Games of Supplier Encroachment Channel Selection and E-tailer's Information Sharing

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Abstract: We consider an e-tailer's upstream supplier who wants to encroach into retailing to earn additional revenue. The supplier needs to decide whether or not to enter the retail market by either selling to consumers on the e-tailer's platform by paying commission fees (agency encroachment) or opening an independent online/offline retail store (direct encroachment). The e-tailer has private demand information and decides whether or not to share it with the supplier. Two leadership scenarios—the supplier-leads (i.e., the supplier selects the channel *before* the e-tailer decides whether to share information) and the e-tailer-leads (i.e., the supplier selects the channel *after* the e-tailer decides whether to share information)—are examined. Our main findings are as follows. First, we show that the e-tailer has no incentive to share information under no encroachment and direct encroachment. Interestingly, this result holds in both leadership scenarios. Second, a medium commission rate gives rise to an equilibrium of agency encroachment with information sharing by the e-tailer. This equilibrium is more likely to sustain in the supplier-leads scenario than in the e-tailer-leads scenario. Third, agency encroachment brings the supplier the highest sales volume (at retail in the encroaching channel plus on wholesale to the e-tailer) when the two parties compete in quantity while direct encroachment does so for a price competition. Fourth, supplier encroachment always improves consumer surplus, but it is not necessarily welfare-improving. Last, we find that the e-tailer is more willing to share information to induce the supplier to encroach through his agency channel if he has a significant selling cost advantage over the supplier or can endogenously determine the commission rate.

Keywords: Supplier Encroachment; Direct Channel; Agency Channel; Information Sharing

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1 Introduction

Thanks to big data and mobile technology development, online platform retailing has become a powerful and popular sales method. Mobile apps allow consumers to easily browse product information and order through a platform or an e-tailer[1]. That, in turn, produces massive data that can help predict the demand of the downstream market (Liu et al. 2021a). Some examples of big e-tailers are JD in China, Amazon in the U.S., and Flipkart in India. The interactions between an e-tailer and consumers benefit both in the sense that the consumers can satisfy their demands quickly and conveniently, and the e-tailer makes a profit as well as acquires the big consumer data produced from these interactions, a win-win situation for both. Many e-tailers reselling suppliers' products also offer additional sales channels whereby suppliers can retail their products to end consumers. For example, half of Amazon's revenue is from buying suppliers' products at wholesale and retailing them to consumers. The other half is from third-party sellers and other services (MarketplacePulse 2020).

Understandably, in the reselling scheme, a supplier is distant from end consumers and lacks the flexibility to set prices. Considering this, a phenomenon called supplier encroachment arises in practice. It means that a supplier (she) already wholesaling her product to an e-tailer (he) expands her market demand by retailing the product in the end market. Usually, a supplier compares respective expected profits under no encroachment and encroachment to determine whether or not to retail the product. Without encroaching, the supplier's revenue is only from wholesaling to the e-tailer; with encroachment, she also earns revenue from retail. When encroaching, we examine the supplier's direct or agency channel choice. A practical instance of direct channel encroachment (or simply *direct encroachment*) is the Chinese smartphone manufacturer OnePlus, which wholesales mobile phones to JD for resale and also sells directly to the end consumers on its online OnePlus store[2] (JD.com-Corporate-Blog 2018). Also, Lee Kum Kee, a Hong Kong-based food company, wholesales its products to HKSuning.com and operates its online store[3] to retail its products directly to consumers. On the other hand, in the agency channel encroachment (or simply *agency encroachment*), the e-tailer gives the supplier another choice of retailing on commission. It is exemplified by Zi Hai Guo, a Chinese producer of the convenient self-cooking hotpot, who wholesales to JD and directly sells via the online platform of JD. Other examples are HLA and MINISO[4].

[1] These online platforms are called e-tailers. See https://www.collinsdictionary.com/us/dictionary/english/e-tailer and https://dictionary.cambridge.org/us/dictionary/english/e-tailer for references.

[2] See website https://www.oneplus.com/cn.

[3] See website https://shop.lkk.com/.

[4] HLA, an international one-stop menswear retail brand, has both an official website(https://hla.jd.com/) and an HLA store operated by JD(https://mall.jd.com/index-1000093192.html). The former adopts a

As both encroachment types are observed in practice, it motivates us to address the following research questions: *When would a supplier encroach into the downstream market? If yes, then through which channel (direct or agency)?* We note that studies are devoted to supplier encroachment or channel management. For instance, Arya et al. (2007), Xu et al. (2010), Huang et al. (2018), and Liu et al. (2021) consider only direct encroachment, whereas Tsunoda and Zennyo (2021) and Ha et al. (2022) consider agency encroachment. However, none to our knowledge consider choosing between the two encroachment channels. We study encroachment channel selection that can help us understand how the parties' profits are affected when a supplier also considers direct encroachment along with an agency channel option offered to her by an e-tailer.

Information technology helps companies effectively share information, which, as confirmed by empirical studies, can increase a supply chain's agility and improve its responsiveness to changing market needs (Swafford et al. 2008). As discussed above, e-tailers such as JD collect big data (for example, consumers' browsing and purchasing data) and can tease out implicit demand information (JD.COM 2019). With this private demand information, an e-tailer can use it to motivate a supplier to establish the agency channel on its platform and thus earn commission fees. Or, the supplier can open a direct channel and avoid commission fees at the cost of operating its own offline/online store. While the e-tailer's information sharing can improve the attractiveness of an agency encroachment, it may also lead to head-to-head competition between him and the supplier in the end market. Notably, an e-tailer may have different policies for sharing information with different suppliers. For instance, JD started to share data with Media in 2013 but started to share data with Dell only in 2016 (Ha et al. 2022). That motivates us to study also the questions: *Will an e-tailer share his demand information? Is sharing information a helpful tool for affecting a supplier's channel selection?*

In practice, certain platform information is exclusively accessible to merchants who establish a store through that platform—for example, JD Business Intelligence[5], JD's official data analysis platform, is accessible to JD's agency-selling merchants only. As Ha et al. (2022) point out, the channel structure is often a long-term strategy, while the e-tailer's information sharing is medium-term. The business practices mentioned above and in the literature indicate that information can be shared *after* a seller selects the agency scheme. On the other hand, there are situations where an e-tailer commits to information sharing to influence a supplier's encroachment channel selection decision (see, e.g., Arya and Mittendorf 2013, Huang et al. 2018). That is, information sharing happens *before* a supplier

revenue-sharing contract and the latter makes a wholesale price contract. MINISO has a store operated by JD (https://minisomz.jd.com/) and its official website (https://mall.jd.com/index-713072.html?from=pc).

[5]See https://sz.jd.com/.

decides on the channel structure. As the specific information sharing timings studied in the existing literature also co-exist in business practice, it motivates us in our quest for a deeper understanding of adopting these timings by the supply chain parties. Specifically, we are interested in *how the timing of information sharing interacts with the supplier's channel selection.*

To answer these questions, we consider a supply chain involving one e-tailer and one supplier. The e-tailer is an e-commerce firm (e.g., JD or Amazon) having private demand information. He procures the product from the supplier and resells it in the end market at wholesale. The supplier decides whether to encroach into the retail market. If yes, then by a direct or an agency channel? The encroaching supplier and the e-tailer then compete in one of two leadership scenarios: a *supplier-leads* game and an *e-tailer-leads* game. The first game has the supplier selecting a channel before the e-tailer decides whether or not to share demand information. The second game has her selecting a channel after the e-tailer's decision.

We find that the supplier's choice of agency encroachment results in the lowest wholesale price, and the choice of no encroachment results in the highest. This indicates that agency encroachment, followed by direct encroachment, performs best in mitigating double marginalization. The above results hold regardless of whether the two players compete in quantity or price. However, suppose the supplier wants to raise the overall sales volume (i.e., her retailing quantity plus the e-tailer's reselling quantity), which can be helpful to boost brand recognition. In that case, agency encroachment outperforms direct encroachment under quantity competition, while the reverse holds under price competition.

Second, we fully characterize the e-tailer's information sharing decision and the supplier's encroachment channel selection in equilibrium. We show that the substitution rate of the products sold by the e-tailer and the supplier and the commission rate under the agency scheme are crucial factors determining the equilibrium strategy. When the substitution rate is low, the supplier prefers to establish her direct channel rather than not encroach. In contrast, when the substitution rate is high, the supplier prefers not to encroach. When the commission rate is extremely low, the e-tailer does not share information, and the supplier selects agency encroachment. When the commission rate is sufficiently high, the e-tailer again does not share information but the supplier selects either no encroachment or direct encroachment.

However, when the commission rate is moderate, agency encroachment with information sharing by the e-tailer reaches equilibrium. The rationales are as follows. When the commission rate is high, the supplier has less incentive to choose the agency scheme because she must pay a hefty commission fee from her retailing revenue. Conversely, when that rate is low, the e-tailer hesitates to share information with the supplier because he is concerned that the negative impact from the double marginalization effect of information sharing (see, e.g., Shang et al. 2016, Ha et al. 2022) might be too harmful. These two factors can only be well-balanced and lead to the equilibrium of agency encroachment with information sharing by the e-tailer if the commission rate is medium. We reveal that this equilibrium is more likely to prevail in the supplier-leads scenario than in the e-tailer-leads scenario.

We show that supplier encroachment always improves consumer surplus. Furthermore, the surplus obtained under agency encroachment is higher than under direct encroachment. However, this does not mean that encroachment is always welfare-improving because direct encroachment may occasionally lead to lower social welfare than no encroachment. Since agency encroachment results in higher consumer surplus and social welfare than no encroachment and direct encroachment, our findings partially imply that selecting agency encroachment can result in a win-win-win outcome for the supplier, the e-tailer and consumers.

We also consider several model extensions. We find that agency encroachment with information sharing by the e-tailer is more likely to appear under price competition than it would be under quantity competition. We also find that the e-tailer is more willing to share information to induce the supplier to encroach through his agency channel if he has a significant selling cost advantage over the supplier or can endogenously determine the commission rate.

The remainder of this paper is organized as follows. Section 2 reviews the related literature. In Section 3, we set up the model and analyze the system performance when either the supplier or the e-tailer acts as the leader in Sections 4.1 and 4.2, respectively. Section 5 discusses price competition, the impact of selling cost disadvantage, and the case in which the commission rate is a decision of the e-tailer. Concluding remarks are provided in Section 6. All the proofs are relegated to the online Appendices.

2 Literature Review

Our work closely relates to the studies on supplier encroachment and dual-channel distribution. Arya et al. (2007) show that a retailer can benefit from its wholesale supplier's encroachment when he has a sales advantage. Xu et al. (2010) study a proprietary component supplier's optimal distribution strategy among three options: wholesale the component to the OEM, develop the end product and sell it directly and exclusively under her brand name, and wholesale the component and direct sell the end product. Khouja et al. (2010) consider a manufacturer who can sell through a direct channel, a manufacturer-owned retail channel, an independent retail channel, or any combination thereof. They identify the manufacturer's optimal distribution strategy. Ryan et al. (2012) study a supply chain consisting of a platform firm and a supplier, where the supplier is already selling its product on its website. They investigate whether or not the supplier should also sell through the platform and at what price if so. Ha et al. (2016) consider quality endogeneity when a supplier encroaches. Guan et al. (2019) investigate the interaction between a supplier encroachment and a buyer's strategic inventory holding decision. Yang et al. (2018) study how capacity limitation affects a supplier's optimal distribution strategy when the supplier may encroach into the market to compete with the buyer. Liu et al. (2021) claim that the number of retailers in the market is critical in determining a supplier's encroachment incentive. Unlike the above literature focusing on supplier encroachment, Li et al. (2022) consider a retailer's private label encroachment problem with quality-level decisions. They find that the retailer's upward encroachment can increase consumer surplus and social welfare. Our results complement theirs by showing that even though *downward* encroachment (such as supplier encroachment) always improves consumer surplus, it is not necessarily welfare-improving. Wang and Li (2021) show that a retailer caring about consumer surplus can perform better than a for-profit retailer because the supplier's encroachment incentive is mitigated. There are also some works, such as Tian et al. (2018), Kwark et al. (2017), and Hu et al. (2022), that study the online platform business format from a retailer's perspective. Our work differs from theirs as we focus on the supplier's *how-to-encroach* issue.

The stream of research on vertical information sharing in the presence of competition is related; see, e.g., Chen (2003) for a comprehensive review. In this stream of research, many studies consider situations where the downstream retailers have more demand information than the suppliers and analyze their information sharing incentives. Li and Zhang (2008) examine the impact of information confidentiality on the information sharing incentives of members in a channel of one manufacturer and multiple retailers. Gal-Or et al. (2008) investigate how information sharing affects a manufacturer's wholesale pricing decision in a supply network of one manufacturer and two retailers, all having private demand information. Ha and Tong (2008) explore how supply chain contracts affect information sharing. Arya and Mittendorf (2013) consider a dual distribution supply chain in which a supplier both direct sells and wholesales to a retailer. They then explore how the existence of potential entry by competitors affects the retailer's information disclosure incentive after observing market information. Shang et al. (2016) consider a supply chain consisting of two competing manufacturers and a common retailer. They examine the impact of a nonlinear production cost on the retailer's information sharing incentive. Yoon et al. (2020) study a multi-tier supply chain consisting of a manufacturer, a first-tier supplier, and a second-tier supplier.

The first-tier supplier can access the second-tier supplier's reliability information and may share that with the manufacturer. They examine different information sharing contracts under which the manufacturer can obtain the shared information and how these impact the profits of the manufacturer and the first-tier supplier. Recently, some scholars have begun paying attention to online platform information sharing incentives. Liu et al. (2021a) study an online platform's optimal information sharing incentives when multiple sellers compete.

Our work is closely related to the literature on the interaction between information asymmetry and supplier encroachment. Some studies focus on the effects of information asymmetry on encroachment. For example, Li et al. (2014) investigate how information asymmetry affects supplier encroachment and the corresponding impact on the retailer. Li et al. (2015) take one further step by considering the role of a supplier's non-linear pricing strategies. Other studies investigate the incentive of information sharing (which can eliminate information asymmetry) in the presence of encroachment. Guan et al. (2020) focus on the interplay between *quality information* disclosure and supplier encroachment. Guan et al. (2023) consider the situation in which the manufacturer has *private information regarding its direct-selling cost*. They find that the manufacturer can profit by revealing that information.

In this stream of literature, our work is most relevant to the studies on the interplay between supplier encroachment and *demand information* sharing. Huang et al. (2018) consider a setting where the retailer knows more than the supplier, and the supplier either does not encroach or does so through a direct channel. They show the retailer can prevent the supplier from encroaching through a direct channel by sharing information freely. Our study differs from theirs in that the supplier has an additional option to encroach, i.e., through an agency channel. We show that the e-tailer can share information to induce the supplier to encroach through his agency channel and earn commission fees.

Ha et al. (2022) focus on the supplier-leads scenario and examine how an e-tailer's information sharing affects the supplier's incentive to encroach through an agency channel. By contrast, we explore how the leadership scenario influences the supplier's encroachment channel selection by considering the e-tailer's information sharing. Tsunoda and Zennyo (2021) consider a setting where a supplier wants to sell online via a platform. They then investigate how the platform's information sharing policy affects supplier selection between wholesale and agency models. In their work, the supplier adopts either the agency model to encroach or the wholesale model without encroaching. We take further steps by considering one additional direct channel, which captures the business reality that when a supplier encroaches, she may have multiple choices. In addition, we consider two co-existing leadership scenarios while Tsunoda and Zennyo (2021) focus on the e-tailer-leads scenario. Table 1 summarizes the critical difference between our work and the most closely related studies

Table 1: Comparison between Our Work and the Most Closely Related Studies

	RL	SL	DE	AE	Remark
Li et al. (2014, 2015)			✓		Do not consider information sharing incentive Only one encroachment option
Guan et al. (2020)			✓		Quality information disclosure Only one encroachment option
Guan et al. (2023)			✓		Direct-selling cost information disclosure Only one encroachment option
Huang et al. (2018)	✓		✓		Demand information sharing Only one encroachment option Only one leadership scenario is examined
Ha et al. (2022)		✓		✓	Demand information sharing Only one encroachment option Only one leadership scenario is examined
Tsunoda and Zennyo (2021)	✓			✓	Demand information sharing Only one encroachment option Only one leadership scenario is examined
This paper	✓	✓	✓	✓	Demand information sharing Two encroachment options to choose from Two leadership scenarios are examined

Note. RL: E-Tailer-Leads, SL: Supplier-Leads, DE: Direct Encroachment, AE: Agency Encroachment

mentioned above.

3 Model Setup

Consider a supply chain with one supplier (she, labeled S) and one e-tailer (he, labeled R)[6]. The e-tailer buys the supplier's product at a unit wholesale price w and resells it in the end market. The supplier is considering whether or not to enter the retail market by direct selling in one of two ways. One way is to directly sell the product through the e-tailer's agency scheme by paying the e-tailer a transaction-based commission fee, which we name the "agency channel encroachment" (or *agency encroachment* for short and denoted by $\mathcal{A}$). For example, e-tailers such as Amazon and JD not only resell but also allow sellers to sell directly through their platforms. Denote the exogenously-given unit commission rate charged by the e-tailer as $\alpha \in (0, 1)$.[7] The other way is to establish her online/offline store, called the "direct channel encroachment" (or *direct encroachment* for short and denoted by $\mathcal{D}$). The supplier

[6]E-tailer is a type of retailer, so we use the label R for the e-tailer.

[7]In practice, there are many reasons to induce the situation where the e-tailer cannot freely adjust the commission rate. For example, if an e-tailer sets a high commission rate, then the supplier would switch to a competitor with a low commission rate. Also, sometimes a government's policy would regulate the commission rates. For instance, on Feb 7, 2021, the State Council, China's cabinet, issued antitrust guidelines on the country's platform economy to ensure fair market competition (Xinhua 2021). These guidelines state that the platforms cannot control the retail price, the commission rate, service fees etc (StateCouncilNews 2021). For completeness, we also discuss the case with an endogenized commission rate in Section 5.3.

incurs a channel operating cost K_1 (K_2) under the agency (direct) channel encroachment. Generally, $K_2 \geq K_1$ since the supplier operates her own store in direct encroachment. Thus, we can set $K_2 = K_1 + K$, where $K \geq 0$. Without loss of generality, we normalize K_1 to zero and let $K_2 = K$ throughout the paper. When the supplier decides not to enter the retail market, we call it "no encroachment" (denoted by $\mathcal{N}$).

The encroaching supplier and the e-tailer compete in Cournot fashion and simultaneously determine their selling quantities. We assume quantity competition for two reasons. First, it is commonly used in the literature on information sharing (see, e.g., Liu et al. 2021a) and supplier encroachment (see, e.g., Huang et al. 2018 and Liu et al. 2021). Second, Cournot competition is a reasonable assumption when production lead time is long, and the production capacity/quantity needs to be determined in advance, making it hard to adjust the production quantity. The examples include agricultural products and computers; see Cabral (2000) page 114 for more examples and discussion. (We also consider a scenario with price competition in Section 5.1). The inverse demand function is $p_i = m - q_i - \gamma q_j$ ($i, j \in \{R, S\}$ and $i \neq j$), where $\gamma \in (0, 1]$ is the substitution rate of the products sold by the e-tailer and the supplier, q_R is the reselling quantity of the e-tailer, and q_S is the direct selling quantity of the supplier if she encroaches. Note that a higher γ indicates a fiercer competition between the two parties. For ease of exposition, we will call q_S the *retailing quantity* to reflect that it is sold in the encroachment channel. The market size m is uncertain: $m = m_H$ with probability $\beta \in (0, 1)$ and $m = m_L$ with probability $1 - \beta$. This structure has been widely used in the literature; see, e.g., Li et al. (2014) and the reference therein. Let $\mu = \beta m_H + (1 - \beta) m_L$ denote the expected value of the market size, and $\sigma^2 = \beta(m_H - \mu)^2 + (1 - \beta)(m_L - \mu)^2$ denote its variance. As the e-tailers considered in our paper are giant e-commerce platforms like JD and Amazon.com, they have advanced big data technology that the relatively small-sized suppliers do not have. Besides, many online retail platforms can collect some data that independent sellers may not have, such as clickstream data and browsing data (Liu et al. 2021a). Therefore, the e-tailer is better informed and can observe the specific demand state. This is a standard assumption adopted in the literature; see, e.g., Huang et al. (2018), Li et al. (2014), and Liu et al. (2021a). The e-tailer then needs to decide whether to share (denoted by Y) or not share (denoted by N) his demand information with the supplier. We restrict our attention to the cases where $m_L > \frac{(2-\gamma)(3\gamma+2)\mu}{8-3\gamma^2}$, which ensures that the e-tailer's reselling quantity is strictly positive (see online Appendix B for the detail). Such an assumption shares the same spirit as that adopted in the literature (see, e.g., Li et al. 2014).

Motivated by the different leadership scenarios observed in practice and considered in the literature, and to understand the role of information sharing fully, we study two leadership

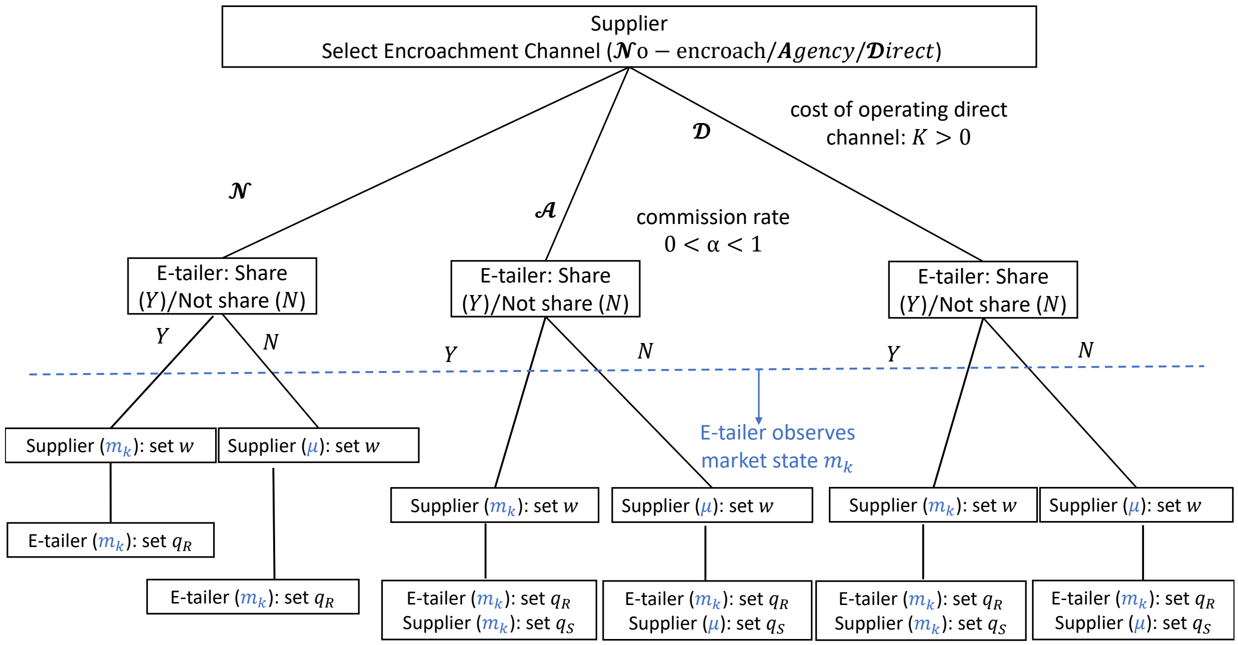


Figure 1: Sequence of Events When Supplier Acts as Leader

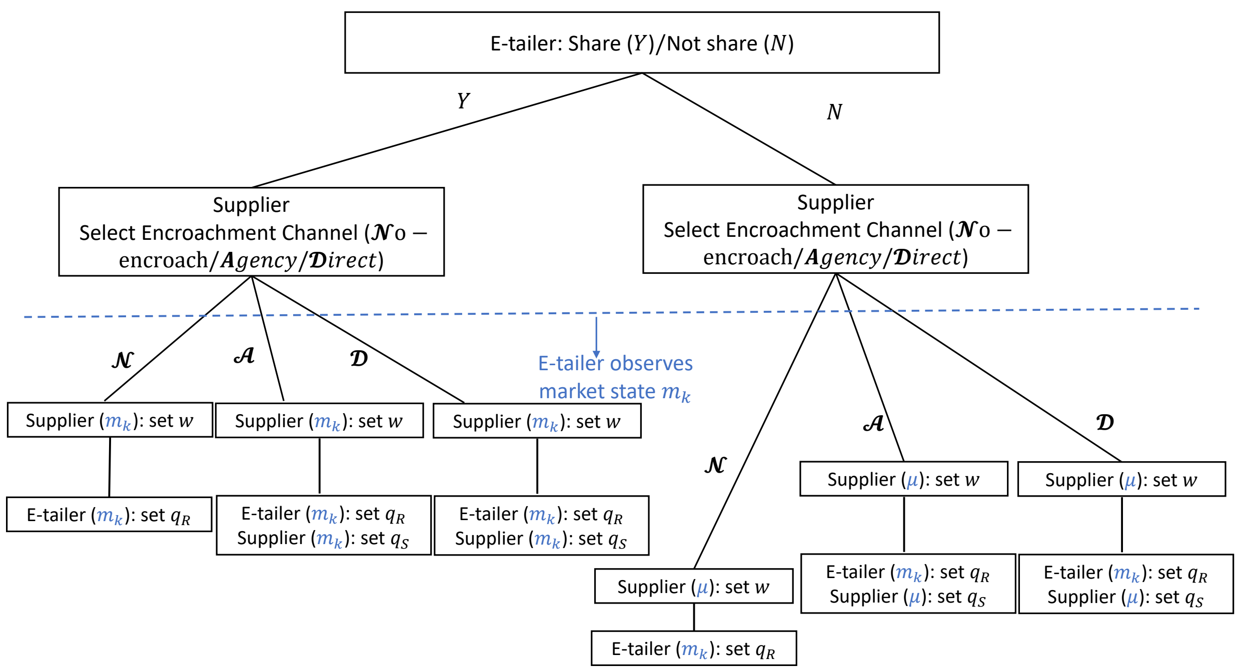


Figure 2: Sequence of Events When E-tailer Acts as Leader

scenarios depending on the sequence in which the e-tailer's information sharing decision and the supplier's channel selection are made. Figure 1 illustrates the sequence of events in the *supplier-leads scenario*. First, the supplier determines whether to encroach and if yes, then through which of the two channels. Next, the e-tailer decides whether or not to share his demand information with the supplier and then commits to it. Then, the e-tailer observes the demand state and shares it with the supplier if he has pre-committed to do so. The supplier then sets the wholesale price, followed by the e-tailer and supplier simultaneously determining the reselling and retailing quantities. Finally, demands realize, and the parties collect the respective revenues.

The other scenario is the *e-tailer-leads scenario*, in which the e-tailer commits to the information sharing decision in the first stage. Then the supplier selects the encroachment channel, as shown in Figure 2. Except for the first two stages, the remaining order of the events and decisions is the same as in the supplier-leads scenario.

Table 2: A List of Main Notations

K	Supplier's direct channel operating cost
α	Commission rate paid by the supplier in agency encroachment
m	Market size, $m = m_H$ w.p β and $m = m_L$ w.p $1 - \beta$
μ	Expected value of market size, $\mu = \beta m_H + (1 - \beta) m_L$
σ	Market size variance, $\sigma^2 = \beta(m_H - \mu)^2 + (1 - \beta)(m_L - \mu)^2$
γ	Substitution rate
w	Wholesale price, a decision variable
q_R	E-tailer's reselling quantity, a decision variable
q_S	Supplier's retailing quantity, a decision variable

Both parties are assumed to be risk-neutral and aim to maximize their respective profits. Backward induction is adopted to ensure subgame perfection. Table 2 summarizes the main notations used in the paper.

4 Equilibrium Analysis

In this section, we analyze the game between the supplier and the e-tailer by characterizing the optimal operational decisions in each channel structure (no encroachment, agency encroachment, and direct encroachment). After that, we derive the supplier's equilibrium encroachment channel selection and the e-tailer's equilibrium information sharing decision. The supplier-leads and the e-tailer-leads scenarios are analyzed in Sections 4.1 and 4.2, respectively.

4.1 Supplier-Leads Scenario

Here, we consider the *supplier-leads scenario.* We first derive the equilibria associated with no encroachment, agency encroachment, and direct encroachment. We then compare them to obtain the supplier's optimal encroachment channel selection and the e-tailer's corresponding information sharing decision.

No Encroachment. When the supplier does not encroach, the e-tailer is the monopoly. If he shares information with the supplier, then for any given wholesale price $w(m_k)$ that he receives from the supplier under each observed market state m_k ($k \in \{H, L\}$), the e-tailer maximizes his profit

$$\Pi_R = (m_k - q_R - w(m_k))q_R$$

by setting the reselling quantity $q_R(w)$. Anticipating the e-tailer's ordering decision, the supplier sets wholesale price w to maximize $\Pi_S(w) = w(m_k)q_R(w)$, which we can show to be concave in w. Solving the first-order condition of Π_S for w yields the optimal wholesale price. Then, we can derive the ex-ante expected profits of the players by taking the expectation over m.

If the e-tailer does not share information with the supplier, the supplier only knows market size value μ. The e-tailer's profit function has the same form as that shown above, while the supplier's objective function becomes $\Pi_S = wE[q_R(w)]$. We can quickly obtain the optimal decisions and the corresponding subgame equilibrium by backward induction.

Agency Encroachment. When the supplier selects the agency channel, she and the e-tailer compete in the downstream market. If the e-tailer shares information with the supplier, for any given market size m_k, the supplier and the e-tailer determine the retailing quantity q_S and reselling quantity q_R to maximize their respective profits as follows:

$$\Pi_R = (m_k - q_R - \gamma q_S - w)q_R + \alpha(m_k - q_S - \gamma q_R)q_S;$$
$$\Pi_S = (1-\alpha)(m_k - q_S - \gamma q_R)q_S + wq_R.$$

Then, for any given w, we can obtain that

$$q_S(w) = \frac{(1-\alpha)(2-\gamma)m_k + (1-\alpha)\gamma w}{(1-\alpha)\left(4-(\alpha+1)\gamma^2\right)};$$
$$q_R(w) = \frac{(1-\alpha)(2-\alpha\gamma-\gamma)m_k - 2(1-\alpha)w}{(1-\alpha)\left(4-(\alpha+1)\gamma^2\right)}.$$

Substituting $q_j(w), j = R, S$ into Π_S, one can check that Π_S is a concave function of w. The optimal wholesale price can be derived by solving the first-order condition regarding w. After deriving the optimal wholesale price w, we can obtain the ex-post optimal quantity decisions q_R and q_S by substituting the optimal wholesale price into $q_j(w), j = R, S$. The ex-post profits of the e-tailer and the supplier are derived by substituting the optimal decisions into their profit functions. Taking the expectation of the demand size m, we can obtain the ex-ante expected profits of the players.

The derivation logic remains the same if the e-tailer does not share information. The only difference is that the supplier now does not know the specific state of the realized demand, so she can only use the expected value of m in her profit function

$$\Pi_S = (1 - \alpha)(E[m] - q_S - \gamma E[q_R])q_S + wE[q_R].$$

The e-tailer's profit function stays the same as when he does not share information. With $E[m] = \mu$ and following the same logic as when the e-tailer shares information, we obtain the optimal wholesale price, resellig quantity, retailing quantity, and the ex-ante expected profits of the e-tailer and the supplier.

Direct Encroachment. When the supplier selects the direct channel, she induces a direct channel operating cost K. If the e-tailer shares information, the supplier's profit is

$$\Pi_S = (m_k - q_S - \gamma q_R)q_S + wq_R - K.$$

If the e-tailer does not share information, we can write her expected profit

$$\Pi_S = (E[m] - q_S - \gamma E[q_R])q_S + wE[q_R] - K.$$

Under both information sharing scenarios, the e-tailer's profit is

$$\Pi_R = (m_k - q_R - \gamma q_S - w)q_R.$$

By applying a similar deriving process as that under agency encroachment, we can obtain the optimal decisions and the ex-ante expected profits of the supplier and the e-tailer. The no-information-sharing case can be derived similarly. We omit the detail here.

To save space, we relegate the subgame outcomes associated with the above three channel structures to Appendix B; see Table B1 there. Below, we first compare the equilibrium wholesale price and selling quantities under the three channel structures and obtain the following:

Lemma 1. *Regardless of whether the e-tailer shares demand information or not, the following statements hold:*

1. *The optimal wholesale price is the highest under no encroachment and the lowest under agency encroachment, i.e.,* $E[w^A] < E[w^D] < E[w^N]$.

2. *The e-tailer's reselling quantity is the highest under no encroachment and the lowest under direct encroachment, i.e.,* $E[q_R^D] < E[q_R^A] < E[q_R^N]$.

3. *The supplier's total sales quantity is the highest under agency encroachment and the lowest under no encroachment, i.e.,* $E[q_R^N] < E[q_R^D + q_S^D] < E[q_R^A + q_S^A]$. *Moreover,* $E[q_R^A + q_S^A] - E[q_R^D + q_S^D]$ *first increases and then decreases in* γ.

Lemma 1 shows that encroachment induces the supplier to lower the wholesale price. That is because when the supplier can earn from the downstream market through retailing, she is willing to reduce income from wholesaling to the e-tailer. In addition, the supplier sets a lower wholesale price for agency encroachment than for direct encroachment. In other words, double marginalization will be the least if the supplier encroaches through the agency channel. It is due to the revenue-sharing arrangement of the commission fee under the agency scheme, making it easier for the two parties to coordinate.

Lemma 1 confirms that supplier encroachment makes the e-tailer resell less (i.e., $\min\{E[q_R^D], E[q_R^A]\} < E[q_R^N]$). The e-tailer, however, can sell comparatively more if the supplier selects the agency scheme rather than open a store independently ($E[q_R^D] < E[q_R^A]$). This is a natural consequence of the relatively lower wholesale price under agency encroachment compared to direct encroachment. Undoubtedly, the supplier's total sales quantity increases if she encroaches. It is somewhat surprising that her total sales quantity is higher under agency encroachment than under direct encroachment. This unexpected result is due to the following reason: compared with direct encroachment, although the supplier sells less retailing quantity under agency encroachment i.e., $E[q_S^A] < E[q_S^D]$ (as shown in the proof of Lemma 1), it can wholesale more to the e-tailer because of the dampened double marginalization, the net effect of which leading to a higher total sales quantity. This suggests that agency encroachment is preferable if a supplier seeks to boost product sales and raise consumers' awareness of the brand. This is particularly important for small manufacturers who want to increase brand awareness. These findings are insightful as they provide guidance on how to choose the retailing channel for encroaching firms with different objectives.

Lemma 1 also reveals a non-monotonic impact of the substitution rate γ (a measure of competition intensity) on the total sales quantity difference between agency encroachment and direct encroachment. In particular, as γ increases, the relative advantage of agency encroachment over direct encroachment in increasing total sales volume first expands and then shrinks. The following two countervailing forces drive such inverted U-shaped relationship. On the one hand, the mitigation of double marginalization via the agency channel rather than the direct channel is more pronounced when the market competition becomes fiercer, enlarging the total sales quantity difference with the increase in γ. On the other hand, an intensified downstream competition impels the supplier to boost her retailing quantity. It can be shown that both $E[q_S^A]$ and $E[q_S^D]$ increase in γ when γ is sufficiently large (see the proof of Lemma 1). This pressurizes the e-tailer to reduce the reselling quantity, which becomes extremely low when γ is large enough, weakening the positive effect of dampening double marginalization. An intermediate γ balances these two effects, yielding the largest quantity difference.

By comparing the e-tailer's profits in different sharing scenarios, we can characterize the e-tailer's optimal information sharing decision for each channel structure. We summarize the result in the following proposition.

Proposition 1. *In the supplier-leads scenario, the e-tailer does not share information with the supplier under no encroachment and direct encroachment. As for agency encroachment, the e-tailer shares information with the supplier when $\alpha > \underline{\alpha}$ and not otherwise, where $\underline{\alpha}$ is given by* (A.1) *in Appendix A.*

When the supplier does not encroach, the conventional wisdom has that the e-tailer has no incentive to share information with the supplier (e.g., Ha et al. 2022 and Shang et al. 2016). Proposition 1 further shows that he also has no incentive to share information when the supplier has committed to encroaching through the direct channel. In this situation, the supplier and the e-tailer compete fiercely in the downstream market. Thus, intuitively, the e-tailer is incentivized to withhold information to keep it private as a competitive weapon. As for agency encroachment, the e-tailer is willing to share information with the supplier only if the commission rate is sufficiently high. Note that the supplier's wholesale price responds positively to the demand state, and information sharing enables her to set the wholesale price more aggressively for higher demand, referred to as the double marginalization effect of information sharing (see Shang et al. 2016). That hurts the e-tailer. However, the shared information also enables the supplier to order accurately, boosting her retailing revenue. The e-tailer benefits from the resultant increased commission fees. Only when the commission rate is high would the latter effect dominate the former, motivating the e-tailer to share information.

Anticipating the e-tailer's information sharing decision for a given channel structure, the supplier makes her encroachment channel selection. Denote (J, I) as the equilibrium outcome under the supplier-leads scenario regarding the supplier's encroachment channel selection and the corresponding information sharing decision of the e-tailer, where $J \in \{\mathcal{N}, \mathcal{A}, \mathcal{D}\}$ and $I \in \{Y, N\}$. For example, $(\mathcal{A}, N)$ represents that in equilibrium, the supplier encroaches through the agency channel and the e-tailer does not share information with the supplier. We summarize the equilibrium outcomes in the following proposition.

Proposition 2. *When the supplier selects a channel before the e-tailer's information sharing decision, the equilibrium is characterized as follows:*

$$(J, I) = \begin{cases} (\mathcal{A}, N), & \text{if and only if } \alpha < \alpha_1; \\ (\mathcal{A}, Y), & \text{if and only if } \underline{\alpha} \leq \alpha \leq \overline{\alpha}_{sl}; \\ (\mathcal{D}, N), & \text{if and only if } (\alpha_1 < \alpha < \underline{\alpha} \text{ or } \alpha > \overline{\alpha}_{sl}) \text{ and } \gamma < \underline{\gamma}; \\ (\mathcal{N}, N), & \text{otherwise.} \end{cases}$$

In the above, $\underline{\alpha}$ is given in Proposition 1; $\overline{\alpha}_{sl}$, α_1, and $\underline{\gamma}$ are respectively characterized by (A.7), (A.8), and (A.16) in the appendix. Moreover, $\alpha_1 \leq \underline{\alpha}$ and $\underline{\gamma}$ decreases in K.

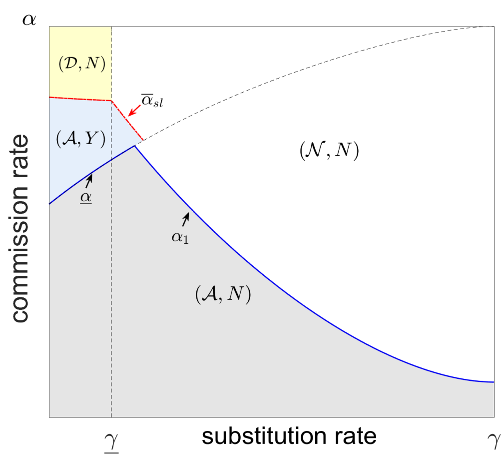


Figure 3: An Illustration of Proposition 2

Proposition 2 implies that the supplier's encroachment channel selection decision highly depends on the commission rate α and substitution rate γ that measures the level of competition intensity; see Figure 3 for the illustration. Specifically, the supplier selects the agency channel, and the e-tailer shares information when the commission rate is moderate ($\underline{\alpha} \leq \alpha \leq \overline{\alpha}_{sl}$), resulting in a $(\mathcal{A}, Y)$ equilibrium. If α is low, the supplier selects the agency channel but the e-tailer has little incentive to share information. If it is high, the supplier will not participate in the agency scheme because she worries that she will lose a significant portion of her retail revenue due to commission payments. A medium commission rate α balances the concerns of the e-tailer and the supplier, resulting in the appearing of $(\mathcal{A}, Y)$ equilibrium.

Our findings also imply that direct encroachment is preferred over no encroachment when the substitution rate γ is below a certain threshold ($\underline{\gamma}$). Since $\underline{\gamma}$ decreases in the direct channel operating cost K, refraining from encroachment would become more desirable as K increases.

4.2 E-tailer-Leads Scenario

In this section, we consider the *e-tailer-leads scenario*, where the e-tailer decides whether to share information, and then the supplier selects the encroachment channel. The derivation is similar to that in the supplier-leads scenario, except that we need to first derive the supplier's channel selection decision given the e-tailer's decision to share or not share information and then derive the e-tailer's information sharing decision in equilibrium.

By comparing the equilibrium wholesale price and selling quantities, we can show that the results stated in Lemma 1 also hold here. The following proposition characterizes the supplier's channel selection for each information sharing scenario.

Proposition 3. *Given the e-tailer's information sharing decision $s \in \{y, n\}$, where $s = y$ (n) represents sharing (no sharing) information, we have:*

$$\text{Supplier's encroachment channel selection} = \begin{cases} \mathcal{N}, & \text{if and only if } \gamma \geq \gamma^s \text{ and } \alpha > \alpha^s; \\ \mathcal{D}, & \text{if and only if } \gamma < \gamma^s \text{ and } \alpha > \alpha^s; \\ \mathcal{A}, & \text{otherwise,} \end{cases}$$

where $\gamma^n = \underline{\gamma}$ is defined in Proposition 2, and γ^y, α^y, and α^n are characterized by (A.9), (A.10) and (A.11), respectively, in the appendix. Moreover, $\alpha^n \geq \alpha^y$, $\gamma^n < \gamma^y$, and γ^n and γ^y both decrease in K.

A close look at Proposition 3 shows that the supplier's encroachment channel selection is similar in the two information sharing scenarios. The only difference lies in their respective thresholds characterizing the specific regions. Proposition 3 reveals that the magnitude of the commission rate α determines the attractiveness of the agency channel. The supplier will adopt agency encroachment as long as α is less than a threshold, under which she does not share much of her retailing revenue with the e-tailer. Since $\alpha^n > \alpha^y$, agency encroachment becomes more likely when the information is not shared than when it is shared. That is because if information is provided, the supplier may determine a more accurate wholesale price, giving her greater motivation to adopt the direct channel to avoid paying commission fees under an agency scheme. Once the commission rate is high enough, the supplier adopts either no encroachment or direct encroachment, depending on the magnitude of the substitution rate γ. In both information sharing scenarios, the supplier selects no encroachment to avoid direct competition with the e-tailer in the downstream market when γ is large, under which the competition intensity is high. Moreover, when the e-tailer shares information, the supplier is more likely to choose direct encroachment rather than no encroachment since $\gamma^n < \gamma^y$.

In anticipation of the supplier's optimal channel selection decision under each information scenario, the e-tailer decides whether or not to share information to maximize his profit. Denote $(\bar{I}, \bar{J})$ as the equilibrium outcome under the e-tailer-leads scenario regarding the e-tailer's information sharing decision and the corresponding encroachment channel selection decision of the supplier, where $\bar{I} \in \{Y, N\}$ and $\bar{J} \in \{\mathcal{N}, \mathcal{A}, \mathcal{D}\}$. For example, $(N, \mathcal{A})$ represents that the e-tailer does not share information with the supplier, and the supplier encroaches through the agency channel in equilibrium. The following proposition summarizes the equilibrium outcome.

Proposition 4. *When the supplier selects a channel after the e-tailer's information sharing decision, the equilibrium is characterized as follows:*

$$(\bar{I}, \bar{J}) = \begin{cases} (N, \mathcal{N}), & \text{if and only if } \gamma > \underline{\gamma} \text{ and } \alpha > \alpha^n; \\ (N, \mathcal{D}), & \text{if and only if } \gamma \leq \underline{\gamma} \text{ and } \alpha > \alpha^n; \\ (Y, \mathcal{A}), & \text{if and only if } \underline{\alpha} < \alpha < \overline{\alpha}_{rl}; \\ (N, \mathcal{A}), & \text{otherwise.} \end{cases}$$

In the above, $\overline{\alpha}_{rl} \triangleq \alpha^y < \overline{\alpha}_{sl}$*, and* α^y *and* α^n *are given in Proposition 3.*

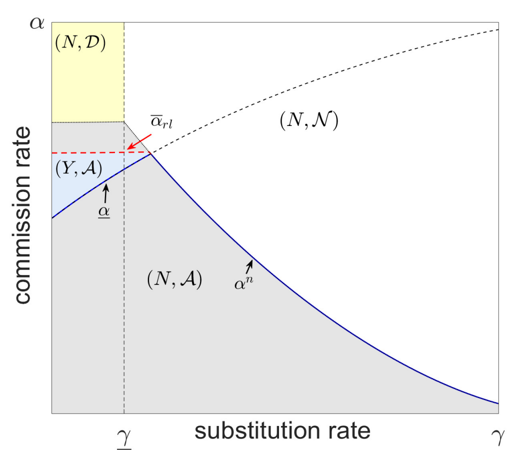


Figure 4: An Illustration of Proposition 4

Considering only the direct channel, Huang et al. (2018) show that the e-tailer's voluntary information sharing might *prevent* the supplier from establishing a direct channel when she makes the encroachment decision after the demand is realized. Here, in Proposition 4, we show that the e-tailer uses information sharing to *encourage* the supplier to encroach through his agency scheme. By comparing Propositions 2 and 4, we can see that if the e-tailer leads, the equilibrium of agency encroachment with information sharing by the e-tailer becomes less likely than if the supplier leads (since $\overline{\alpha}_{rl} < \overline{\alpha}_{sl}$). This finding is important as it indicates that who takes the leadership role does play a significant role in determining the final supply chain structure and the associated information scenario. Similar to the supplier-leads scenario, the substitution rate γ characterizes the equilibrium outcome between no encroachment and direct encroachment; see Figure 4 for the illustration.

We now examine how consumer surplus and social welfare (containing the supplier's profit, the e-tailer's profit and consumer surplus) are affected by the supplier's encroachment channel selection and the e-tailer's information sharing decision. Let CS^{JI} and SW^{JI} denote consumer surplus and social welfare under a given channel structure and information sharing outcome (J, I). Note from Propositions 2 and 4 that in both leadership scenarios, $(\mathcal{D}, Y)/(Y, \mathcal{D})$ and $(\mathcal{N}, Y)/(Y, \mathcal{N})$ will never arise in equilibrium. Thus, we have the following:

Proposition 5. *In both the supplier-leads and e-tailer-leads scenarios:*

1. *The consumer surplus is the highest under agency encroachment and the lowest under no encroachment. Specifically,* $CS^{AY} > CS^{AN} > CS^{DN} > CS^{NN}$.

2. *Regarding social welfare,*

$$\begin{cases} SW^{AY} > SW^{AN} > SW^{NN} > SW^{DN}, & \text{if and only if } \gamma > \gamma^{sw}; \\ SW^{AY} > SW^{AN} > SW^{DN} \geq SW^{NN}, & \text{otherwise,} \end{cases}$$

where γ^{sw} *is given by* (A.12) *in the online appendix.*

Proposition 5 implies that supplier encroachment always improves consumer surplus. Furthermore, agency encroachment with information sharing is the most preferable equilibrium for consumers. This outcome offers concrete proof that consumers are pleased with the growth of online marketplaces with the agency selling mode (like JD) and the associated information exchange technology, as it allows more consumers to purchase products at lower prices.

Proposition 5 shows that, regardless of whether the e-tailer shares information, agency encroachment leads to the highest social welfare. In other words, the growth of the agency channel on the online platform benefits society the most. It does not follow, however, that encroachment is always welfare-improving. Specifically, encroachment reduces social welfare when the direct channel is the only option and the competition is intense (i.e., a large γ). In this situation, despite the increase in consumer surplus, direct encroachment significantly reduces the total profit of the supplier and the e-tailer due to the exacerbated double marginalization and intensified market competition, resulting in lower social welfare than that under no encroachment.

We note that Li et al. (2022) consider a retailer's brand encroachment (i.e., upward encroachment along the supply chain) and show that upward encroachment always improves consumer surplus and social welfare. Here, in contrast, we consider a downward encroachment and show that even though supplier encroachment always improves consumer surplus, it is not necessarily welfare-improving.

Table 3 summarizes our key comparison results regarding no encroachment, direct encroachment and agency encroachment.

Table 3: Summary of Main Findings Regarding No, Direct and Agency Encroachment

Equilibrium Outcome	**Comparison Result**
Wholesale Price	$E[w^A] < E[w^D] < E[w^N]$
E-tailer's Reselling Quantity	$E[q_R^D] < E[q_R^A] < E[q_R^N]$
Supplier's Total Sales Quantity	$E[q_R^N] < E[q_R^D + q_S^D] < E[q_R^A + q_S^A]$
Consumer Surplus	$CS^{NN} < CS^{DN} < CS^{AN} < CS^{AY}$
Social Welfare	$\max\{SW^{DN}, SW^{NN}\} < SW^{AN} < SW^{AY}$; $SW^{DN} < SW^{NN}$ if $\gamma > \gamma^{sw}$
Leadership Scenario	**Supplier Leads vs. E-tailer Leads**
Information Sharing	Sharing arises only under agency encroachment under both scenarios; $(\mathcal{A}, Y)$ is more likely to sustain than $(Y, \mathcal{A})$

5 Discussion

In this section, we discuss several model extensions. First, we extend our base model to a situation where the supplier and the e-tailer compete on price to check whether our main results still hold in Section 5.1. Second, in practice, the supplier may not be as capable as the e-tailer in retailing. We then consider how such a selling-cost disadvantage affects the equilibrium outcomes in Section 5.2. Last, we endogenize the commission rate α in Section 5.3 to examine its impact.

5.1 Price Competition

In this subsection, we assume that once the supplier encroaches, she compete with the e-tailer in Bertrand fashion. Following the classical literature (e.g., Arya et al. 2007 and Huang et al. 2018), we assume $q_i = \frac{(1-\gamma)m - p_i + \gamma p_j}{1-\gamma^2}$ $(i, j\{S, R\}, i \neq j)$, where $\gamma \in (0, 1)$. Then, by the logic similar to Section 4.1, we can derive the equilibrium outcomes of subgames, presented in Table B2 in the online appendix.

By comparing the equilibrium wholesale prices and resulting quantities under three encroachment channel structures, we then obtain the following:

Lemma 2. *Under price competition, in both supplier-leads and e-tailer-leads scenarios, regardless of whether the e-tailer shares demand information or not, the following results hold:* $E[w^A] < E[w^D] < E[w^N]$, $E[q_R^D] < \min\{E[q_R^A], E[q_R^N]\}$, *and* $\max\{E[q_R^A + q_S^A], q_R^N\} < E[q_R^D + q_S^D]$.

Recall from Lemma 1 that under quantity competition, the double marginalization effect is the lowest under agency encroachment and the highest under no encroachment. Here, Lemma 2 suggests that the above conclusion is still valid under price competition (i.e., $E[w^A] < E[w^D] < E[w^N]$). The e-tailer orders the least reselling quantity from the supplier under direct encroachment. These outcomes mirror those of quantity competition.

The type of competition (price or quantity), however, does impact the performance of total sales quantity in different channel structures. Now, the supplier has the highest sales volume under direct encroachment, in contrast to quantity competition, where she has the highest sales volume under agency encroachment. That is because the competition between the players in the direct channel is more intense than in the agency channel, where revenue-based commission payments mitigate it. In this way, the two competitors would set their prices as low as possible to outbid each other under direct encroachment, increasing the total amount of product supplied to the market. This finding implies that when a supplier and an e-tailer compete on price, the supplier will benefit more from choosing the direct channel because it will enable her to access more downstream consumers. It is crucial for a supplier who wants to increase brand recognition by selling as many products as possible.

Proposition 6. *In the supplier-leads scenario, under price competition, the e-tailer still does not share information under no encroachment and direct encroachment. In contrast, under agency encroachment, he shares information with the supplier if and only if* $\underline{\alpha}_p < \alpha < \overline{\alpha}_p$, *where* $\underline{\alpha}_p < \underline{\alpha}$, $\overline{\alpha}_p = 1$ *if* $\gamma \geq \frac{1}{2}$, $\underline{\alpha}$ *is defined in Proposition 1, and* $\underline{\alpha}_p$ *and* $\overline{\alpha}_p$ *are characterized by* (A.15) *in the online appendix.*

A close look at Propositions 1 and 6 reveals that regardless of the nature of competition (price or quantity), when the supplier takes the lead, the e-tailer withholds information from her when she does not encroach or selects direct encroachment. Differently, under quantity competition, a specific commission rate threshold characterizes the information decision (see Proposition 1), while under price competition, there are two such commission rate thresholds (see Proposition 6). A simple comparison of these thresholds indicates that if the commission rate is sufficiently high, the e-tailer prefers not to share information with the supplier under price competition but is still willing to share information with the supplier under quantity competition. Note that a firm's perceived demand elasticity is higher in price competition than in quantity competition, which restricts the two players' capability to adjust prices in price competition (Singh and Vives 1984). When the commission rate is sufficiently high, the supplier is induced to reduce her retail business, which hurts the e-tailer's commission revenue. Although the negative impact of the double marginalization due to information sharing is weaker under larger commission (Ha et al. 2022), such mitigation cannot compensate for the e-tailer's loss in commission revenue because of his low ability to adjust reselling price under price competition.

The result $\underline{\alpha}_p < \underline{\alpha}$ suggests that the minimum commission fee required by the e-tailer to share information with the supplier is lower under price competition than under quantity competition. In this regard, price competition makes it easier to achieve information sharing.

Proposition 7. *Under price competition, the following statements hold:*

1. *When the supplier leads, direct encroachment is preferred over no encroachment if and only if $\gamma < \underline{\gamma}_p$. In addition, $(\mathcal{A}, Y)$ is an equilibrium if and only if $\alpha \in \left(\underline{\alpha}_p, \hat{\alpha}_{sl}\right)$. $\underline{\gamma}_p$ and $\hat{\alpha}_{sl}$ are respectively characterized by (A.16) and (A.17) in Appendix A.*

2. *When the e-tailer leads, $(Y, \mathcal{A})$ is the equilibrium if and only if $\alpha \in (\underline{\alpha}_p, \hat{\alpha}_{rl})$, where $\hat{\alpha}_{rl}$ is given by (A.21) in Appendix A. Moreover, $\hat{\alpha}_{rl} < \hat{\alpha}_{sl}$ when $\gamma \geq \frac{1}{2}$.*

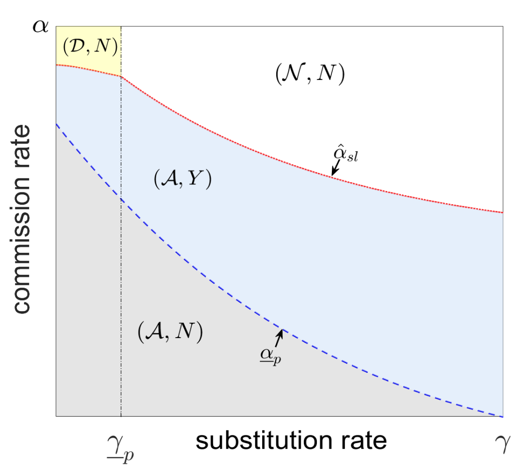


Figure 5: Equilibrium Outcomes under Price Competition When Supplier Leads

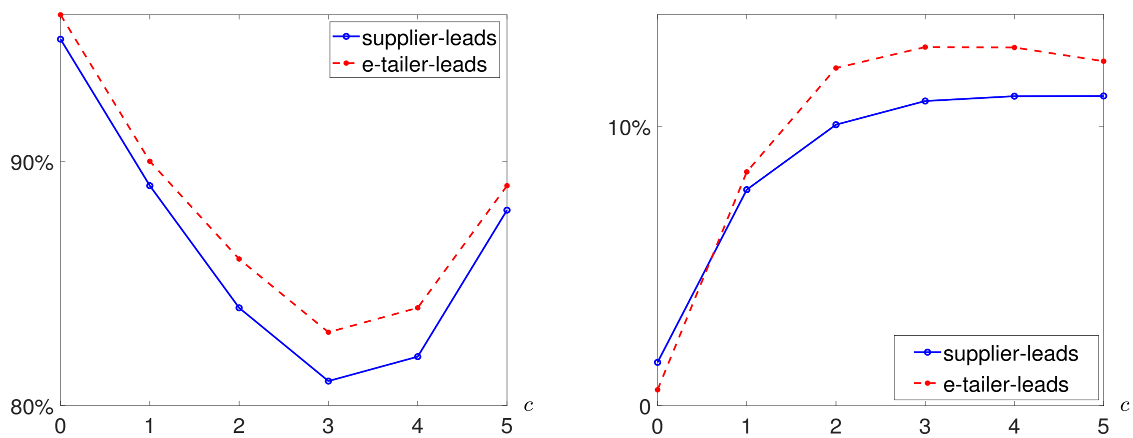
Proposition 7 shows that the equilibrium $(\mathcal{A}, Y)/(Y, \mathcal{A})$ arises under price competition when the commission rate is moderate, consistent with that under quantity competition. By Proposition 7, when the competition intensity is high (a large γ), it is still true that the equilibrium $(\mathcal{A}, Y)/(Y, \mathcal{A})$ becomes less likely if the e-tailer leads than it would be if the supplier leads. Using the same set of parameter values used for Figure 3, Figure 5 depicts the equilibrium outcomes for the supplier-leads scenario under price competition. We can observe that the $(\mathcal{A}, Y)$ region now becomes larger under price competition. The underlying reason is that the supplier and the e-tailer compete more intensely under price competition than under quantity competition. Under price competition, one might anticipate a reduction in the e-tailer's incentives for information sharing. However, recall that under agency encroachment, the e-tailer's profit comes in two ways: the profit from reselling and the profit from supplier commission. When the fierce price competition limits the e-tailer's ability to profit from his own reselling business, the e-tailer has to resort to revenue from commission fees, increasing his willingness to share information with the supplier. As a result, the equilibrium $(\mathcal{A}, Y)$ region becomes larger under price competition than that under quantity competition.

5.2 Impact of Selling Cost Disadvantage

In certain situations, the supplier might be less efficient than the e-tailer in retail operations. In this subsection, we consider this scenario by assuming that the supplier incurs a unit cost c when selling directly in her store or via the e-tailer's agency scheme. Then, the profit functions of the supplier and e-tailer become $\Pi_R = (m - q_R - \gamma q_S - w)q_R + \alpha(m - q_S - \gamma q_R)q_S$ and $\Pi_S = (1 - \alpha)(m - q_S - \gamma q_R)q_S - cq_S + wq_R$ under agency encroachment and $\Pi_S = (m - q_S - \gamma q_R - c)q_S + wq_R - K$ and $\Pi_R = (m - q_R - \gamma q_S - w)q_R$ under direct encroachment.

The analysis is routine and the subgame outcomes are presented in Table B3 in online Appendix B. As the expressions of equilibrium outcomes now become very complex, we rely on extensive numerical studies to investigate the impact of direct selling cost c. Specifically, we vary the magnitude of the direct selling cost c and for each given c, we further vary the values of other parameters with $2,760,000$ different combinations; see Table B4 in online Appendix B for details. We then derive the corresponding equilibrium outcomes for both supplier-leads and e-tailer-leads scenarios. Table B5 in online Appendix B presents the summary statistics about the occurrences of each equilibrium; see Figure 6 for the illustration. By Figure 6, we make the following observations. First, the presence of c reduces the incentives for the supplier to encroach (see Figure 6(a), where $c = 0$ has the highest encroachment possibility). Additionally, the possibility of the supplier direct selling (via either direct encroachment or agency encroachment) first decreases and then increases in her direct selling cost c. The reasons are as follows. On the one hand, a higher selling cost c drives the supplier to reduce direct sales q_S in an encroachment channel, which dampens her incentive to encroach. On the other hand, a larger c, in some ways, lessens the competition between the supplier and the e-tailer. Because of this, the e-tailer is more willing to share information, which is helpful for the supplier's direct selling business in the encroachment channel. As a result, the supplier is more likely to encroach. The net effect of these two countervailing forces determines the likelihood of supplier encroachment.

Second, as c increases, the equilibrium $(\mathcal{A}, Y)/(Y, \mathcal{A})$ becomes more attractive (see Figure 6(b)). More importantly, when c is sufficiently large, agency encroachment with information sharing becomes more likely if the e-tailer leads than if the supplier leads. It differs when the supplier is as capable as the e-tailer in retailing (i.e., $c = 0$). This implies that if the e-tailer has a significant selling cost advantage over the supplier, he is more willing to share information to induce the supplier to encroach through his agency channel and earn commission fees.



(a) Likelihood of Encroachment (b) Percentage of $(\mathcal{A}, Y)/(Y, \mathcal{A})$ being Sustained

Figure 6: Impact of Unit Direct Selling Cost c

5.3 Endogenous Commission Rate

In the base model, we have assumed that the commission rate α is exogenous. However, the e-tailer may have α as his decision variable (Hu et al. 2022). In this subsection, we examine this situation by considering that the e-tailer determines the commission rate α at the beginning of the game. After that, the subsequent interactions with the supplier are the same as in Figures 1 and 2 for respective scenarios. Similar to Section 5.2, we change the parameter values according to Table B5. The only difference is that here, for each combination of parameter values, we need to find the optimal commission rate determined by the e-tailer. After that, we count the occurrences of each equilibrium outcome regarding the supplier's encroachment channel selection and the e-tailer's information sharing decision. The results are summarized in Table B6 in online Appendix B. They imply that if the e-tailer can endogenously determine the commission rate, he would set it so that the supplier would always encroach via the agency channel. Still, similar to the base model, information sharing is more likely to appear if the supplier leads than when the e-tailer leads, even when the commission rate is endogenous.

6 Conclusion

The development of online platforms gives suppliers more choices when they intend to enter the retail business to reap additional profits. In this study, we consider a supplier who wholesales her product to the e-tailer and also intends to retail. For retail, she has two options: agency encroachment (open an online store on the e-tailer's platform and pay commission) or direct encroachment (operate her own store and incur direct channel operating cost). The e-tailer has private access to demand information and decides whether to share his information with the supplier. We analyze the supplier's encroachment decision and the e-tailer's information sharing incentive under two leadership scenarios: the supplier as the leader and the e-tailer as the leader. In the former, the supplier selects the channel structure before the e-tailer decides on information sharing. It is, for example, the practice of JD, which allows independent sellers to use its information tools only after they open stores on its platform. In the latter, the e-tailer decides whether to share information before the supplier selects an encroaching channel.

We compare the optimal decisions in different supply chain structures associated with the supplier's encroachment channel selection. We find that a supplier sells the highest *total quantity* (retailing plus wholesaling) under agency encroachment. Hence, if the supplier seeks to boost product sales (which increases consumer awareness of the brand), then agency encroachment is desirable.

Overall, we characterize entirely the two player's equilibrium strategies, depending on the commission rate in the agency scheme, the substitution rate, and the direct channel operating cost. We show that in both leadership scenarios, no information sharing and no encroachment or no information sharing and direct encroachment always appear together in equilibrium. More importantly, we show that the e-tailer can exploit information sharing to motivate the supplier to open an agency channel and collect transaction-based commission fees. It sharply contrasts with Huang et al. (2018), who show that an e-tailer's information sharing could deter a supplier from encroaching. Also, in our setting, the e-tailer's information sharing tool does not work if he wants to use it to prevent the supplier from encroaching or make the supplier select the direct channel. We also find that agency encroachment with information sharing by the e-tailer is more likely to appear in the supplier-leads scenario than in the e-tailer-leads scenario.

Additionally, we demonstrate that supplier encroachment always benefits consumers. Consumer surplus is the highest when agency encroachment with information sharing by the e-tailer reaches equilibrium. Consumers still favor agency encroachment over direct encroachment, even when the e-tailer does not share information. However, we do show that supplier encroachment may not be welfare-improving and can occasionally harm social welfare.

We also discuss the case of price competition. We show that contrary to the quantity competition case, the supplier now sells the highest *total quantity* under direct encroachment. We find that if the e-tailer has a significant selling cost advantage over the supplier and can endogenously determine the commission rate, he is more willing to share information to induce the supplier to encroach through his agency channel.

We conclude the paper by suggesting possible future research directions. First, there are examples where a supplier can also adopt both channels. One could therefore extend our paper to include this possibility as another option. A challenging direction is to incorporate demand learning when the supplier encroaches directly. But this would necessitate at least a two-period game where the supplier who opts for direct encroachment can obtain some demand information in the first period that would affect her price and quantity decisions in the second period. Last, one could explore the case when the e-tailer can share information partially.

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Online Appendix
" Games of Supplier Encroachment Channel Selection and E-tailer's Information Sharing "

Appendix A Proofs

Proof of Lemma 1. Based on Table B1 in the online Appendix B, one can easily check that $E[w^{JY}] = E[w^{JN}]$, $E[q_R^{JY}] = E[q_R^{JN}]$, $E[q_S^{JY}] = E[q_S^{JN}]$ for $J = \{A, N, D\}$. Therefore, in the following, we omit the superscript that denotes the specific information scenario. We can show that $E[w^D - w^A] = \frac{\mu\alpha\gamma\left((3\alpha+5)\gamma^4-8(\alpha+5)\gamma^2+4\gamma^3-8\gamma+64\right)}{2(8-3\gamma^2)(8-(\alpha+3)\gamma^2)} > 0$, and $E[w^N - w^D] = \frac{\mu(1-\gamma)\gamma^2}{16-6\gamma^2} > 0$. Therefore, $E[w^A] < E[w^D] < E[w^N]$ holds regardless of whether the e-tailer shares information or not. Besides, we can show $\frac{dE[w^{DN}-w^{AN}]}{d\alpha} = \frac{\mu\gamma\left(\left(\alpha^2+6\alpha+5\right)\gamma^4-8(2\alpha+5)\gamma^2+4\gamma^3-8\gamma+64\right)}{2(8-(\alpha+3)\gamma^2)^2} > 0$ and $\frac{dE[w^{DN}-w^{AN}]}{d\gamma} = \frac{\alpha\mu\left(\left(9\alpha^2+42\alpha+45\right)\gamma^8-24\left(2\alpha^2+15\alpha+15\right)\gamma^6+64\left(\alpha^2+17\alpha+28\right)\gamma^4-16(\alpha+15)\gamma^5-512(2\alpha+9)\gamma^2+1024\gamma^3-1024\gamma+4096\right)}{2(8-3\gamma^2)^2(8-(\alpha+3)\gamma^2)^2}$ > 0. Hence, $E[w^D - w^A]$ increases in both γ and α.

As for the e-tailer's reselling quantity, we can show that $E[q_R^N - q_R^A] = \frac{\mu\gamma(8-(\alpha+3)\gamma)}{4(8-(\alpha+3)\gamma^2)} > 0$ and $E[q_R^A - q_R^D] = \frac{2\mu\alpha(1-\gamma)\gamma^2}{(8-3\gamma^2)(8-(\alpha+3)\gamma^2)} > 0$. Hence, $E[q_R^D] < E[q_R^A] < E[q_R^N]$ holds regardless of whether the e-tailer shares information or not. Besides, we can show that $E[q_S^D] - E[q_S^A] = \frac{\mu\alpha(1-\gamma)\gamma^3}{(8-3\gamma^2)(8-(\alpha+3)\gamma^2)} > 0$. Hence, $E[q_S^A] < E[q_S^D]$ holds regardless of whether the e-tailer shares information or not. Besides, $\frac{dE[q_S^A]}{d\gamma} = -\frac{\mu\left((\alpha+3)\gamma^2-16\gamma+8\right)}{(8-(\alpha+3)\gamma^2)^2}$ and $\frac{dE[q_S^D]}{d\gamma} = -\frac{\mu\left(3\gamma^2-16\gamma+8\right)}{(8-3\gamma^2)^2}$. The basic algebra analysis implies that if $\gamma > \frac{2}{3}\left(4-\sqrt{10}\right)$, $\frac{dE[q_S^D]}{d\gamma} > 0$; otherwise, $\frac{dE[q_S^D]}{d\gamma} \leq 0$. Similarly, if $\gamma > \frac{8-2\sqrt{2(5-\alpha)}}{\alpha+3}$, $\frac{dE[q_S^A]}{d\gamma} > 0$; otherwise, $\frac{dE[q_S^A]}{d\gamma} \leq 0$.

In addition, we can show that $E[q_S^A + q_R^A - q_S^D - q_R^D] = \frac{\mu\alpha\gamma^2(2-\gamma)(1-\gamma)}{(8-3\gamma^2)(8-(\alpha+3)\gamma^2)} > 0$, and $E[q_S^D + q_R^D - q_R^N] = \frac{\mu\left(\gamma^2-12\gamma+16\right)}{4(8-3\gamma^2)} > 0$. Hence, $E[q_R^N] < E[q_R^D + q_S^D] < E[q_R^A + q_S^A]$. One can prove that $\frac{dE[q_S^A+q_R^A-q_S^D-q_R^D]}{d\gamma} = \frac{\alpha\mu\gamma g_0}{(8-3\gamma^2)^2(8-(\alpha+3)\gamma^2)^2}$, where $g_0 = 9(\alpha+3)\gamma^5 - 4(7\alpha+33)\gamma^4 + 24(\alpha+6)\gamma^3 + 256\gamma^2 - 576\gamma + 256$. It can be shown that g_0 increases in α because $(9\gamma^2 - 28\gamma + 24)\gamma^3 > 0$. One can show that $g_0\big|_{\alpha=0} = (8-3\gamma^2)(32 - 9\gamma^3 + 44\gamma^2 - 72\gamma)$ and $g_0\big|_{\alpha=1} = 4(9\gamma^5 - 40\gamma^4 + 42\gamma^3 + 64\gamma^2 - 144\gamma + 64)$. After some basic algebra, we can derive that they are both positive when γ is small and become negative when γ is large. Thus, there exists a unique $\hat{\gamma}$ that satisfies

$$9(\alpha+3)\gamma^5 - 4(7\alpha+33)\gamma^4 + 24(\alpha+6)\gamma^3 + 256\gamma^2 - 576\gamma + 256 = 0$$

such that if $\gamma < \hat{\gamma}$, $g_0 > 0$; otherwise, $g_0 \leq 0$. Therefore, we have that $E[q_S^A + q_R^A - q_S^D - q_R^D]$ first increases and then decreases in γ. □

Proof of Proposition 1. Based on Table B1 in Appendix B, we can easily show that

$$\Pi_R^{NY} - \Pi_R^{NN} = \frac{\sigma^2+\mu^2}{16} - \frac{4\sigma^2+\mu^2}{16} = \frac{-3\sigma^2}{16} < 0;$$
$$\Pi_R^{AY} - \Pi_R^{AN} = \frac{\sigma^2 f_1}{4\left(8-(\alpha+3)\gamma^2\right)^2};$$
$$\Pi_R^{DY} - \Pi_R^{DN} = -\frac{(2-\gamma)(3\gamma+2)\left(12-3\gamma^2-4\gamma\right)\sigma^2}{4\left(8-3\gamma^2\right)^2} < 0,$$

where $f_1 = \alpha^3\gamma^4 + \alpha^2\left(5\gamma^2-16\right)\gamma^2 - \alpha\left(\gamma^4-8\gamma^3+36\gamma^2-64\right) - 9\gamma^4 + 64\gamma^2 - 32\gamma - 48$. The above results imply that the e-tailer does not share information under no encroachment and direct encroachment. We can further show that $\frac{df_1}{d\alpha} = 3\alpha^2\gamma^4 + \alpha\left(10\gamma^4-32\gamma^2\right) - \gamma^4 + 8\gamma^3 - 36\gamma^2 + 64$ and $\frac{d^2 f_1}{d\alpha^2} = 2\gamma^2\left((3\alpha+5)\gamma^2-16\right) < 0$. Thus, $\frac{df_1}{d\alpha}$ decreases in α. In addition, since $\frac{df_1}{d\alpha}\Big|_{\alpha\to 1} = 4(\gamma+1)(4-3\gamma)\left(4-\gamma^2-\gamma\right) > 0$, $\frac{df_1}{d\alpha} > 0$ always holds when $\alpha \in (0,1)$. Combining this with $f_1\big|_{\alpha\to 0} = (2-\gamma)(3\gamma+2)\left(3\gamma^2+4\gamma-12\right) < 0$, $f_1\big|_{\alpha\to\frac{3}{4}} = -\frac{1}{64}\gamma\left(417\gamma^3-384\gamma^2-1792\gamma+2048\right) < 0$ and $f_1\big|_{\alpha\to 1} = 4(1-\gamma)^2\left(4-\gamma^2\right) > 0$, we can conclude that there exists a unique $\underline{\alpha}$ that satisfies

$$\alpha^3\gamma^4 + \alpha^2\left(5\gamma^2-16\right)\gamma^2 - \alpha\left(\gamma^4-8\gamma^3+36\gamma^2-64\right) - 9\gamma^4 + 64\gamma^2 - 32\gamma - 48 = 0 \quad \text{(A.1)}$$

such that $f_1 > 0$ (i.e., $\Pi_R^{AY} > \Pi_R^{AN}$) if $\alpha > \underline{\alpha}$; otherwise, $f_1 \le 0$ (i.e., $\Pi_R^{AY} \le \Pi_R^{AN}$). □

Proof of Proposition 2. We first compare the supplier's profits under no encroachment and direct encroachment since the e-tailer does not share information in these two situations. Since $\Pi_S^{NN} = \frac{\mu^2}{8}$ and $\Pi_S^{DN} = \frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4(8-3\gamma^2)} - K$, $\Pi_S^{DN} - \Pi_S^{NN} = \frac{\left(5\gamma^2-16\gamma+16\right)\mu^2}{8(8-3\gamma^2)} - K$. Denote $K^n(\gamma)$ as the solution to

$$K = \frac{\left(5\gamma^2-16\gamma+16\right)\mu^2}{8\left(8-3\gamma^2\right)}. \quad \text{(A.2)}$$

Clearly, $\Pi_S^{DN} > \Pi_S^{NN}$ if $K < K^n(\gamma)$ and $\Pi_S^{DN} \le \Pi_S^{NN}$ otherwise. In addition, we have $\frac{dK^n(\gamma)}{d\gamma} = -\frac{2\left(3\gamma^2-11\gamma+8\right)\mu^2}{\left(8-3\gamma^2\right)^2} < 0$; thus, $K^n(\gamma)$ decreases in γ. As there is a one-to-one mapping between $K^n(\gamma)$ and γ, $K \le K^n(\gamma)$ (resp. $K > K^n(\gamma)$) is equivalent to $\gamma \le \gamma^n$ (resp. $\gamma > \gamma^n$), where γ^n is the unique solution that satisfies (A.2). Here, the superscript n denotes the comparison under the no information sharing scenario. In the proposition in the main manuscript, we let $\underline{\gamma} \triangleq \gamma^n$.

We can show that $\frac{d\Pi_S^{AY}}{d\alpha} = -\frac{\left(8-\alpha\gamma^2-\gamma^2-2\gamma\right)\left(8-\alpha\gamma^2-5\gamma^2+2\gamma\right)\left(\mu^2+\sigma^2\right)}{4\left(8-(\alpha+3)\gamma^2\right)^2} < 0$ and $\frac{d\Pi_S^{AN}}{d\alpha} = -\frac{\left(8-\alpha\gamma^2-\gamma^2-2\gamma\right)\left(8-\alpha\gamma^2-5\gamma^2+2\gamma\right)\mu^2}{4\left(8-(\alpha+3)\gamma^2\right)^2} < 0$. Thus, both Π_S^{AY} and Π_S^{AN} decrease in α. Next, we consider the following two cases.

Case (1): $K \le K^n(\gamma)$ (i.e., $\gamma \le \gamma^n$). Then, $\Pi_S^{DN} \ge \Pi_S^{NN}$. The supplier then compares Π_S^{DN} and Π_S^A to make the channel selection, where $\Pi_S^A = \begin{cases} \Pi_S^{AN}, & \text{if } \alpha \le \underline{\alpha}; \\ \Pi_S^{AY}, & \text{if } \alpha > \underline{\alpha}. \end{cases}$

(1.a) When $\alpha \leq \underline{\alpha}$, $\Pi_S^{DN} - \Pi_S^{AN} = \frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4(8-3\gamma^2)} - \frac{\mu^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4(8-(\alpha+3)\gamma^2)} - K$, which increases in α. Define $F_1(\alpha) \triangleq \frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4(8-3\gamma^2)} - \frac{\mu^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4(8-(\alpha+3)\gamma^2)}$. It can be shown that $F_1(0) = -K < 0$, implying that agency encroachment is chosen if $\alpha \to 0$. There exists a unique $\alpha_{sl}^{(1)}$ that solves

$$\frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4\left(8-3\gamma^2\right)} - \frac{\mu^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4\left(8-(\alpha+3)\gamma^2\right)} - K = 0 \tag{A.3}$$

such that $\Pi_S^{DN} > \Pi_S^{AN}$ if $\alpha > \alpha_{sl}^{(1)}$ and $\Pi_S^{DN} \leq \Pi_S^{AN}$ otherwise. In addition, we let $\alpha_{sl}^{(1)} = \underline{\alpha}$ if $F_1(\underline{\alpha}) < 0$.

(1.b) When $\alpha > \underline{\alpha}$, $\Pi_S^{DN} - \Pi_S^{AY} = \frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4(8-3\gamma^2)} - \frac{\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)(\mu^2+\sigma^2)}{4(8-(\alpha+3))} - K$ also increases in α. Define $F_2(\alpha) \triangleq \frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4(8-3\gamma^2)} - \frac{(\mu^2+\sigma^2)\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4(8-(\alpha+3)\gamma^2)}$. If and only if $F_2\left(\underline{\alpha}\right) < K$ and $F_2(1) = \frac{\left(2\gamma^4+2\gamma^3-15\gamma^2+16\right)\mu^2+(\gamma-1)^2\left(3\gamma^2-8\right)\sigma^2}{4(2-\gamma^2)(8-3\gamma^2)} > K$, there exists a unique $\alpha_{sl}^{(2)}$ that satisfies

$$\frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4\left(8-3\gamma^2\right)} - \frac{\left(\mu^2+\sigma^2\right)\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4\left(8-(\alpha+3)\gamma^2\right)} - K = 0 \tag{A.4}$$

such that $\Pi_S^{DN} > \Pi_S^{AY}$ if $\alpha > \alpha_{sl}^{(2)}$ and $\Pi_S^{DN} \leq \Pi_S^{AY}$ otherwise. If $F_2(\underline{\alpha}) > K$, we let $\alpha_{sl}^{(2)} = \underline{\alpha}$; and if $F_2(1) < K$, we let $\alpha_{sl}^{(2)} = 1$. Since $F_2(\alpha) < F_1(\alpha)$, it must have $\alpha_{sl}^{(1)} < \alpha_{sl}^{(2)}$.

Case (2): $K > K^n(\gamma)$ (i.e., $\gamma > \gamma^n$). Then, $\Pi_S^{DN} < \Pi_S^{NN}$. The supplier then compares Π_S^{NN} and Π_S^{A} to make the channel selection, where $\Pi_S^A = \begin{cases} \Pi_S^{AN}, & \text{if } \alpha \leq \underline{\alpha}; \\ \Pi_S^{AY}, & \text{if } \alpha > \underline{\alpha}. \end{cases}$

(2.a) For $\alpha \leq \underline{\alpha}$, the supplier compares $\Pi_S^{NN} = \frac{\mu^2}{8}$ and $\Pi_S^{AN} = \frac{\mu^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4(8-(\alpha+3)\gamma^2)}$. It can be easily shown that $\Pi_S^{AN} - \Pi_S^{NN} = \frac{\mu^2\left((\alpha(2\alpha+5)+5)\gamma^2-16(\alpha-1)-16\gamma\right)}{64-8(\alpha+3)\gamma^2}$, which decreases in α. In addition, $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=0} = \frac{\left(5\gamma^2-16\gamma+16\right)\mu^2}{64-24\gamma^2} > 0$. Therefore, there exists a unique $\alpha_{sl}^{(3)}$ that satisfies

$$\frac{\mu^2\left((\alpha(2\alpha+5)+5)\gamma^2-16(\alpha-1)-16\gamma\right)}{64-8(\alpha+3)\gamma^2} = 0, \tag{A.5}$$

such that if $\alpha < \alpha_{sl}^{(3)}$, $\Pi_S^{AN} > \Pi_S^{NN}$; otherwise, $\Pi_S^{AN} \leq \Pi_S^{NN}$. Note that if $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=\underline{\alpha}} > 0$, we let $\alpha_{sl}^{(3)} = \underline{\alpha}$.

(2.b) For $\alpha > \underline{\alpha}$, the supplier compares $\Pi_S^{NN} = \frac{\mu^2}{8}$ and $\Pi_S^{AY} = \frac{(\mu^2+\sigma^2)\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4(8-(\alpha+3)\gamma^2)}$. We can derive that $\Pi_S^{AY} - \Pi_S^{NN} = \frac{\mu^2\left(2\alpha^2\gamma^2+5\alpha\gamma^2-16\alpha+5\gamma^2-16\gamma+16\right)+2\sigma^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{64-8(\alpha+3)\gamma^2}$, which decreases in α. Therefore, there exists a unique $\alpha_{sl}^{(4)}$ that satisfies

$$\frac{\mu^2\left(2\alpha^2\gamma^2+5\alpha\gamma^2-16\alpha+5\gamma^2-16\gamma+16\right)+2\sigma^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{64-8(\alpha+3)\gamma^2}=0 \quad \text{(A.6)}$$

such that if $\alpha<\alpha_{sl}^{(4)}$, $\Pi_S^{AY}>\Pi_S^{NN}$; otherwise, $\Pi_S^{AY}\leq\Pi_S^{NN}$. We can show that $\Pi_S^{AY}-\Pi_S^{NN}\big|_{\alpha=1}=\frac{4\gamma(3\gamma-4)\mu^2+8(\gamma-1)^2\sigma^2}{32(2-\gamma^2)}$. When $\sigma^2\geq\frac{4\gamma(4-3\gamma)\mu^2}{8(1-\gamma)^2}$, $\Pi_S^{AY}>\Pi_S^{NN}$ for any $\alpha<1$. Thus, we let $\alpha_{sl}^{(4)}=1$. When $\sigma^2<\frac{4\gamma(4-3\gamma)\mu^2}{8(1-\gamma)^2}$, if $\Pi_S^{AY}-\Pi_S^{NN}\big|_{\alpha=\underline{\alpha}(\gamma)}<0$, we let $\alpha_{sl}^{(4)}=\underline{\alpha}(\gamma)$. In addition, since $\Pi_S^{AY}>\Pi_S^{AN}$, it must have $\alpha_{sl}^{(3)}\leq\alpha_{sl}^{(4)}$.

Based on the above discussions, we can conclude that $(\mathcal{A},Y)$ is the equilibrium if and only if $(\gamma\leq\gamma^n,\alpha\in[\underline{\alpha},\alpha_{sl}^{(2)}])$ or $(\gamma>\gamma^n,\alpha\in[\underline{\alpha},\alpha_{sl}^{(4)}])$, where $\gamma^n=\underline{\gamma}$. We further define

$$\overline{\alpha}_{sl}=\begin{cases}\alpha_{sl}^{(2)}, & \text{when } \gamma\leq\underline{\gamma};\\ \alpha_{sl}^{(4)}, & \text{when } \gamma>\underline{\gamma}.\end{cases} \quad \text{(A.7)}$$

Then, $(\mathcal{A},Y)$ is the equilibrium if and only if $\alpha\in[\underline{\alpha},\overline{\alpha}_{sl}]$. Moreover, $(\mathcal{A},N)$ is the equilibrium if and only if $(\gamma\leq\gamma^n,\alpha\leq\alpha_{sl}^{(1)})$ or $(\gamma>\gamma^n,\alpha\leq\alpha_{sl}^{(3)})$, which is equivalent to $\alpha\leq\alpha_1$, where

$$\alpha_1=\begin{cases}\alpha_{sl}^{(1)}, & \text{when } \gamma\leq\underline{\gamma};\\ \alpha_{sl}^{(3)}, & \text{when } \gamma>\underline{\gamma}.\end{cases} \quad \text{(A.8)}$$

Regarding $(\mathcal{D},N)$, it is the equilibrium if and only if (1) $\gamma\leq\gamma^n=\underline{\gamma}$ and (2) either $\alpha_{sl}^{(1)}<\alpha<\underline{\alpha}$ or $\alpha>\alpha_{sl}^{(2)}$, which is equivalent to $\alpha_1<\alpha<\underline{\alpha}$ or $\alpha>\overline{\alpha}_{sl}$. In the other situations, $(\mathcal{N},N)$ is the equilibrium. □

Proof of Proposition 3 . First, consider the situation in which the e-tailer commits to sharing information with the supplier. Then, the supplier compares the following profits: $\Pi_S^{NY}=\frac{\mu^2+\sigma^2}{8}$, $\Pi_S^{AY}=\frac{\left(\alpha^2\gamma^2-2\alpha\left(4-\gamma^2\right)+\gamma^2-8\gamma+12\right)\left(\mu^2+\sigma^2\right)}{4(8-(\alpha+3)\gamma^2)}$ and $\Pi_S^{DY}=\frac{\left(\gamma^2-8\gamma+12\right)\left(\mu^2+\sigma^2\right)}{4(8-3\gamma^2)}-K$. It can be shown that $\Pi_S^{DY}-\Pi_S^{NY}=\frac{\left(\gamma^2-8\gamma+12\right)\left(\mu^2+\sigma^2\right)}{4(8-3\gamma^2)}-K-\frac{\mu^2+\sigma^2}{8}=\frac{\left(5\gamma^2-16\gamma+16\right)\left(\mu^2+\sigma^2\right)}{8(8-3\gamma^2)}-K$.

Denote $K^y(\gamma)$ as follows:

$$K^y(\gamma)=\frac{\left(5\gamma^2-16\gamma+16\right)\left(\mu^2+\sigma^2\right)}{8\left(8-3\gamma^2\right)}. \quad \text{(A.9)}$$

Then, $\Pi_S^{DY}\geq\Pi_S^{NY}$ if $K\leq K^y(\gamma)$, and $\Pi_S^{DY}<\Pi_S^{NY}$ otherwise. Besides, it can be shown that $\frac{dK^y(\gamma)}{d\gamma}=-\frac{2\left(3\gamma^2-11\gamma+8\right)(\mu^2+\sigma^2)}{(8-3\gamma^2)^2}<0$. Thus, $K^y(\gamma)$ decreases in γ. In other words, there is a one-to-one mapping between $K^y(\gamma)$ and γ. $K\leq K^y(\gamma)$ (resp. $K>K^y(\gamma)$) is equivalent to $\gamma\leq\gamma^y$ (resp. $\gamma>\gamma^y$), and γ^y is the unique solution characterized by (A.9). Since $K^n(\gamma)<K^y(\gamma)$, it must have $\gamma^n<\gamma^y$.

(1.a) When $K \leq K^y(\gamma)$ (i.e., $\gamma \leq \gamma^y$), the supplier needs to compare Π_S^{DY} and Π_S^{AY}. We have shown that Π_S^{AY} decreases in α in the proof of Proposition 2. Besides, one can check that $\Pi_S^{AY}\big|_{\alpha=0} - \Pi_S^{DY} = K > 0$ and $\Pi_S^{AY}\big|_{\alpha=1} - \Pi_S^{DY} = K - \frac{\left(2\gamma^4+2\gamma^3-15\gamma^2+16\right)\left(\mu^2+\sigma^2\right)}{4(2-\gamma^2)(8-3\gamma^2)}$. Thus, there exists a unique $\alpha_{rl}^{(1)}$ such that if $\alpha \leq \alpha_{rl}^{(1)}$, $\Pi_S^{AY} \geq \Pi_S^{DY}$; otherwise, $\Pi_S^{AY} < \Pi_S^{DY}$. Here, note that if $\Pi_S^{AY}\big|_{\alpha=1} - \Pi_S^{DY} \geq 0$, we let $\alpha_{rl}^{(1)} = 1$.

(1.b) When $K > K^y(\gamma)$ (i.e., $\gamma > \gamma^y$), the supplier needs to compare Π_S^{NY} and Π_S^{AY}. Since $\Pi_S^{AY}\big|_{\alpha=0} - \Pi_S^{NY} = \frac{\left(5\gamma^2-16\gamma+16\right)\left(\mu^2+\sigma^2\right)}{8(8-3\gamma^2)} > 0$ and $\Pi_S^{AY}\big|_{\alpha=1} - \Pi_S^{NY} = -\frac{\gamma(4-3\gamma)\left(\mu^2+\sigma^2\right)}{8(2-\gamma^2)} < 0$, there must exist a unique $\alpha_{rl}^{(2)}$ such that if $\alpha \leq \alpha_{rl}^{(2)}$, $\Pi_S^{AY} \geq \Pi_S^{NY}$; otherwise, $\Pi_S^{AY} < \Pi_S^{NY}$.

Also, note that when $K = K^y(\gamma)$, $\Pi_S^{DY} = \Pi_S^{NY}$. Therefore, $\alpha_{rl}^{(1)} = \alpha_{rl}^{(2)}$ when $\gamma = \gamma^y$.

Second, consider the situation in which the e-tailer does not share information. The supplier then compares $\Pi_S^{NN} = \frac{\mu^2}{8}$, $\Pi_S^{DN} = \frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4(8-3\gamma^2)} - K$ and $\Pi_S^{AN} = \frac{\left(\alpha^2\gamma^2-2\alpha\left(4-\gamma^2\right)+\gamma^2-8\gamma+12\right)\mu^2}{4(8-(\alpha+3)\gamma^2)}$. Combining the analysis in the proof of Proposition 2, we have the following:

(2.a) For $K \leq K^n(\gamma)$ (i.e., $\gamma \leq \gamma^n$), the supplier compares Π_S^{DN} and Π_S^{AN}. Case (1.a) in the proof of Proposition 2 implies that $\Pi_S^{DN} > \Pi_S^{AN}$ if $\alpha > \alpha_{sl}^{(1)}$ and $\Pi_S^{DN} \leq \Pi_S^{AN}$ otherwise. $\alpha_{sl}^{(1)}$ has been characterized by (A.3). Here, we let $\alpha_{sl}^{(1)} = 1$ if $\Pi_S^{AN}\big|_{\alpha=1} - \Pi_S^{DN} > 0$.

(2.b) For $K > K^n(\gamma)$ (i.e., $\gamma > \gamma^n$), the supplier compares Π_S^{NN} and Π_S^{AN}. Since $\Pi_S^{AN}\big|_{\alpha=0} - \Pi_S^{NN} = \frac{\left(5\gamma^2-16\gamma+16\right)\mu^2}{8(8-3\gamma^2)} > 0$ and $\Pi_S^{AN}\big|_{\alpha=1} - \Pi_S^{NN} = -\frac{\gamma(4-3\gamma)\mu^2}{8(2-\gamma^2)} < 0$, there must exist a unique $\alpha_{sl}^{(3)}$ that satisfies (A.5) such that if $\alpha < \alpha_{sl}^{(3)}$, $\Pi_S^{AN} > \Pi_S^{NN}$; otherwise, $\Pi_S^{AN} \leq \Pi_S^{NN}$.

One can easily check that $\Pi_S^{AN} - \Pi_S^{DN} - (\Pi_S^{AY} - \Pi_S^{DY}) = \frac{\alpha\sigma^2\left((3\alpha+5)\gamma^4-4(2\alpha+13)\gamma^2+8\gamma^3+64\right)}{4(8-3\gamma^2)(8-(\alpha+3)\gamma^2)} > 0$. This implies that $\alpha_{sl}^{(1)} \geq \alpha_{rl}^{(1)}$. Similarly, we can show that $\alpha_{sl}^{(3)} \geq \alpha_{rl}^{(2)}$. Combining the above, we can have the following: under the information sharing scenario, the supplier selects agency encroachment if and only if $\alpha \leq \alpha^y$, where

$$\alpha^y = \begin{cases} \alpha_{rl}^{(1)}, & \text{if } \gamma \leq \gamma^y; \\ \alpha_{rl}^{(2)}, & \text{if } \gamma > \gamma^y. \end{cases} \tag{A.10}$$

The supplier selects direct encroachment when $\alpha > \alpha^y$ and $\gamma \leq \gamma^y$. Otherwise, the supplier does not encroach. Similarly, under no information sharing scenario, the supplier selects agency encroachment if and only if $\alpha \leq \alpha^n$, where $\alpha^n \geq \alpha^y$ and

$$\alpha^n = \begin{cases} \alpha_{sl}^{(1)}, & \text{if } \gamma \leq \gamma^n; \\ \alpha_{sl}^{(3)}, & \text{if } \gamma > \gamma^n. \end{cases} \tag{A.11}$$

The supplier selects direct encroachment when $\alpha > \alpha^n$ and $\gamma \leq \gamma^n$. Otherwise, the supplier does not encroach. □

Proof of Proposition 4. The e-tailer will compare the profits under different information scenarios to derive the final information decision. Based on Proposition 3, we consider the following subcases:

1. When $\alpha \le \alpha^y$, the supplier selects channel $\mathcal{A}$ in both information scenarios. The e-tailer compares Π_R^{AY} and Π_R^{AN}. We have shown that $\Pi_R^{AY} - \Pi_R^{AN}$ increases in α, and $\Pi_R^{AY} - \Pi_R^{AN} > 0$ if and only if $\alpha > \underline{\alpha}$ in the proof of Proposition 1. Therefore, if $\underline{\alpha} < \alpha < \alpha^y$, the e-tailer shares information and $(Y, \mathcal{A})$ is the equilibrium; if $\alpha \le \underline{\alpha}$, the e-tailer is not willing to share information with the supplier, and the resulting equilibrium is $(N, \mathcal{A})$.

2. When $\gamma < \gamma^n$ and $\alpha > \alpha^n$, the supplier selects channel $\mathcal{D}$ in both information scenarios. The e-tailer then compares Π_R^{DN} and Π_R^{DY}. We have shown that $\Pi_R^{DN} > \Pi_R^{DY}$ in the proof of Proposition 1. Thus, the e-tailer does not share information. In this case, $(N, \mathcal{D})$ is the equilibrium.

3. When $\gamma < \gamma^y$ and $\alpha^y < \alpha \le \alpha^n$, the supplier selects channel $\mathcal{D}$ in information sharing scenario but selects channel $\mathcal{A}$ in no information sharing scenario. The e-tailer then compares $\Pi_R^{AN} = \frac{\mu^2\left(\alpha^3\gamma^4 - 2\alpha^2\left(8-3\gamma^2\right)\gamma^2 + \alpha\left(5\gamma^4+8\gamma^3-52\gamma^2+64\right)+16(1-\gamma)^2\right)}{4(8-(\alpha+3)\gamma^2)^2} + \frac{\sigma^2}{4}$ and $\Pi_R^{DY} = \frac{4(1-\gamma)^2\left(\mu^2+\sigma^2\right)}{(8-3\gamma^2)^2}$. Since Π_R^{AN} increases in α, $\Pi_R^{AN} > \Pi_R^{AN}\big|_{\alpha=0} = \frac{4(1-\gamma)^2\mu^2}{(8-3\gamma^2)^2} + \frac{\sigma^2}{4}$. Moreover, $\frac{4(1-\gamma)^2\mu^2}{(8-3\gamma^2)^2} + \frac{\sigma^2}{4} - \Pi_R^{DY} = \frac{(2-\gamma)(3\gamma+2)\left(12-3\gamma^2-4\gamma\right)\sigma^2}{4(8-3\gamma^2)^2} > 0$. Hence, $\Pi_R^{AN} > \Pi_R^{DY}$ for any $\alpha^y < \alpha \le \alpha^n$. That is, $(N, \mathcal{A})$ is the equilibrium.

4. When $\gamma^n \le \gamma < \gamma^y$ and $\alpha > \alpha^n$, the supplier selects channel $\mathcal{D}$ when the e-tailer shares information but selects channel $\mathcal{N}$ when information is not shared. The e-tailer then compares $\Pi_R^{DY} = \frac{4(1-\gamma)^2\left(\mu^2+\sigma^2\right)}{(8-3\gamma^2)^2}$ and $\Pi_R^{NN} = \frac{\mu^2+4\sigma^2}{16}$. Since $\frac{d\Pi_R^{DY}}{d\gamma} = -\frac{8(1-\gamma)\left(3\gamma^2-6\gamma+8\right)\left(\mu^2+\sigma^2\right)}{(8-3\gamma^2)^3} < 0$ and $\Pi_R^{DY}\big|_{\gamma=0} = \frac{\mu^2+\sigma^2}{16} < \Pi_R^{NN}$, $\Pi_R^{DY} < \Pi_R^{NN}$ always holds. In this case, $(N, \mathcal{N})$ is the equilibrium.

5. When $\gamma \ge \gamma^y$ and $\alpha > \alpha^n$, the supplier selects channel $\mathcal{N}$ in both information scenarios. The e-tailer then compares Π_R^{NY} and Π_R^{NN}. We have shown that $\Pi_R^{NN} > \Pi_R^{NY}$ in the proof of Proposition 1. The e-tailer thus does not share information. In this case, $(N, \mathcal{N})$ is the equilibrium.

For ease of exposition, we let $\overline{\alpha}_{rl} \triangleq \alpha^y$ and $\alpha_2 \triangleq \alpha^n$, where α^y and α^n are given in Proposition 3. Combining $\overline{\alpha}_{sl} = \begin{cases} \alpha_{sl}^{(2)}, & \text{when } \gamma \le \underline{\gamma}; \\ \alpha_{sl}^{(4)}, & \text{when } \gamma > \underline{\gamma}. \end{cases}$ (from Proposition 2), $\alpha^n =$

$\begin{cases}\alpha_{sl}^{(1)}, & \text{if } \gamma \leq \gamma^n = \underline{\gamma}; \\ \alpha_{sl}^{(3)}, & \text{if } \gamma > \gamma^n. \end{cases}$, $\alpha_{sl}^{(1)} < \alpha_{sl}^{(2)}$, and $\alpha_{sl}^{(3)} < \alpha_{sl}^{(4)}$ (see the proof of Proposition 2), we have $\alpha^n < \overline{\alpha}_{sl}$. Since $\overline{\alpha}_{rl} = \alpha^y \leq \alpha^n$, we then have $\overline{\alpha}_{rl} < \overline{\alpha}_{sl}$. □

Proof of Proposition 5 . Recall from Propositions 2 and 4 that in both leadership scenarios, $(\mathcal{D}, Y)/(Y, \mathcal{D})$ or $(\mathcal{N}, Y)/(Y, \mathcal{N})$ will never arise in equilibrium. We thus only need to consider $(\mathcal{D}, N)$ for direct encroachment and $(\mathcal{N}, N)$ for no encroachment. Based on Arya et al. (2007), under no encroachment, the consumer surplus can be expressed as $CS = \frac{q_R^2}{2}$. Combining this with the results listed in Table B1, we can show that $CS^{NN} = \frac{E[(2m_k-\mu)^2]}{32} = \frac{\mu^2+4\sigma^2}{32}$. According to Singh and Vives (1984), under the inverse demand function given by $p_i = a - q_i - \gamma q_j$ $(i, j = \{R, S\}, i \neq j)$, the consumer surplus is given by $CS = \frac{q_i^2+2\gamma q_i q_j+q_j^2}{2}$. Substituting the equilibrium outcomes listed in Table B1 into the above equation, we can then obtain the consumer surplus under different channel structures as follows: $CS^{AY} = \frac{\left((\alpha^2+10\alpha+9)\gamma^4+4(3-\alpha)\gamma^3-4(4\alpha+19)\gamma^2+80\right)(\mu^2+\sigma^2)}{8(8-(\alpha+3)\gamma^2)^2}$, $CS^{AN} = \frac{1}{8}\left(\frac{\mu^2\left((\alpha^2+10\alpha+9)\gamma^4+4(3-\alpha)\gamma^3-4(4\alpha+19)\gamma^2+80\right)}{(8-(\alpha+3)\gamma^2)^2} + \sigma^2\right)$, and $CS^{DN} = \frac{1}{8}\left(\frac{(9\gamma^4+12\gamma^3-76\gamma^2+80)\mu^2}{(8-3\gamma^2)^2} + \sigma^2\right)$. It can be shown that

$$CS^{AY} - CS^{AN} = \frac{(1-\gamma)\sigma^2\left(4-\alpha\gamma^3-3\gamma^2+4\gamma\right)}{2\left(8-(\alpha+3)\gamma^2\right)^2} > 0;$$

$$CS^{AN} - CS^{DN} = \frac{\alpha(1-\gamma)\gamma^2\mu^2\left(3(\alpha+6)\gamma^4-4(\alpha-6)\gamma^3-4(\alpha+18)\gamma^2-9\gamma^5+64\right)}{2\left(8-3\gamma^2\right)^2\left(8-(\alpha+3)\gamma^2\right)^2};$$

$$CS^{DN} - CS^{NN} = \frac{\left(27\gamma^4+48\gamma^3-256\gamma^2+256\right)\mu^2}{32\left(8-3\gamma^2\right)^2} > 0.$$

Define $f_2(\gamma, \alpha) = 3(\alpha+6)\gamma^4 - 4(\alpha-6)\gamma^3 - 4(\alpha+18)\gamma^2 - 9\gamma^5 + 64$. It can be shown that $f_2(\gamma, \alpha)$ decreases in α. $f_2(\gamma, 1) = 64 - 9\gamma^5 + 21\gamma^4 + 20\gamma^3 - 76\gamma^2$, which can be shown to be decreasing in γ. Since $f_2(1, 1) = 20 > 0$, $f_2(\gamma, \alpha) > 0$ shall always hold. Thus, we have $CS^{AY} > CS^{AN} > CS^{DN} > CS^{NN}$.

We now consider social welfare, which is the sum of the supplier profit, e-tailer profit and consumer surplus; that is, $SW = CS + \Pi_S + \Pi_R$. Based on Table B1 and the results obtained above, we can obtain that

$$SW^{NN} = \frac{1}{32}\left(7\mu^2 + 12\sigma^2\right),$$

$$SW^{DN} = \frac{1}{8}\left(\frac{\left(3\gamma^4+60\gamma^3-100\gamma^2-192\gamma+304\right)\mu^2}{\left(8-3\gamma^2\right)^2} + 3\sigma^2\right) - K,$$

$$SW^{AN} = \frac{1}{8}\left(\frac{\mu^2\left(3(\alpha+1)^2\gamma^4+4(7\alpha+15)\gamma^3-4(16\alpha+25)\gamma^2-192\gamma+304\right)}{\left(8-(\alpha+3)\gamma^2\right)^2} + 3\sigma^2\right),$$

$$SW^{AY} = \frac{\left(3(\alpha+1)^2\gamma^4+4(7\alpha+15)\gamma^3-4(16\alpha+25)\gamma^2-192\gamma+304\right)\left(\mu^2+\sigma^2\right)}{8\left(8-(\alpha+3)\gamma^2\right)^2}.$$

We can show that $SW^{AY} - SW^{AN} = \frac{(1-\gamma)\sigma^2\left(3(\alpha+2)\gamma^3-(4\alpha+9)\gamma^2-20\gamma+28\right)}{2(8-(\alpha+3)\gamma^2)^2} > 0$, where the inequality holds because $3(\alpha+2)\gamma^3 - (4\alpha+9)\gamma^2 - 20\gamma + 28$ decreases in α, whose lowest value $9\gamma^3 - 13\gamma^2 - 20\gamma + 28 > 0$. And $SW^{AN} - SW^{NN} = \frac{\mu^2 g_1(\alpha,\gamma)}{32(8-(\alpha+3)\gamma^2)^2}$, where $g_1(\alpha,\gamma) = (5\alpha^2 - 18\alpha - 51)\gamma^4 + 16(7\alpha+15)\gamma^3 - 16(9\alpha+4)\gamma^2 - 768\gamma + 768$. Since $\frac{\partial g_1}{\partial \alpha} = 2\gamma^2\left((5\alpha-9)\gamma^2 + 56\gamma - 72\right) < 0$ and $g_1(1,\gamma) = -16\left(4\gamma^4 - 22\gamma^3 + 13\gamma^2 + 48\gamma - 48\right) > 0$, it must have $g_1(\alpha,\gamma) > 0$. Consequently, $SW^{AN} > SW^{NN}$.

We can show that $SW^{AN} - SW^{DN} = \frac{\alpha(1-\gamma)\gamma^2\mu^2 g_2(\alpha,\gamma)}{2(8-3\gamma^2)^2(8-(\alpha+3)\gamma^2)^2} + K$, where $g_2(\alpha,\gamma) = 192 - ((6\alpha+9)\gamma^5) + 9(\alpha+2)\gamma^4 + 4(5\alpha+18)\gamma^3 - 4(7\alpha+30)\gamma^2 - 128\gamma$. We can further show that $\frac{\partial g_2}{\partial \alpha} = \gamma^2\left(-6\gamma^3 + 9\gamma^2 + 20\gamma - 28\right) < 0$, and $g_2(1,\gamma) = -15\gamma^5 + 27\gamma^4 + 92\gamma^3 - 148\gamma^2 - 128\gamma + 192$ decreases in γ. Thus, $g_2(\alpha,\gamma) > g_2(1,\gamma) > g_2(1,1) = 20 > 0$. Hence, $SW^{AN} > SW^{DN}$. Last, we can show that $SW^{DN} - SW^{NN} = \frac{\left(768-51\gamma^4+240\gamma^3-64\gamma^2-768\gamma\right)\mu^2}{32(8-3\gamma^2)^2} - K$ and $\frac{d(SW^{DN}-SW^{NN})}{d\gamma} = \frac{\left(45\gamma^4-126\gamma^3-72\gamma^2+512\gamma-384\right)\mu^2}{2(8-3\gamma^2)^3} < 0$. Therefore, there exists a unique γ^{sw} that satisfies

$$\frac{\left(768 - 51\gamma^4 + 240\gamma^3 - 64\gamma^2 - 768\gamma\right)\mu^2}{32\left(8-3\gamma^2\right)^2} = K \tag{A.12}$$

such that $SW^{DN} > SW^{NN}$ if $\gamma < \gamma^{sw}$ and $SW^{DN} \leq SW^{NN}$ otherwise. If $(SW^{DN} - SW^{NN})\big|_{\gamma=0} < 0$, we let $\gamma^{sw} = 0$, and if $(SW^{DN} - SW^{NN})\big|_{\gamma=1} > 0$, we let $\gamma^{sw} = 1$. □

Proof of Lemma 2. The proof is based on the results listed in Table B2. By comparing the wholesale price in different channel structures, we can show that $E[w^A] - E[w^D] = -\frac{\alpha\gamma\mu\left(64(1-\alpha)-8\left(1-\alpha^2\right)\gamma^2+(\alpha+1)^2\gamma^4+8(\alpha+3)\gamma\right)}{2(\gamma^2+8)((\alpha+1)^2\gamma^2-8\alpha+8)}$. We can obtain that $64(1-\alpha) - 8\left(1-\alpha^2\right)\gamma^2 + (\alpha+1)^2\gamma^4 + 8(\alpha+3)\gamma$ decreases in α (whose first-order derivative with respect to α is $2(\alpha+1)\gamma^4 + 16\alpha\gamma^2 + 8\gamma - 64 < 0$) and approaches $4\gamma^4 + 32\gamma > 0$ when $\alpha \to 1$. Then, we shall have $E[w^A] - E[w^D] < 0$. And $E[w^D - w^N] = \frac{(\gamma-1)\gamma^2\mu}{2(\gamma^2+8)} < 0$. Thus, $E[w^A] < E[w^D] < E[w^N]$.

Substituting p_S^{AI} and p_R^{AI} into $q_i = \frac{(1-\gamma)m_k - p_i + \gamma p_j}{1-\gamma^2}$ $(i,j = \{S,R\}, i \neq j; I = \{Y,N\})$ and taking expectation with respect to m_k, we can obtain that

$$E[q_S^A] = E[q_S^{AY}] = E[q_S^{AN}] = \frac{\mu\left(\alpha^2\left(\gamma^3+\gamma^2\right) - \alpha\left(8 - 2\gamma^3 - 2\gamma^2 + 6\gamma\right) + \gamma^3 + \gamma^2 + 2\gamma + 8\right)}{2(\gamma+1)\left((\alpha+1)^2\gamma^2 - 8\alpha + 8\right)},$$

and $E[q_R^A] = E[q_R^{AY}] = E[q_R^{AN}] = \frac{\mu\left(\alpha\gamma^2-2\alpha+\gamma^2+2\right)}{(\gamma+1)((\alpha+1)^2\gamma^2-8\alpha+8)}$. Similarly, we can obtain that $E[q_S^D] = E[q_S^{DY}] = E[q_S^{DN}] = \frac{(\gamma+2)\left(\gamma^2-\gamma+4\right)\mu}{2(\gamma+1)(\gamma^2+8)}$ and $E[q_R^D] = E[q_R^{DY}] = E[q_R^{DN}] = \frac{\left(\gamma^2+2\right)\mu}{(\gamma+1)(\gamma^2+8)}$. Based on the above results, we can show that

$$E[q_R^D]-E[q_R^A]=\frac{\alpha\gamma^2\mu\left(\alpha\left(\gamma^2+2\right)+\gamma^2-10\right)}{(\gamma+1)\left(\gamma^2+8\right)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)}<0;$$
$$E[q_R^D]-E[q_R^N]=-\frac{\gamma\left(\gamma^2-3\gamma+8\right)\mu}{4(\gamma+1)\left(\gamma^2+8\right)}<0;$$
$$E[q_R^A]-E[q_R^N]=-\frac{\gamma\mu g_3(\alpha,\gamma)}{4(\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)};$$
$$E[q_S^D]-E[q_S^A]=\frac{\alpha\gamma\mu\left(16-(3\alpha+7)\gamma^2\right)}{(\gamma+1)\left(\gamma^2+8\right)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)}>0;$$
$$E[q_R^A+q_S^A]-E[q_R^D+q_S^D]=\frac{\alpha(1-\gamma)\gamma\mu\left((\alpha+1)\gamma^2-2(\alpha+3)\gamma-16\right)}{(\gamma+1)\left(\gamma^2+8\right)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)}<0;$$
$$E[q_R^N]-E[q_R^D+q_S^D]=-\frac{\left(\gamma^3+5\gamma^2-4\gamma+16\right)\mu}{4(\gamma+1)\left(\gamma^2+8\right)}<0,$$

where $g_3(\alpha,\gamma)=(\alpha+1)^2\gamma^2+(\alpha-3)(\alpha+1)\gamma-8\alpha+8$. It can be shown that $g_3(\alpha,\gamma)$ decreases in α. Since $g_3(0,\gamma)=8-3\gamma+\gamma^2>0$ and $g_3(1,\gamma)=4(\gamma-1)\gamma$, there exists a unique $\tilde{\alpha}_p$ that satisfies $(\alpha+1)^2\gamma^2+(\alpha-3)(\alpha+1)\gamma-8\alpha+8=0$ such that if $\alpha\le\tilde{\alpha}_p$, $g_3(\alpha,\gamma)\ge 0$; otherwise, $g_3(\alpha,\gamma)<0$. Consequently, $E[q_R^A]>E[q_R^N]$ if $\alpha>\tilde{\alpha}_p$ and $E[q_R^A]\le E[q_R^N]$ otherwise. □

Proof of Proposition 6. Note that when the supplier does not encroach, the equilibrium results remain unchanged regardless of whether market competition is based on price or quantity (Huang et al. 2018). By using the similar derivation process in Sections 4.1 and 4.2, we can obtain the subgame equilibrium outcomes in price competition under agency encroachment and direct encroachment, respectively, which we summarize in Table B2 in Appendix B. Next, we analyze the supplier's channel selection and information sharing decisions in two scenarios using the results summarized in the table.

Under price competition, for any given channel structure, it can be easily shown that $\Pi_R^{NY}-\Pi_R^{NN}=\frac{\sigma^2+\mu^2}{16}-\frac{4\sigma^2+\mu^2}{16}=\frac{-3\sigma^2}{16}<0$, $\Pi_R^{DY}-\Pi_R^{DN}=-\frac{3(1-\gamma)\left(16-\gamma^4\right)\sigma^2}{4(\gamma+1)\left(\gamma^2+8\right)^2}<0$ and $\Pi_R^{AY}-\Pi_R^{AN}=\frac{y_1(\alpha,\gamma)}{4(\gamma+1)\left(\alpha^2\gamma^2+2\alpha(\gamma^2-4)+\gamma^2+8\right)^2}$, where $y_1(\alpha,\gamma)=\alpha^5\gamma^4(\gamma+1)+\alpha^4\gamma^2\left(5\gamma^3+3\gamma^2-16\gamma-16\right)+\alpha^3\left(6\gamma^5+6\gamma^4-28\gamma^3-4\gamma^2+64\gamma+64\right)-3\gamma^5+3\gamma^4+48\gamma-48-2\alpha^2\left(\gamma^5-5\gamma^4-12\gamma^3-4\gamma^2+40\gamma+88\right)+\alpha\left(160-7\gamma^5+9\gamma^4+36\gamma^3-4\gamma^2-32\gamma\right)$. Clearly, the sign of $\Pi_R^{AY}-\Pi_R^{AN}$ is determined by the sign of $y_1(\alpha,\gamma)$. Applying some basic algebra, we can show that $\frac{\partial^3 y_1(\alpha,\gamma)}{\partial\alpha^3}>0$, which indicates that $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2}$ increases in α. Furthermore, $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2}\Big|_{\alpha=0}=-4\left(\gamma^5-5\gamma^4-12\gamma^3-4\gamma^2+40\gamma+88\right)<0$ and $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2}\Big|_{\alpha=1}=8\left(14\gamma^5+14\gamma^4-39\gamma^3-25\gamma^2+28\gamma+4\right)$. We can further show that there exists a unique $\bar{\gamma}_p(\approx 0.826)\in(0,1)$ solving

$$14\gamma^5+14\gamma^4-39\gamma^3-25\gamma^2+28\gamma+4=0 \tag{A.13}$$

such that when $\gamma<\bar{\gamma}_p$, $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2}\Big|_{\alpha=1}>0$; otherwise, $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2}\Big|_{\alpha=1}\le 0$.

1. When $\gamma < \bar{\gamma}_p$, there exists a unique $\alpha_p^{(1)} \in (0,1)$ that satisfies

$$\begin{aligned}\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2} =& 20\alpha^3(\gamma+1)\gamma^4 + 12\alpha^2\left(5\gamma^3+3\gamma^2-16\gamma-16\right)\gamma^2 \\ &+ 6\alpha\left(6\gamma^5+6\gamma^4-28\gamma^3-4\gamma^2+64\gamma+64\right) - 4\left(\gamma^5-5\gamma^4-12\gamma^3-4\gamma^2+40\gamma+88\right) = 0\end{aligned} \tag{A.14}$$

   such that $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2} < 0$ if $\alpha < \alpha_p^{(1)}$ and $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2} \geq 0$ otherwise. In this case, $\frac{\partial y_1(\alpha,\gamma)}{\partial\alpha}$ first decreases and then increases in α. We can show that $\frac{\partial y_1(\alpha,\gamma)}{\partial\alpha}\Big|_{\alpha=0} = 160 - 7\gamma^5 + 9\gamma^4 + 36\gamma^3 - 4\gamma^2 - 32\gamma > 0$ and $\frac{\partial y_1(\alpha,\gamma)}{\partial\alpha}\Big|_{\alpha=1} = 32\gamma^2\left(2\gamma^2 + (\gamma^2-2)\gamma - 2\right) < 0$. Thus, $y_1(\alpha,\gamma)$ first increases and then decreases in α. Furthermore, we have $y_1(0,\gamma) = -3(\gamma-2)(\gamma-1)(\gamma+2)\left(\gamma^2+4\right) < 0$, $y_1(\frac{3}{4},\gamma) = \frac{3\gamma\left(2048-1715\gamma^4+6517\gamma^3+8064\gamma^2-1792\gamma\right)}{1024} > 0$ and $y_1(1,\gamma) = 16\gamma^2(\gamma+1)(2\gamma-1)$. So, if $\gamma \geq \frac{1}{2}$, there exists a threshold $\underline{\alpha}_p \in (0,\frac{3}{4})$ such that $y_1(\alpha,\gamma) > 0$ if and only if $\alpha > \underline{\alpha}_p$. If $\gamma < \frac{1}{2}$, then there exist two thresholds $\underline{\alpha}_p \in (0,\frac{3}{4})$ and $\overline{\alpha}_p \in (\frac{3}{4},1)$ such that $y_1(\gamma,\alpha) > 0$ if and only if $\alpha \in \left(\underline{\alpha}_p, \overline{\alpha}_p\right)$.

2. When $\gamma \geq \bar{\gamma}_p$, $\frac{\partial^2 y_1(\alpha,\gamma)}{\partial\alpha^2} < 0$ always holds. That is, $\frac{\partial y_1(\alpha,\gamma)}{\partial\alpha}$ decreases in α. The subsequent analysis is similar to that shown in the above case 1.

Based on the above analysis, we can obtain that when $\gamma < \frac{1}{2}$, $y_1(\alpha,\gamma) > 0$ (i.e., the e-tailer shares information under agency encroachment) if and only if $\alpha \in \left(\underline{\alpha}_p, \overline{\alpha}_p\right)$, where $\underline{\alpha}_p, \overline{\alpha}_p$ are the two roots of

$$y_1(\alpha,\gamma) = 0. \tag{A.15}$$

And $\underline{\alpha}_p\left(\in (0,\frac{3}{4})\right) < \overline{\alpha}_p$. When $\gamma \geq \frac{1}{2}$, there is a unique solution that satisfies (A.15). In this case, $y_1(\alpha,\gamma) > 0$ if and only if $\alpha \in \left(\underline{\alpha}_p, 1\right)$. Furthermore, recall from the proof of Proposition 1 that the e-tailer shares information under agency encroachment when quantity competition is played only if $\alpha > \underline{\alpha} > \frac{3}{4}$. Then, $\underline{\alpha} > \underline{\alpha}_p$. □

Proof of Proposition 7 . This proof is conducted based on the results from Table B2. First, note that under price competition, $\Pi_S^{DN} - \Pi_S^{NN} = \frac{(\gamma+2)\left(\gamma^2-\gamma+6\right)\mu^2}{4(\gamma+1)(\gamma^2+8)} - K - \frac{\mu^2}{8} = \frac{\left(\gamma^3+\gamma^2+16\right)\mu^2}{8(\gamma+1)(\gamma^2+8)} - K$. Define $K_p^n \triangleq \frac{\left(\gamma^3+\gamma^2+16\right)\mu^2}{8(\gamma+1)(\gamma^2+8)}$. We can obtain that $\frac{dK_p^n}{d\gamma} = -\frac{2\left(-\gamma^3+\gamma^2+\gamma+8\right)\mu^2}{(\gamma+1)^2(\gamma^2+8)^2} < 0$. Then, there is a one-to-one mapping relationship between K_p^n and γ. Furthermore, $K_p^n - K^n = \frac{\left(\gamma^3+\gamma^2+16\right)\mu^2}{8(\gamma+1)(\gamma^2+8)} - \frac{\left(5\gamma^2-16\gamma+16\right)\mu^2}{8(8-3\gamma^2)} = \frac{\gamma^2(1-\gamma)\left(\gamma^2+4\right)\mu^2}{(\gamma+1)(\gamma^2+8)(8-3\gamma^2)} > 0$. Therefore, $\Pi_S^{DN} \geq \Pi_S^{NN}$ if and only if $K \leq K_p^n$ (or equivalently, $\gamma \leq \gamma_p^n$), and $\Pi_S^{DN} < \Pi_S^{NN}$ otherwise, where γ_p^n is the unique solution of

$$\frac{\left(\gamma^3+\gamma^2+16\right)\mu^2}{8(\gamma+1)\left(\gamma^2+8\right)} = K. \tag{A.16}$$

For ease of exposition, we let $\underline{\gamma}_p \triangleq \gamma_p^n$. In the following, we will use them interchangeably whenever necessary. Besides, $\gamma_p^n > \gamma^n$ because $K_p^n > K^n$. We can show that $\frac{d\Pi_S^{AY}}{d\alpha} = -\frac{(\mu^2+\sigma^2)\left(4(\alpha+1)\gamma^2\left(7-4\alpha^2(\gamma+1)+\alpha\gamma-\alpha+\gamma\right)+(\alpha+1)^4\gamma^5+(\alpha+1)^4\gamma^4+64(1-\alpha)^2\gamma+64(1-\alpha)^2\right)}{4(\gamma+1)((\alpha+1)^2\gamma^2-8\alpha+8)^2} < 0$ and $\frac{d\Pi_S^{AN}}{d\alpha} = -\frac{\mu^2\left(4(\alpha+1)\gamma^2\left(7-4\alpha^2(\gamma+1)+\alpha\gamma-\alpha+\gamma\right)+(\alpha+1)^4\gamma^5+(\alpha+1)^4\gamma^4+64(1-\alpha)^2\gamma+64(1-\alpha)^2\right)}{4(\gamma+1)((\alpha+1)^2\gamma^2-8\alpha+8)^2} < 0$. Thus, both Π_S^{AY} and Π_S^{AN} decrease in α.

(1) When $\gamma > \gamma_p^n$, the supplier compares $\Pi_S^{NN} = \frac{\mu^2}{8}$ and $\Pi_S^A = \begin{cases} \Pi_S^{AY}, & \text{if } \alpha \in \left(\underline{\alpha}_p, \overline{\alpha}_p\right); \\ \Pi_S^{AN}, & \text{otherwise.} \end{cases}$

(1.a) For $\alpha \in \left(\underline{\alpha}_p, \overline{\alpha}_p\right)$, $\Pi_S^{AY} - \Pi_S^{NN}$ decreases in α. There exists at most one solution $\alpha_p^{n_1}$ that satisfies

$$\frac{(1-\alpha)\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)\left(\mu^2+\sigma^2\right)}{4(\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)} = \frac{\mu^2}{8}$$

such that $\Pi_S^{AY} > \Pi_S^{NN}$ if $\alpha < \alpha_p^{n_1}$ and $\Pi_S^{AY} \leq \Pi_S^{NN}$ otherwise. In addition, we let $\alpha_p^{n_1} = \overline{\alpha}_p$ if $\Pi_S^{AY} - \Pi_S^{NN}\big|_{\alpha=\overline{\alpha}_p} > 0$ and let $\alpha_p^{n_1} = \underline{\alpha}_p$ if $\Pi_S^{AY} - \Pi_S^{NN}\big|_{\alpha=\underline{\alpha}_p} < 0$.

(1.b) For $\alpha \leq \underline{\alpha}_p$ or $\alpha > \overline{\alpha}_p$, $\Pi_S^{AN} - \Pi_S^{NN}$ decreases in α. It can be shown that $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=0} = \frac{\left(\gamma^3+\gamma^2+16\right)\mu^2}{8(\gamma+1)(\gamma^2+8)} > 0$ and $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=1} = -\frac{\mu^2}{8} < 0$. Again, there exists at most one solution $\alpha_p^{n_2}$ that satisfies

$$\frac{(1-\alpha)\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)\mu^2}{4(\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)} = \frac{\mu^2}{8}.$$

If $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=\underline{\alpha}_p} > 0$ and $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=\overline{\alpha}_p} < 0$, then $\alpha_p^{n_2} \in (\underline{\alpha}_p, \overline{\alpha}_p)$. That is, $\Pi_S^{AN} \geq \Pi_S^{NN}$ when $\alpha \leq \underline{\alpha}_p$ and $\Pi_S^{AN} < \Pi_S^{NN}$ when $\alpha > \overline{\alpha}_p$. If $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=\underline{\alpha}_p} \leq 0$, then $\alpha_p^{n_2} \leq \underline{\alpha}_p$. If $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=\overline{\alpha}_p} \geq 0$, then $\alpha_p^{n_2} \geq \overline{\alpha}_p$.

(2) When $\gamma \leq \gamma_p^n$, the supplier needs to compare $\Pi_S^{DN} = \frac{(\gamma+2)\left(\gamma^2-\gamma+6\right)\mu^2}{4(\gamma+1)(\gamma^2+8)} - K$ and $\Pi_S^A = \begin{cases} \Pi_S^{AY}, & \text{if } \alpha \in \left(\underline{\alpha}_p, \overline{\alpha}_p\right); \\ \Pi_S^{AN}, & \text{otherwise.} \end{cases}$

(2.a) For $\alpha \in \left(\underline{\alpha}_p, \overline{\alpha}_p\right)$, $\Pi_S^{AY} - \Pi_S^{DN}$ decreases in α. There exists at most one solution $\alpha_p^{n_3}$ that satisfies

$$\frac{(1-\alpha)\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)\left(\mu^2+\sigma^2\right)}{4(\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)} = \frac{(\gamma+2)\left(\gamma^2-\gamma+6\right)\mu^2}{4(\gamma+1)\left(\gamma^2+8\right)} - K.$$

(2.b) For $\alpha \leq \underline{\alpha}_p$ or $\alpha > \overline{\alpha}_p$, we can show that $\Pi_S^{AN} - \Pi_S^{DN}$ decreases in α. Similar to case (2.a), there exists at most one solution $\alpha_p^{n_4}$ that satisfies

$$\frac{(1-\alpha)\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)\mu^2}{4(\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)} = \frac{(\gamma+2)\left(\gamma^2-\gamma+6\right)\mu^2}{4(\gamma+1)\left(\gamma^2+8\right)} - K.$$

Besides, we can show that $\Pi_S^{AN} - \Pi_S^{DN}\big|_{\alpha=0} = K > 0$ and $\Pi_S^{AN} - \Pi_S^{NN}\big|_{\alpha=1} = K - \frac{(\gamma+2)\left(\gamma^2-\gamma+6\right)\mu^2}{4(\gamma+1)(\gamma^2+8)}$. If $\Pi_S^{AN} - \Pi_S^{DN}\big|_{\alpha=\underline{\alpha}_p} > 0$ and $\Pi_S^{AN} - \Pi_S^{DN}\big|_{\alpha=\overline{\alpha}_p} < 0$, then $\alpha_p^{n_4} \in (\underline{\alpha}_p, \overline{\alpha}_p)$. That is, $\Pi_S^{AN} \geq \Pi_S^{DN}$ when $\alpha \leq \underline{\alpha}_p$ and $\Pi_S^{AN} < \Pi_S^{DN}$ when $\alpha > \overline{\alpha}_p$. If $\Pi_S^{AN} - \Pi_S^{DN}\big|_{\alpha=\underline{\alpha}_p} \leq 0$, then $\alpha_p^{n_4} \leq \underline{\alpha}_p$. If $\Pi_S^{AN} - \Pi_S^{DN}\big|_{\alpha=\overline{\alpha}_p} \geq 0$, then $\alpha_p^{n_4} \geq \overline{\alpha}_p$.

Combining the above analysis, we obtain that $(\mathcal{A}, Y)$ is an equilibrium when (1) $\gamma > \gamma_p^n$ and $\alpha \in (\underline{\alpha}_p, \alpha_p^{n_1})$ or (2) $\gamma \leq \gamma_p^n$ and $\alpha \in (\underline{\alpha}_p, \alpha_p^{n_3})$. Define

$$\hat{\alpha}_{sl} = \begin{cases} \alpha_p^{n_1}, & \text{if } \gamma > \gamma_p^n = \underline{\gamma}_p; \\ \alpha_p^{n_3}, & \text{otherwise.} \end{cases} \tag{A.17}$$

Then, $(\mathcal{A}, Y)$ is an equilibrium if and only if $\alpha \in (\underline{\alpha}_p, \hat{\alpha}_{sl})$.

We next analyze the e-tailer-leads scenario. For any given information scenario, by applying the same derivation process used in the proof of Proposition 3, we can obtain that the supplier does not encroach if and only if $\gamma \geq \gamma_p^s$ and $\alpha > \alpha_p^s$ ($s = \{y, n\}$), the supplier selects direct channel if and only if $\gamma < \gamma_p^s$ and $\alpha > \alpha_p^s$, and the supplier selects agency channel otherwise, where γ_p^n has been defined in (A.16). γ_p^y is the unique solution of $\Pi_S^{DY} = \Pi_S^{NY}$ that satisfies

$$\frac{(\gamma+2)(\gamma^2-\gamma+6)(\mu^2+\sigma^2)}{4(\gamma+1)(\gamma^2+8)} - K = \frac{\mu^2+\sigma^2}{8}. \tag{A.18}$$

α_p^n is the unique root that solves $\Pi_S^{DN} = \Pi_S^{AN}$ when $\gamma \leq \gamma_p^n$ and solves $\Pi_S^{NN} = \Pi_S^{AN}$ when $\gamma > \gamma_p^n$. That is,

$$\alpha_p^n = \begin{cases} \alpha_p^{n_4}, & \text{if } \gamma \leq \gamma_p^n \\ \alpha_p^{n_2}, & \text{otherwise.} \end{cases} \tag{A.19}$$

α_p^y is the unique root that solves $\Pi_S^{DY} = \Pi_S^{AY}$ when $\gamma \leq \gamma_p^y$ and solves $\Pi_S^{NY} = \Pi_S^{AY}$ when $\gamma > \gamma_p^y$. Specifically, when $\gamma \leq \gamma_p^y$, define $\alpha_p^{y_1}$ as the unique root that solves

$$\frac{(\gamma+2)(\gamma^2-\gamma+6)(\mu^2+\sigma^2)}{4(\gamma+1)(\gamma^2+8)} - K = \frac{(1-\alpha)\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)(\mu^2+\sigma^2)}{4(\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)}.$$

When $\gamma > \gamma_p^y$, define $\alpha_p^{y_2}$ as the unique root that solves

$$\frac{\mu^2+\sigma^2}{8} = \frac{(1-\alpha)\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)(\mu^2+\sigma^2)}{4(\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha+8\right)}.$$

Then,

$$\alpha_p^y = \begin{cases} \alpha_p^{y_1}, & \text{if } \gamma \leq \gamma_p^y; \\ \alpha_p^{y_2}, & \text{otherwise.} \end{cases} \tag{A.20}$$

By comparing (A.16) and (A.18), we can show that $\gamma_p^n < \gamma_p^y$. Similarly, we can show that $\alpha_p^n > \alpha_p^y$ through comparing (A.19) and (A.20).

In the following, we explore the conditions under which $(Y, \mathcal{A})$ is the equilibrium. Note that when $\alpha \leq \alpha_p^y$, the supplier selects agency channel in both information scenarios. The e-tailer then compares Π_R^{AY} and Π_R^{AN}. Combining this with Proposition 6, we can obtain that when $\underline{\alpha}_p < \alpha < \min\{\alpha_p^y, \overline{\alpha}_p\}$, the e-tailer shares information and $(Y, \mathcal{A})$ is the equilibrium. Define

$$\hat{\alpha}_{rl} = \min\{\alpha_p^y, \overline{\alpha}_p\}. \tag{A.21}$$

Then, we have $\hat{\alpha}_{rl} \leq \alpha_p^y < \alpha_p^n$. When $\gamma \geq \frac{1}{2}$, $\overline{\alpha}_p = 1$. In this situation, one can easily show that $\alpha_p^{n_3} > \alpha_p^{n_4}$ and $\alpha_p^{n_1} > \alpha_p^{n_2}$. Combining this with (A.17) and (A.19), we have $\alpha_p^n < \hat{\alpha}_{sl}$. Thus, we have $\hat{\alpha}_{rl} < \hat{\alpha}_{sl}$ when $\gamma \geq \frac{1}{2}$. □

Appendix B Equilibrium Outcomes under Different Settings

(1) Table B1 summarizes the subgame outcomes under quantity competition of Section 4. Here, we focus on the situation in which all the equilibrium decisions are positive. That is, $q_R^{NN}, q_R^{AN}, q_R^{DN} > 0$, which requires $m_L > \max\{\frac{\mu}{2}, \frac{4-(\alpha+3)\gamma^2+4\gamma}{8-(\alpha+3)\gamma^2}\mu, \frac{4-3\gamma^2+4\gamma}{8-3\gamma^2}\mu\}$. We can show that $\frac{4-3\gamma^2+4\gamma}{8-3\gamma^2}\mu - \frac{\mu}{2} = \frac{\gamma(8-3\gamma)\mu}{16-6\gamma^2} > 0$, and $\frac{4-3\gamma^2+4\gamma}{8-3\gamma^2}\mu - \frac{4-(\alpha+3)\gamma^2+4\gamma}{8-(\alpha+3)\gamma^2}\mu = \frac{4\alpha(1-\gamma)\gamma^2\mu}{(8-3\gamma^2)(8-(\alpha+3)\gamma^2)} \geq 0$. Therefore, throughout the paper, we focus on the parameter values that satisfy $m_L > \frac{4-3\gamma^2+4\gamma}{8-3\gamma^2}\mu = \frac{(2-\gamma)(3\gamma+2)\mu}{8-3\gamma^2}$.

Table B1: Subgame Outcomes under Quantity Competition

	No Encroachment
Share	$\Pi_S^{NY} = \frac{\mu^2+\sigma^2}{8}$, $w^{NY} = \frac{m_k}{2}$, $\Pi_R^{NY} = \frac{\mu^2+\sigma^2}{16}$, $q_R^{NY} = \frac{m_k}{4}$
Not Share	$\Pi_S^{NN} = \frac{\mu^2}{8}$, $w^{NN} = \frac{\mu}{2}$, $\Pi_R^{NN} = \frac{\mu^2+4\sigma^2}{16}$, $q_R^{NN} = \frac{2m_k-\mu}{4}$
	Agency Encroachment
Share	$\Pi_S^{AY} = \frac{\left(\alpha^2\gamma^2-2\alpha\left(4-\gamma^2\right)+\gamma^2-8\gamma+12\right)\left(\mu^2+\sigma^2\right)}{4(8-(\alpha+3)\gamma^2)}$ $w^{AY} = \frac{\left((\alpha+1)^2\gamma^3-8\alpha\gamma-4\gamma^2+8\right)m_k}{2(8-(\alpha+3)\gamma^2)}$, $q_S^{AY} = \frac{m_k\left(8-2\gamma-(1+\alpha)\gamma^2\right)}{2(8-(\alpha+3)\gamma^2)}$ $\Pi_R^{AY} = \frac{\left(\alpha\left((\alpha+1)(\alpha+5)\gamma^4-4(4\alpha+13)\gamma^2+8\gamma^3+64\right)+16(1-\gamma)^2\right)\left(\mu^2+\sigma^2\right)}{4(8-(\alpha+3)\gamma^2)^2}$ $q_R^{AY} = \frac{2(1-\gamma)m_k}{8-(\alpha+3)\gamma^2}$
Not Share	$\Pi_S^{AN} = \frac{\mu^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)}{4(8-(\alpha+3)\gamma^2)}$ $w^{AN} = \frac{\mu\left(\alpha^2\gamma^3+2\alpha\left(\gamma^2-4\right)\gamma+\gamma^3-4\gamma^2+8\right)}{2(8-(\alpha+3)\gamma^2)}$, $q_S^{AN} = \frac{\mu\left(8-2\gamma-(1+\alpha)\gamma^2\right)}{2(8-(\alpha+3)\gamma^2)}$ $\Pi_R^{AN} = \frac{\mu^2\left(\alpha^3\gamma^4-2\alpha^2\left(8-3\gamma^2\right)\gamma^2+\alpha\left(5\gamma^4+8\gamma^3-52\gamma^2+64\right)+16(1-\gamma)^2\right)}{4(8-(\alpha+3)\gamma^2)^2} + \frac{\sigma^2}{4}$ $q_R^{AN} = \frac{1}{2}\left(m_k - \frac{4-(\alpha+3)\gamma^2+4\gamma}{8-(\alpha+3)\gamma^2}\mu\right)$
	Direct Encroachment
Share	$\Pi_S^{DY} = \frac{\left(\gamma^2-8\gamma+12\right)\left(\mu^2+\sigma^2\right)}{4(8-3\gamma^2)} - K$, $w^{DY} = \frac{m_k\left(\gamma^3-4\gamma^2+8\right)}{2(8-3\gamma^2)}$, $q_S^{DY} = \frac{m_k\left(8-\gamma^2-2\gamma\right)}{2(8-3\gamma^2)}$ $\Pi_R^{DY} = \frac{4(1-\gamma)^2\left(\mu^2+\sigma^2\right)}{(8-3\gamma^2)^2}$, $q_R^{DY} = \frac{2m_k(1-\gamma)}{8-3\gamma^2}$
Not Share	$\Pi_S^{DN} = \frac{\left(\gamma^2-8\gamma+12\right)\mu^2}{4(8-3\gamma^2)} - K$, $w^{DN} = \frac{\mu\left(\gamma^3-4\gamma^2+8\right)}{2(8-3\gamma^2)}$, $q_S^{DN} = \frac{\left(8-\gamma^2-2\gamma\right)\mu}{2(8-3\gamma^2)}$ $\Pi_R^{DN} = \frac{\left(8-3\gamma^2\right)^2\sigma^2+16(\gamma-1)^2\mu^2}{4(8-3\gamma^2)^2}$, $q_R^{DN} = \frac{m_k\left(8-3\gamma^2\right)-\left(4-3\gamma^2+4\gamma\right)\mu}{2(8-3\gamma^2)}$

(2) Table B2 summarizes the subgame outcomes under price competition of Section 5.1.

Table B2: Subgame Outcomes under Price Competition

	No Encroachment
Share	$\Pi_S^{NY} = \frac{\mu^2+\sigma^2}{8}$, $w^{NY} = \frac{m_k}{2}$, $\Pi_R^{NY} = \frac{\mu^2+\sigma^2}{16}$, $q_R^{NY} = \frac{m_k}{4}$
Not Share	$\Pi_S^{NN} = \frac{\mu^2}{8}$, $w^{NN} = \frac{\mu}{2}$, $\Pi_R^{NN} = \frac{\mu^2+4\sigma^2}{16}$, $q_R^{NN} = \frac{2m_k-\mu}{4}$
	Agency Encroachment
Share	$\Pi_S^{AY} = \frac{(1-\alpha)\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)\left(\mu^2+\sigma^2\right)}{4(\gamma+1)((\alpha+1)^2\gamma^2-8\alpha+8)}$ $w^{AY} = \frac{(1-\alpha)m_k\left((\alpha+1)^2\gamma^3-8\alpha\gamma+8\right)}{2((\alpha+1)^2\gamma^2-8\alpha+8)}$, $p_S^{AY} = \frac{m_k\left(\alpha^2\gamma^2+2\alpha\gamma-8\alpha-\gamma^2+2\gamma+8\right)}{2((\alpha+1)^2\gamma^2-8\alpha+8)}$ $\Pi_R^{AY} = \frac{T(\mu^2+\sigma^2)}{4(\gamma+1)((\alpha+1)^2\gamma^2-8\alpha+8)}$ $p_R^{AY} = \frac{m_k\left(12-\alpha^2\gamma^3+2\alpha^2\gamma^2-2\alpha\gamma^3+4\alpha\gamma^2+4\alpha\gamma-12\alpha-\gamma^3+2\gamma^2-4\gamma\right)}{2((\alpha+1)^2\gamma^2-8\alpha+8)}$
Not Share	$\Pi_S^{AN} = \frac{(1-\alpha)\mu^2\left((\gamma+1)\left((\alpha+1)^2\gamma^2-8\alpha\right)+4(\gamma+3)\right)}{4(\gamma+1)((\alpha+1)^2\gamma^2-8\alpha+8)}$ $w^{AN} = \frac{(1-\alpha)\mu\left((\alpha+1)^2\gamma^3-8\alpha\gamma+8\right)}{2((\alpha+1)^2\gamma^2-8\alpha+8)}$, $p_S^{AN} = \frac{\mu\left(\alpha^2\gamma^2+2\alpha\gamma-8\alpha-\gamma^2+2\gamma+8\right)}{2((\alpha+1)^2\gamma^2-8\alpha+8)}$ $\Pi_R^{AN} = \frac{T\mu^2}{4(\gamma+1)((\alpha+1)^2\gamma^2-8\alpha+8)} + \frac{(1-\gamma)\sigma^2}{4(\gamma+1)}$ $p_R^{AN} = \frac{1}{2}\left(\frac{\mu\left(\alpha^2\gamma^2-2\alpha\left(2-\gamma^2+2\gamma\right)+(\gamma+2)^2\right)}{(\alpha+1)^2\gamma^2-8\alpha+8} + m_k(1-\gamma)\right)$
	Direct Encroachment
Share	$\Pi_S^{DY} = \frac{(\gamma+2)\left(\gamma^2-\gamma+6\right)\left(\mu^2+\sigma^2\right)}{4(\gamma+1)(\gamma^2+8)} - K$, $w^{DY} = \frac{m_k\left(\gamma^3+8\right)}{2(\gamma^2+8)}$, $p_S^{DY} = \frac{m_k\left(8-\gamma^2+2\gamma\right)}{2(\gamma^2+8)}$ $\Pi_R^{DY} = \frac{(1-\gamma)\left(\gamma^2+2\right)^2\left(\mu^2+\sigma^2\right)}{(\gamma+1)(\gamma^2+8)^2}$, $p_R^{DY} = \frac{m_k\left(12-\gamma^3+2\gamma^2-4\gamma\right)}{2(\gamma^2+8)}$
Not Share	$\Pi_S^{DN} = \frac{(\gamma+2)\left(\gamma^2-\gamma+6\right)\mu^2}{4(\gamma+1)(\gamma^2+8)} - K$, $w^{DN} = \frac{\left(\gamma^3+8\right)\mu}{2(\gamma^2+8)}$, $p_S^{DN} = \frac{\left(8-\gamma^2+2\gamma\right)\mu}{2(\gamma^2+8)}$ $\Pi_R^{DN} = \frac{(1-\gamma)\left(4\left(\gamma^2+2\right)^2\mu^2+\left(\gamma^2+8\right)^2\sigma^2\right)}{4(\gamma+1)(\gamma^2+8)^2}$, $p_R^{DN} = \frac{m_k\left(8-\gamma^3+\gamma^2-8\gamma\right)+(\gamma+2)^2\mu}{2(\gamma^2+8)}$
Note	$T = 16(1-\alpha)^2(4\alpha+1) - (\alpha+1)^3\left(4-\alpha^2-\alpha\right)\gamma^5 + (\alpha+1)^3\left(\alpha^2+\alpha+4\right)\gamma^4$ $-4(\alpha+1)\left(4\alpha^3-\alpha^2-9\alpha+4\right)\gamma^3 + 4(\alpha+1)\left(4-4\alpha^3-\alpha^2-\alpha\right)\gamma^2$ $+16(4\alpha-1)(1-\alpha)^2\gamma$

(3) Table B3 summarizes the subgame outcomes under quantity competition of Section 5.2, in which the supplier has a selling cost disadvantage relative to the e-tailer. That is, the supplier incurs a unit cost c when selling directly.

Table B3: Subgame Outcomes under Quantity Competition: Selling Cost Disadvantage

	No Encroachment
Share	$\Pi_S^{NY} = \frac{\mu^2+\sigma^2}{8}$, $w^{NY} = \frac{m_k}{2}$, $\Pi_R^{NY} = \frac{\mu^2+\sigma^2}{16}$, $q_R^{NY} = \frac{m_k}{4}$
Not Share	$\Pi_S^{NN} = \frac{\mu^2}{8}$, $w^{NN} = \frac{\mu}{2}$, $\Pi_R^{NN} = \frac{\mu^2+4\sigma^2}{16}$ $q_R^{NN} = \frac{2m_k-\mu}{4}$
	Agency Encroachment
Share	$\Pi_S^{AY} = \frac{(1-\alpha)^2\left(\alpha^2\gamma^2-2\alpha\left(4-\gamma^2\right)+\gamma^2-8\gamma+12\right)\left(\mu^2+\sigma^2\right)+c^2\left(\alpha^2\gamma^2-2\alpha\left(4-\gamma^2\right)+\gamma^2+8\right)-2(1-\alpha)c\mu\left(\alpha^2\gamma^2-2\alpha\left(4-\gamma^2\right)+\gamma^2-4\gamma+8\right)}{4(1-\alpha)^2(8-(\alpha+3)\gamma^2)}$ $w^{AY} = \frac{(1-\alpha)\left((\alpha+1)^2\gamma^3-8\alpha\gamma-4\gamma^2+8\right)m_k+c\gamma\left(8\alpha-(\alpha+1)^2\gamma^2\right)}{2(1-\alpha)(8-(\alpha+3)\gamma^2)}$, $q_S^{AY} = \frac{m_k\left(\alpha^2\gamma^2+2\alpha(\gamma-4)-\gamma^2-2\gamma+8\right)-c\left(8-(\alpha+1)\gamma^2\right)}{2(1-\alpha)(8-(\alpha+3)\gamma^2)}$ $\Pi_R^{AY} = \frac{\left(\alpha\left((\alpha+1)(\alpha+5)\gamma^4-4(4\alpha+13)\gamma^2+8\gamma^3+64\right)+16(1-\gamma)^2\right)\left(\mu^2+\sigma^2\right)}{4(8-(\alpha+3)\gamma^2)^2} + \frac{c^2\left(16\gamma^2-\alpha\left(8-(\alpha+1)\gamma^2\right)^2\right)}{4(1-\alpha)^2(8-(\alpha+3)\gamma^2)^2} + \frac{(1-\gamma)\gamma c\mu\left(\alpha(\alpha+1)\gamma^2-8\alpha+8\right)}{(1-\alpha)(8-(\alpha+3)\gamma^2)^2}$ $q_R^{AY} = \frac{2((1-\alpha)(1-\gamma)m_k+c\gamma)}{(1-\alpha)(8-(\alpha+3)\gamma^2)}$
Not Share	$\Pi_S^{AN} = \frac{(1-\alpha)^2\mu^2\left((\alpha+1)^2\gamma^2-8\alpha-8\gamma+12\right)+c^2\left((\alpha+1)^2\gamma^2+8(1-\alpha)\right)-2(1-\alpha)c\mu\left((\alpha+1)^2\gamma^2-8\alpha-4\gamma+8\right)}{4(1-\alpha)^2(8-(\alpha+3)\gamma^2)}$ $w^{AN} = \frac{(1-\alpha)\mu\left(\alpha^2\gamma^3+2\alpha\left(\gamma^2-4\right)\gamma+\gamma^3-4\gamma^2+8\right)-c\left(\alpha^2\gamma^3+2\alpha\left(\gamma^2-4\right)\gamma+\gamma^3\right)}{2(1-\alpha)(8-(\alpha+3)\gamma^2)}$, $q_S^{AN} = \frac{\mu\left(\alpha^2\gamma^2-2\alpha(4-\gamma)-\gamma^2-2\gamma+8\right)-c\left(8-(\alpha+1)\gamma^2\right)}{2(1-\alpha)(8-(\alpha+3)\gamma^2)}$ $\Pi_R^{AN} = \frac{\mu^2\left(\alpha^3\gamma^4-2\alpha^2\left(8-3\gamma^2\right)\gamma^2+\alpha\left(5\gamma^4+8\gamma^3-52\gamma^2+64\right)+16(1-\gamma)^2\right)}{4(8-(\alpha+3)\gamma^2)^2} + \frac{\sigma^2}{4}$ $+ \frac{4(1-\alpha)c(1-\gamma)\gamma\mu\left(\alpha(\alpha+1)\gamma^2-8\alpha+8\right)-c^2\left(\alpha^3\gamma^4+2\alpha^2\left(\gamma^2-8\right)\gamma^2+\alpha\left(8-\gamma^2\right)^2-16\gamma^2\right)}{4(1-\alpha)^2(8-(\alpha+3)\gamma^2)^2}$ $q_R^{AN} = \frac{1}{2}\left(m_k + \frac{4c\gamma-\mu(1-\alpha)\left(4-(\alpha+3)\gamma^2+4\gamma\right)}{(1-\alpha)(8-(\alpha+3)\gamma^2)}\right)$
	Direct Encroachment
Share	$\Pi_S^{DY} = \frac{\left(\gamma^2+8\right)c^2+\left(\gamma^2-8\gamma+12\right)\left(\mu^2+\sigma^2\right)-2\left(\gamma^2-4\gamma+8\right)c\mu}{4(8-3\gamma^2)} - K$, $w^{DY} = \frac{m_k\left(\gamma^3-4\gamma^2+8\right)-c\gamma^3}{2(8-3\gamma^2)}$, $q_S^{DY} = \frac{m_k\left(8-\gamma^2-2\gamma\right)-c\left(8-\gamma^2\right)}{2(8-3\gamma^2)}$ $\Pi_R^{DY} = \frac{4\left(c^2\gamma^2+2c\gamma(1-\gamma)\mu+(1-\gamma)^2\left(\mu^2+\sigma^2\right)\right)}{(8-3\gamma^2)^2}$, $q_R^{DY} = \frac{2(m_k(1-\gamma)+c\gamma)}{8-3\gamma^2}$
Not Share	$\Pi_S^{DN} = \frac{\left(\gamma^2+8\right)c^2+\left(\gamma^2-8\gamma+12\right)\mu^2-2\left(\gamma^2-4\gamma+8\right)c\mu}{4(8-3\gamma^2)} - K$, $w^{DN} = \frac{\mu\left(\gamma^3-4\gamma^2+8\right)-c\gamma^3}{2(8-3\gamma^2)}$, $q_S^{DN} = \frac{\left(8-\gamma^2-2\gamma\right)\mu-c\left(8-\gamma^2\right)}{2(8-3\gamma^2)}$ $\Pi_R^{DN} = \frac{16c^2\gamma^2+\left(8-3\gamma^2\right)^2\sigma^2+32c(1-\gamma)\gamma\mu+16(\gamma-1)^2\mu^2}{4(8-3\gamma^2)^2}$, $q_R^{DN} = \frac{m_k\left(8-3\gamma^2\right)-\left(4-3\gamma^2+4\gamma\right)\mu+4c\gamma}{2(8-3\gamma^2)}$

Parameter Setting Used in Section 5.2:

In the numerical study conducted in Section 5.2, we keep $m_H = 10$ and $\beta = 0.2$ but vary the values of other parameters according to the following Table B4.

Table B4: Parameter Values Used in the Numerical Studies in Section 5.2

Parameter	Minimum Value	Maximum Value	Step Size
m_L	2	$m_H - 1$	1
γ	0	0.99	0.01
α	0	0.99	0.01
K	0.1	10	0.2
c	0	5	1

For each combination of parameter values, we calculate the final equilibrium outcome. We also count the number of occurrences of each equilibrium. The results are summarized in Table B5. Note that the total number of combinations when fixing the value of unit selling cost c is $2,760,000$. Our numerical results show that now, the equilibrium $(Y, \mathcal{D})$ can be sustained. Recall that $(Y, \mathcal{D})$ cannot be sustained when the supplier has no selling cost disadvantage ($c = 0$). This implies that in the e-tailer-leads scenario, when the supplier is less efficient in direct selling, the e-tailer is willing to share information under direct encroachment.

Table B5: Number of Occurrence of Equilibrium Outcomes Under Different c

	Leadership	$(\mathcal{N}, N)$	$(\mathcal{D}, N)$	$(\mathcal{A}, Y)$	$(\mathcal{A}, N)$	Remark
$c = 0$	supplier-leads	134640	1483852	42757	1098751	
	e-tailer leads	122327	1516160	15628	1105885	
$c = 1$	supplier-leads	313100	1067202	213368	1166330	
	e-tailer leads	251503	1100139	230962	1163622	13774 $(Y, \mathcal{D})$
$c = 2$	supplier-leads	454619	642889	277567	1384925	
	e-tailer leads	370507	668350	333560	1373667	13916 $(Y, \mathcal{D})$
$c = 3$	supplier-leads	533354	322268	300965	1603413	
	e-tailer leads	458221	343791	354260	1596484	7244 $(Y, \mathcal{D})$
$c = 4$	supplier-leads	496377	134934	305741	1822948	
	e-tailer leads	435256	147822	353866	1820435	2621 $(Y, \mathcal{D})$
$c = 5$	supplier-leads	340325	48443	305950	2065282	
	e-tailer leads	301313	53113	340292	2064468	814 $(Y, \mathcal{D})$

(4) Equilibrium outcomes of Section 5.3, in which the commission rate α is the e-tailer's decision variable.

In the numerical study, we vary the values of m_L, α and K according to Table B5. As a result, we have $27,600$ combinations in total. For each parameter value combination, we calculate the optimal commission rate determined by the e-tailer and derive the corresponding supplier's channel selection and e-tailer's information decision. We then count the total number of occurrence of each equilibrium outcome. Table B6 summarizes the result.

Table B6: Number of Occurrence of Equilibrium Outcomes When α Is Endogenous

Leadership	$(\mathcal{N}, N)$	$(\mathcal{D}, N)$	$(\mathcal{A}, Y)$	$(\mathcal{A}, N)$
supplier-leads	0	0	3045	24555
e-tailer leads	0	0	1069	26531