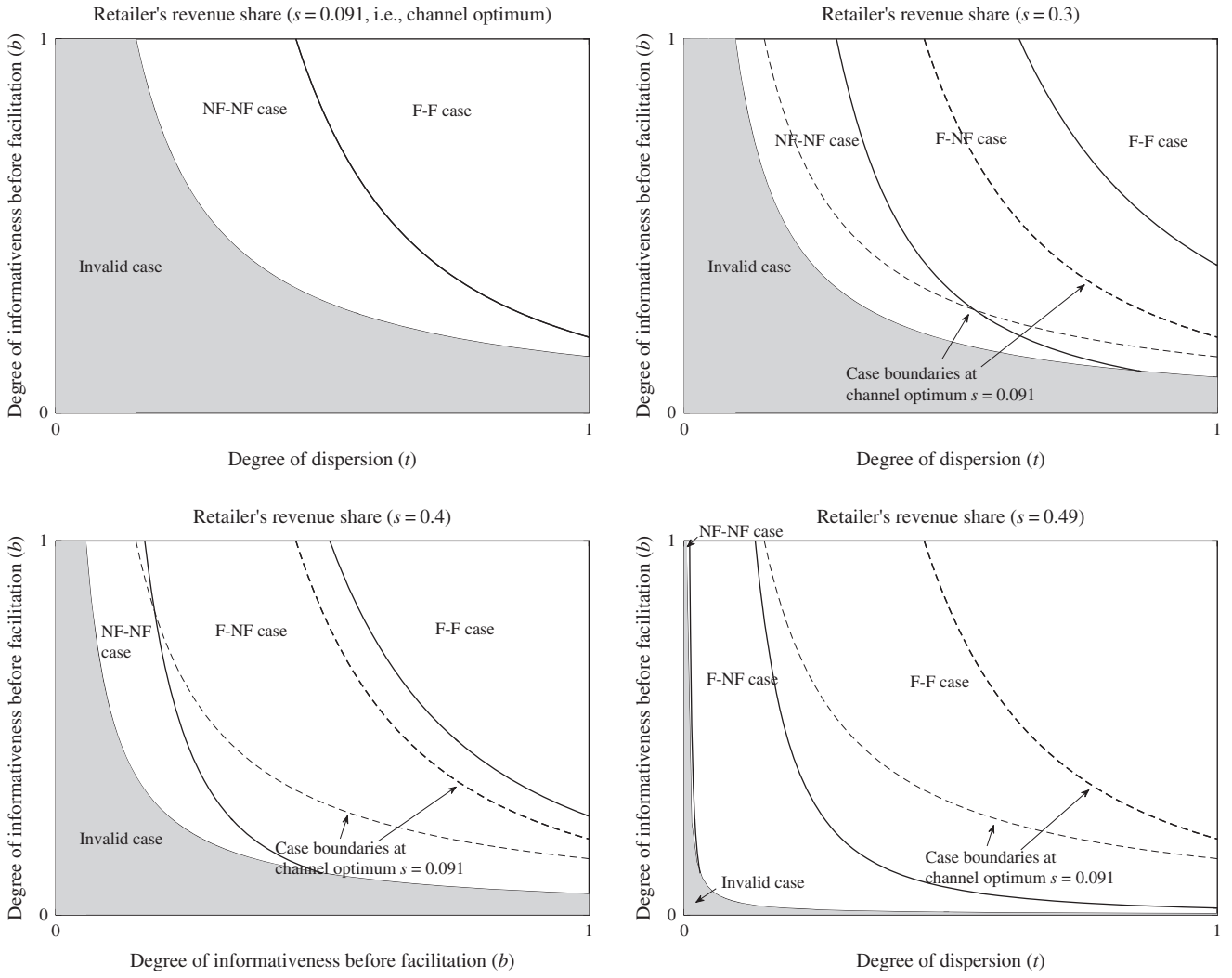
Note that our assumption on marginal costs[4] (i.e., $c_R < (s/2)\cdot(1/3 + c_S/(1-s))$ and $c_S > (1-s)/3$) is a sufficient condition for $c_R < s \cdot c_S/(1-s)$. In such a case, any upward price adjustment will incur a *higher* percentage increase in the supplier's margin than it incurs to the retailer's: The supplier's relatively higher marginal cost sets the absolute value of his margin to be relatively low before facilitation. Therefore, when the upward price adjustment causes the supplier to break even after facilitation, i.e., the percentage increase in the supplier's margin equals the percentage reduction in equilibrium demand, the percentage increase in the retailer's margin is still in deficit to cover such equilibrium demand reduction. Therefore, the retailer will not choose to facilitate at the time the suppliers chooses to.

Essentially, the agency pricing model fails to reconcile the disproportional percentage changes in the two parties' margins during facilitation because the revenue sharing percentage (i.e., $s = s^{CO}$) needed to proportionally vary the margins conflicts with the retailer's incentive to exploit her low marginal cost. Although a coordinated distribution channel is required to coordinate the two parties' facilitation decision for products with all different levels of (b,t), to induce both parties to facilitate for a product with a *given* level of (b,t), an uncoordinated distribution channel may actually be helpful.

Figure 3 shows the impact of revenue sharing percentage s on the distribution of the F-F, the F-NF, and the NF-NF case. When s starts to increase from channel optimum s^{CO}, the F-NF case starts to appear. As s increases beyond an intermediate threshold, the F-NF case moves toward the low (b,t) region and eventually shrink. Meanwhile, the F-F case starts to expand, including further lower (b,t) region. Once s reaches beyond a certain threshold, it becomes sufficient to include a product with the given (b,t) in the F-F case.

Recall supplier's margin $m_i^{S,A} = p_i^A(1-s) - c_S$ $(i \in \{F, NF\})$. Because the supplier dictates retail price p_i^A in the agency pricing model, he essentially acts like a firm with equivalent marginal cost $c_S/(1-s)$. A higher retailer's revenue sharing percentage s boosts such supplier's equivalent marginal cost and thus leads him to charge a higher retail price before facilitation (i.e., $dp_{NF}^{A^*}/ds > 0$). This will amplify the first-stage demand augmentation and thus lessen the equilibrium demand reduction according to Lemma 1. When s is beyond a certain level, the equilibrium demand reduction is lessened to a degree that it will be dominated by both parties' equilibrium margin augmentation, leading both parties' profits to increase after facilitation. On the other hand, a higher s is detrimental to coordinating two parties' facilitation decision according to Corollary 1: The percentage changes of the two parties' margins become even more disproportional. Essentially, revenue sharing percentage s plays dual roles in the context of facilitating information disclosure, a *demand-side* role that determines how significant the equilibrium demand reduction will be, and a *supply-side* role that determines how disproportional the two parties' equilibrium margin augmentation will be. If the goal is to encourage both parties to facilitate product disclosure, the supply-side role requires s to be relatively low (e.g., close to s^{CO} such that the F-NF case shrinks) while the demand-side role requires s to be relatively high, i.e., the F-F case expands.

Figure 3. Redistribution of Facilitation Cases When Retailer's Revenue Share Increases



4.2. Wholesale Pricing Model

Proposition 2 (Retailer's Facilitation Decision in the Whole Pricing Model). *The retailer will choose to facilitate when the channel marginal cost is relatively high (i.e., $c_C > 1/2$). When it is relatively medium (i.e., $3/7 < c_C < 1/2$), she will choose to facilitate when* (i) *the product is high dispersion (i.e., $t_2^{R,W} < t < 1$), or* (ii) *the product is medium dispersion and the prefacilitation information is highly informative (i.e., $t_1^{R,W} < t < t_2^{R,W}$ and $b_1^{R,W} < b < 1$). When the channel marginal cost is relatively low (i.e., $c_C < 3/7$), she will choose to facilitate when $t_1^{R,W} < t < 1$ and $b_1^{R,W} < b < 1$. In any other market condition, the retailer will not choose to facilitate. The above thresholds are*

$$t_1^{R,W} = 1 - 2c_C, \quad t_2^{R,W} = 7(1 - 2c_C) \quad \textit{and}$$
$$b_1^{R,W} = \frac{(1 - 2c_C)^2}{t^2}.$$

Comparing Proposition 2 with Lemma 2, we find that when the channel marginal cost is relatively medium or high (i.e., $c_C > 3/7$), the market conditions for the retailer to facilitate in the wholesale pricing model are qualitatively the same as the conditions for the supplier to facilitate in the agency pricing model. The difference is that the conditions here, instead of depending on the supplier's marginal cost, depend on the channel marginal cost. This is because, in the agency pricing model, only the supplier's marginal cost will affect the retail price due to the supplier's retail price control, while in the wholesale pricing model, the supplier's and the retailer's marginal cost will affect the retail price because of double marginalization. We discuss the rationale behind the results when the channel marginal cost is relatively low (i.e., $c_C < 3/7$) in Proposition 7 in Section 5.

Proposition 3 (Comparison of the Two Parties' Facilitation Decisions in the Wholesale Pricing Model). *When the true valuation distribution is uniform and thus leads to a linear demand, the supplier and the retailer make identical facilitation decisions for products with all different levels of*

dispersions and all different levels of informativeness of prefacilitation information in the wholesale pricing model.

When the demand is linear, the retailer's equilibrium margin is proportional to the supplier's at a constant rate, which is independent of c_R, c_S and t (i.e., $m_F^{R,W*}/m_F^{S,W*} = 1/2$). Bresnahan and Reiss (1985) have documented this proportional relationship between the two parties' equilibrium margins in the wholesale pricing model. Essentially, the retailer's marginal cost in the wholesale pricing model will be negatively passed into the supplier's equilibrium wholesale price (i.e., $dw_i^{W*}/dc_R < 0$) due to the negative externality caused by the retailer's pricing right on the supplier's demand. Therefore, when the retailer's marginal cost increases, not only the retailer's equilibrium margin but also the supplier's equilibrium margin will decrease because of the reduced wholesale price. On the other hand, when the supplier's marginal cost increases, not only will the supplier's equilibrium margin decrease but the retailer's equilibrium margin will also decrease due to the increased wholesale price, which offsets the retailer's margin. Eventually, double marginalization prevents any increase or decrease in one party's marginal cost from only reducing or boosting that party's margin, but instead makes two margins co-vary in the same direction. When the demand is linear, this co-variation of two margins becomes exactly proportional, leading to identical facilitation decisions.

Corollary 1 shows that in the agency pricing model, such constant equilibrium margin ratio only holds when marginal costs c_R and c_S satisfy $c_R/s = c_S/(1-s)$. Hence, we can see an interesting distinction between the two models in the context of facilitation. In the wholesale pricing model, double marginalization leads to identical facilitation decisions at the two parties' profit-maximizing choices even though the distribution channel is not coordinated at this time. In the agency pricing model, a coordinated distribution channel is required to coordinate the two parties' facilitation decision. The revenue sharing mechanism in the agency pricing model essentially ties the requirement for reaching identical facilitation decisions to the requirement for coordinating the distribution channel.

Note that all the results we have derived so far for both supply chain contracts are based on linear demand functions. These results may need to be revised when the demand function is not linear. In Proposition 4, we generalize our key finding to a category of non-linear demand functions. Denote the curvature of a demand function $D(\cdot)$ by κ and by definition $\kappa = D''D/(D')^2$.

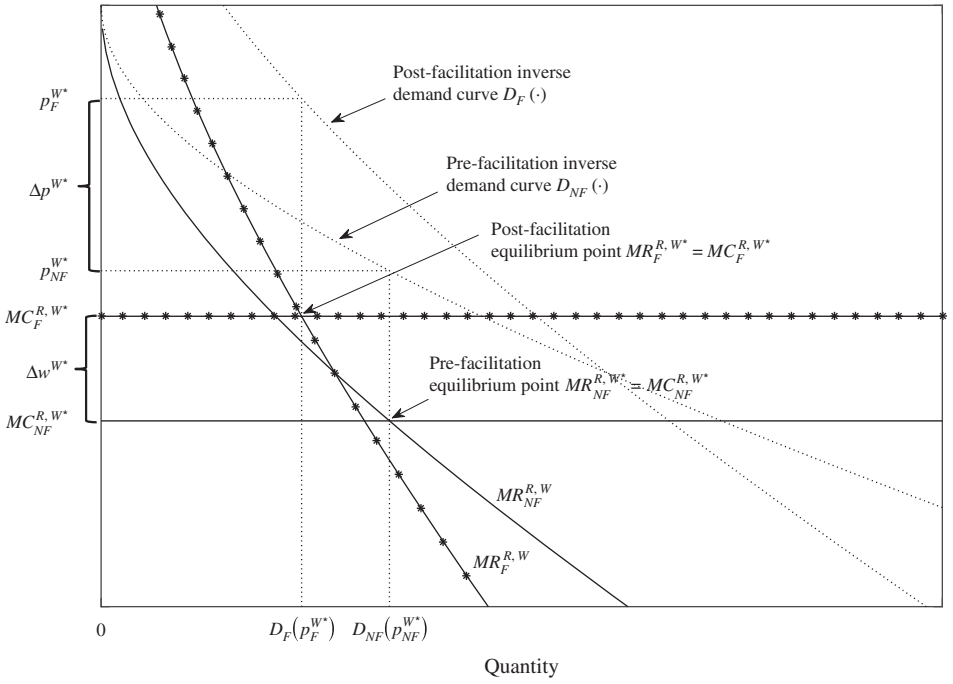
Proposition 4 (Agency Pricing vs. Wholesale Pricing Under Log-Concave Demand). *When the true valuation distribution leads to a log-concave demand function D_F with its positive curvature increasing in price (i.e., $0 < \kappa_F < 1$ and $d\kappa_F/dp_F > 0$), more information disclosure benefits the supplier and hurts the retailer in the agency pricing model* whereas *the same scenario benefits the retailer and hurts the supplier in the wholesale pricing model, if it benefits one and only one of the two parties.*

We call those situations with only one beneficiary of information disclosure a *misaligned* case. Hence, neither the F-F case nor the NF-NF case is considered in Proposition 4. Proposition 4 also makes the following generalizations: First, the degree of informativeness does not have to reach full discovery (i.e., $\beta_F = 1$) after facilitation; it can be any point between prefacilitation informativeness and full discovery (i.e., $b < \beta_F < 1$). Second, Proposition 4 replaces the requirement for the true valuation distribution to be uniform with a new requirement, i.e., that any distribution that must lead to a log-concave demand function with positive curvature increasing in price.[5] Log-concavity essentially shows that the demand function is more convex than linear demand function but less convex than exponential demand function.

For the agency pricing model, the result under the log-concave demand remains the same as that under the linear demand in Proposition 1, i.e., the supplier benefits from more information discourse and thus has incentive to facilitate while the retailer suffers and thus has no incentive to facilitate. This is because the key condition for this result, i.e., the second-stage upward price adjustment incurs a *higher* percentage increase in the supplier's margin than in the retailer's, still holds under the log-concave demand due to the revenue sharing mechanism and the retailer's low marginal cost. For the wholesale pricing model, however, the two parties' incentives on information discourse are no longer identical. Instead, the retailer benefits from more information disclosure while the supplier suffers. Note that this new direction of the misalignment in the wholesale pricing model is exactly the *opposite* of that in the agency pricing model. The direct reason is that the second-stage upward price adjustment incurs, instead of a higher percentage increase in the agency pricing model, a *lower* percentage increase in the supplier's margin compared to the retailer's, or equivalently, a higher retailer-to-supplier equilibrium margin ratio $m_F^{R,W*}/m_F^{S,W*}$.

We find that whether ratio $m_F^{R,W*}/m_F^{S,W*}$ will increase with more information disclosure depends on whether the retailer's marginal revenue becomes less sensitive to the retail price (i.e., $dMR^{R,W*}/dp^{W*}$) during the same course. Suppose, after the demand curve rotation, the supplier increases the wholesale price by one unit. To regain the equality between her marginal cost and her marginal revenue, the retailer must raise the retail price and hence lift her marginal revenue to cover that one-unit increase in her gross marginal cost caused by the supplier. If her marginal revenue becomes less (more) sensitive to the retail price, the retailer must raise the retail price by a large (small) amount to

Figure 4. Interplay Between Double Marginalization and Information Disclosure Facilitation



fulfill the need to lift her marginal revenue, thus leading to a higher (lower) ratio $m^{R,W*}/m^{S,W*}$ after facilitation. Figure 4 illustrates a scenario wherein ratio $m^{R,W*}/m^{S,W*}$ increases after facilitation. We can see that the magnitude of the retailer's equilibrium price change (i.e., Δp^{W*}) is greater than that of the wholesale equilibrium price change (i.e., Δw^{W*}) in the figure.

Tyagi (1999) demonstrated that this sensitivity $dMR^{R,W*}/dp^{W*}$ is determined by the curvature of demand. Specifically, he shows that $dMR^{R,W*}/dp^{W*} = 2 - \kappa^*$ where κ^* denotes the curvature of demand at price point p^{W*}. Therefore, if curvature of demand κ^* increases after facilitation, sensitivity $dMR^{R,W*}/dp^{W*}$ decreases and hence ratio $m^{R,W*}/m^{S,W*}$ increases. The following proposition shows that curvature of demand κ^* will increase after facilitation when and only when the equilibrium demand drops. Note that the requirement for demand function D_F is the same as that in Proposition 4.

Proposition 5 (Impact of Information Disclosure on Curvature of Demand). *If* (i) *demand function D_F is log-concave with its positive curvature κ_F increasing in price* (*i.e.*, $0 < \kappa_F < 1$ *and* $d\kappa_F/dp > 0$) *and* (ii) *the inverse demand curve of D_F is a mean-preserving clockwise rotation* from *that of D_{NF}. The curvature of a demand curve of D_F at price point p_F is higher than the curvature of a demand curve of D_{NF} at price point p_{NF} when and only when the demand D_F at p_F is lower than the demand D_{NF} at p_{NF}, i.e., $\kappa_F > \kappa_{NF}$ when and only when $D_F(p_F) < D_{NF}(p_{NF})$.*

Note that Proposition 5 itself does not require equilibrium prices: p_F and p_{NF} can be any legitimate price points on demand curve D_F and D_{NF}, respectively. First, we find that the two parties benefit from facilitation at the same time only when the equilibrium demand increases after facilitation (i.e., $D_F(p_F^{W*}) > D_{NF}(p_{NF}^{W*})$). The retailer, if she suffers from facilitation yet $D_F(p_F^W) > D_{NF}(p_{NF}^W)$, can further increase the retail price to reach the state $D_F(p_F^W) = D_{NF}(p_{NF}^W)$ where her margin $m^{R,W*}$ is higher than that before facilitation due to (i) higher retail price p^{W*} and (ii) same $dMR^{R,W*}/dp^{W*}$ because of $D_F(p_F^W) = D_{NF}(p_{NF}^W)$. This guarantees that the increased wholesale price cannot overturn the increase in the retailer's margin led by higher p^{W*}. Second, the supplier cannot be worse off when $D_F(p_F^{W*}) > D_{NF}(p_{NF}^{W*})$ because otherwise he can raise the wholesale price to induce the retailer to at least reach $D_F(p_F^W) = D_{NF}(p_{NF}^W)$ where his margin increases and the demand remains the same.

Hence, the misaligned case must occur with a decline in the equilibrium demand. According to Proposition 5, this decline causes curvature of demand κ^* to increase after facilitation (i.e., $\kappa_F^* > \kappa_{NF}^*$) and hence the sensitivity $dMR^{R,W*}/dp^{W*}$ drops after facilitation. This leads to a higher equilibrium marginal ratio $m_F^{R,W*}/m_F^{S,W*}$ after facilitation. Consequently, the retailer benefits from more information while the supplier does not benefit when there is only one beneficiary in the wholesale pricing model.

5. Impact of Product Quality on Facilitation Decisions

Product quality is a feature of the preference order on which all consumers agree: Consumers prefer high

quality to low quality, all other factors fixed (Kwark et al. 2014, 2017). Hence, a higher (lower) product quality essentially shifts out (in) the inverse demand curve. To reflect this, in this section we vary the distribution parameter q to indicate different levels of product quality, i.e., a high (low) product quality is associated with a high (low) value of q. Correspondingly, we update our assumptions to $(1-s)(3q-1)/6 < c_S < (1-s)(q+1)/2$ and $c_R < (s/2)\cdot(q/2-1/6+c_S/(1-s))$ for the agency pricing model, and $c_S + c_R < (q+1)/2$ for the wholesale pricing model. If $q = 1$, those assumptions reduce to those used in previous sections. Meanwhile, to avoid the market being fully covered before facilitation, we assume that q is not excessively high, i.e., $q < 3$ in the agency pricing model and $q < 7$ in the wholesale pricing model.

Proposition 6 (Supplier's and Retailer's Facilitation Decision in the Agency Pricing Model). *The supplier and the retailer will choose to facilitate when the supplier's marginal cost is higher than a certain threshold (i.e., $c_S > \tilde{c}^A_{S1}$). Otherwise (i.e., $c_S \le \tilde{c}^A_{S1}$),*

- *the supplier will choose to facilitate when* (i) *the product is high dispersion (i.e., $\tilde{t}_2^{S,A} < t < 1$), or* (ii) *the product is medium dispersion and the prefacilitation information is highly informative (i.e., $\tilde{t}_1^{S,A} < t < \tilde{t}_2^{S,A}$ and $\tilde{b}_1^{S,A} < b < 1$). In any other market condition, the supplier will not choose to facilitate;*
- *the retailer will choose to facilitate when* (i) *the product has high dispersion,* (ii) *prefacilitation information is highly informative (i.e., $\tilde{t}_1^{R,A} < t < 1$ and $\tilde{b}_1^{R,A} < b < 1$), and* (iii) *either of the following conditions RA*1 *or RA*2 *holds*:

*Condition RA*1: *the product quality is relatively low (i.e., $1 < q < 5/3$).*

*Condition RA*2: *the product quality is relatively high (i.e., $5/3 < q < 3$), plus the supplier's marginal cost is relatively high (i.e., $\tilde{c}^A_{S2} < c_S \le \tilde{c}^A_{S1}$), or the supplier's marginal cost is relatively low and the retailer's is relatively high (i.e., $c_S \le \tilde{c}^A_{S2}$ and $c_R > \tilde{c}^A_{R1}$).*

In any other market condition, the retailer will not choose to facilitate. The above thresholds are

$$\tilde{t}_1^{S,A} = q - \frac{2c_S}{1-s}, \quad t_2^{S,A} = 3\left(q - \frac{2c_S}{1-s}\right),$$

$$\tilde{t}_1^{R,A} = \frac{\sqrt{s((1-s)q-2c_S)(s((1-s)q+2c_S)-4(1-s)c_R)}}{s(1-s)},$$

$$\tilde{b}_1^{S,A} = \frac{(2c_S+(s-1)q)^2}{t^2(1-s)^2},$$

$$\tilde{b}_1^{R,A} = \frac{((1-s)q-2c_S)(s((1-s)q+2c_S)-4(1-s)c_R)}{st^2(1-s)^2},$$

$$\tilde{c}^A_{S1} = \frac{q(1-s)}{2}, \quad \tilde{c}^A_{S2} = \frac{(1-s)\sqrt{q^2-1}}{2} \quad \text{and}$$

$$\tilde{c}^A_{R1} = \frac{s}{4}\left(q - \frac{2c_S}{1-s}\right).$$

Comparing Proposition 6 with Proposition 1 and Lemma 2, we find that product quality does not affect the qualitative profile of the supplier's facilitation decisions; he will still facilitate when the product (i) is high dispersion, or (ii) is medium dispersion with highly informative prefacilitation information. In fact, the supplier's results in Proposition 6 reduces to those in Lemma 2 if $q = 1$. However, product quality does not affect the qualitative profile of the retailer's facilitation decisions only when it is relatively low (i.e., condition RA1). When product quality is relatively high (i.e., condition RA2), the retailer will choose not to facilitate regardless of dispersion and prefacilitation information if the supplier's and the retailer's marginal costs are relatively low (i.e., $c_S < \tilde{c}^A_{S2}$ and $c_R < \tilde{c}^A_{R1}$). This is because a higher product quality shifts out the inverse demand curve. According to Figure 1, holding other factors constant, higher product quality tends to push the market to low-valuation-consumer-overload condition, which discourages facilitation. A lower supplier's marginal cost tends to achieve the same outcome. In addition, a lower retailer's marginal cost further diminishes the percentage increase in the retailer's margin during second-stage upward price adjustments. These three factors work together in the same direction to dominate any influence from a higher dispersion and more informative prefacilitation information that will give the retailer incentive to facilitate.

Proposition 7 (Supplier's and Retailer's Facilitation Decision in the Wholesale Pricing Model). *When the demand is linear, the supplier and the retailer make identical facilitation decisions regardless of product quality. Specifically, they will always choose to facilitate when the channel marginal cost is relatively high (i.e., $c_C > q/2$). When it is relatively medium (i.e., $(7q-1)/14 < c_C < q/2$), the retailer will choose to facilitate when* (i) *the product is high dispersion (i.e., $\tilde{t}_2^{R,W} < t < 1$), or* (ii) *the product is medium dispersion and the prefacilitation information is highly informative (i.e., $\tilde{t}_1^{R,W} < t < \tilde{t}_2^{R,W}$ and $\tilde{b}_1^{R,W} < b < 1$). When the channel marginal cost is relatively medium-low (i.e., $(q-1)/2 < c_C < (7q-1)/14$), she will choose to facilitate when $\tilde{t}_1^{R,W} < t < 1$ and $\tilde{b}_1^{R,W} < b < 1$. In any other market condition, the retailer will not choose to facilitate. The above thresholds are*

$$\tilde{t}_1^{R,W} = q - 2c_C, \quad \tilde{t}_2^{R,W} = 7(q-2c_C) \quad \text{and}$$

$$\tilde{b}_1^{R,W} = \frac{(q-2c_C)^2}{t^2}.$$

We find that product quality does not affect the qualitative profile of the supplier's and the retailer's facilitation decisions in the wholesale pricing model. Note that Proposition 7 reduces to Proposition 2 and Proposition 3 if $q = 1$. Nonetheless the impact of product quality on facilitation decisions is evident when it grows very high relative to the channel marginal cost, i.e., $c_C < (q-1)/2$, or equivalently $q > 1 + 2c_C$.

Both parties will not choose to facilitate regardless of dispersion and prefacilitation information. The rationale is similar to the case wherein the supplier's and the retailer's margins are low in the agency pricing model: High product quality and low channel marginal cost together push the market into such a significant low-valuation-consumer-overload condition that will dominate any influence from a higher dispersion product and more informative prefacilitation information. When the channel marginal cost is relatively medium-low (i.e., $(q-1)/2 < c_C < (7q-1)/14$, or $c_C < 3/7$ in Proposition 2), or equivalently the product quality is relatively medium-high, product quality has not reached a level that completely dominates the influence from dispersion and prefacilitation information. Nonetheless, dispersion and prefacilitation information have to jointly pull the market toward the high-valuation-consumer-underload condition to incentivize both parties to facilitate (i.e., $\tilde{t}_1^{R,W} < t < 1$ and $\tilde{b}_1^{R,W} < b < 1$).

6. Discussion and Conclusions

Our study investigates a supplier's and a retailer's incentives to facilitate information disclosure under two supply chain contracts, i.e., the agency pricing model and the wholesale pricing model. We provide several practical insights. First, we have identified two primary factors that affect two parties' interest in disclosure, i.e., (i) the supplier's marginal cost of the product, and (ii) the quality of the product. When the supplier's marginal cost is sufficiently high, the supplier and the retailer will benefit from more information disclosure regardless of other factors such as (i) which contract type, agency or wholesale pricing, is chosen for the distribution channel, (ii) the existing level of disclosure or (iii) the level of consumers' heterogeneity in terms of their true valuations of the product. When the product's quality is sufficiently high, the two parties will be hurt by more disclosure, also regardless of the aforementioned factors. In the other market conditions, factors such as the degree of heterogeneity in consumers' true product valuations and the choice of the channel contract type start to play important roles in determining the two parties' interest in disclosure and the alignment of their interests. For products with moderate or high heterogeneity in consumers' valuation and with a mediocre existing level of disclosure (e.g., apparel or shoes with product descriptions and consumer reviews that do not reveal the exact fit to individual consumers) the two parties might have conflicting interests as to disclosure depending on the contract type. Hence, the retailer and the supplier should check the supply chain contract to determine who will be hurt by more information disclosure: In the agency pricing model it is the retailer, while in the wholesale pricing model, it is the supplier under commonly seen non-linear demand curves.

Our study also sheds light on how to reconcile such misalignment of interests if it happens. There is a case where the two parties' interests are always aligned, i.e., when the distribution channel is coordinated. While research studies of channel coordination have shown that it is not easy to achieve coordination by using basic contracts with a limited number of parameters, our results provide an additional justification for investing efforts in this area: Coordination not only improves the channel efficiency but also aligns the two parties' interests in disclosure. Nonetheless, note that an uncoordinated channel does not always end the game: The wholesale pricing model under linear product demand also guarantees to coordinate the two parties' interests in disclosure. Hence, when channel coordination is difficult to achieve but the demand is approximately linear, the retailer and the supplier may want to consider opting for the wholesale pricing model if disclosing product information is crucial for successful product sales.

In our study, we posit the retailer's revenue sharing percentage to be exogenous because we believe the degree of informativeness of product information can vary in a short time while revenue sharing percentage is a long-term parameter that is contractually fixed at the time a supplier agrees to sell. Therefore, a revenue sharing percentage is unlikely to respond to change of degree of information disclosure. In addition, an online retail platform's choice of a revenue sharing percentage is significantly driven by factors outside our model. For example, Amazon.com may want to set a revenue sharing percentage that can induce a healthy number of participating suppliers who help the company to exploit the cross-side externality of a two-sided market. Still, since our study does not focus on any market dynamics driven by two-sidedness, we choose not to pursue an endogenous revenue sharing percentage.

Note also that our model does not take into account the cost of facilitating information disclosure. What happens if facilitation is costly to the retailer? In the agency pricing model, facilitation will reduce the percentage increase in the retailer's margin in a way that leads the percentage increase in the supplier's margin to exceed the retailer's increase by a greater amount. Hence, the misalignment result in the agency pricing model remains the same, i.e., the supplier benefits from more information disclosure while the retailer suffers whenever they have opposing interests in disclosure. In the wholesale pricing model, the retailer will consider facilitation cost as her additional marginal cost. Therefore, at the second stage of the game where the wholesale price is already given, she will raise the retail price by a greater amount compared to the case with no facilitation cost. Foreseeing such retailer's response

in the second stage, the supplier in the first stage will reduce his increase in the wholesale price to avoid excessive demand reduction. This would eventually lead the percentage increase in the retailer's margin to exceed the supplier's increase by a greater amount compared to the case with no facilitation cost. Hence, the misalignment result in the whole pricing model also remains the same, i.e., the retailer benefits from more information disclosure while the supplier suffers whenever they have opposing interests in disclosure. Admittedly, the retailer will refuse to facilitate information disclosure in some cases, e.g., where facilitation is more costly than in earlier instances. However, interestingly, the retailer's facilitation cost may not affect our key insights, i.e., (i) which party in a distribution channel wants consumers to be more informed when that benefits one and only one party, and (ii) how the answer to question (i) depends on the choice between the agency pricing model and the wholesale pricing model. Therefore, we follow other literature on information disclosure (Kwark et al. 2014, 2017; Sun 2011) and adopt zero cost of facilitation.

There are a few limitations to our study. Here, we consider how all product related information, revealed by the supplier or the retailer, through product description or consumer review, will affect the consumers' willingness to pay distribution through a single parameter, i.e., the degree of informativeness of information. In a real world setting, however, the two parties may have access to different information related to the same product, and information owned by different parties may not be identically helpful to consumers. A more granular study could investigate the specific ways in which the information owned by different parties jointly determines the degree of informativeness. We also acknowledge, as a limitation of our study, the absence of a full analysis of how facilitation cost complicates interplay between information disclosure facilitation and supply chain contracts. We believe this is an avenue for future research.

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Endnotes

[1] We relax the assumption of uniform distribution in Proposition 4.

[2] In Proposition 4 we relax the requirement for $\beta_F = 1$ and show that our main insights hold for any $b < \beta_F \leq 1$.

[3] When the true valuation distribution follows other common distributions such as normal or logistic and thus leads to log-concave demand, we find $d\Delta^A_{D,p}/dc_S > 0$, which is a stronger result that supports our conclusion. See Proposition 4 for detailed requirements for qualified distributions.

[4] The literature often assumes that the retailer's marginal product cost is zero, which is a stronger condition to $c_R < (s/2) \cdot (1/3 + c_S/(1-s))$ and $c_R < s \cdot c_S/(1-s)$.

[5] A broad set of commonly used distributions fulfill this requirement, for example, normal, logistic, Gumbel, Gamma distribution with shape parameter greater than 1, etc. Fabinger and Weyl (2016) provided a detailed list of distributions that satisfies such a requirement with corresponding mathematical proofs in their online appendix.

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