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Original Article

Information Sharing Strategies Under Platform Supply Chain

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Abstract *- This paper investigates offline retailer and online platform retailers' information sharing strategies in the platform supply chain. The supplier sells products through the agency channel and reselling channel on the platform retailer, and sells products through the offline retailer's retail channel. Our research shows that the information sharing between offline retailer and platform retailer are beneficial for them. However, information sharing with the supplier may hurt the platform retailer and offline retailer as the competition intensity and commission rate change. Interestingly, they still share information because the supplier will provide some compensation to make up for their losses. This study expands the field of study on information sharing in the platform supply chain.*

Keywords *- Supply chain management, Information sharing, Agency channel, Reselling channel, Offline retailer.*

1. Introduction

Over the past decades, online platform retailer has become an essential component of global retail. Global online retail sales are anticipated to exceed 5.7 trillion dollars in 2023. With the rapid growth of online platform retailer, many platform retailers offer supplier different online channels, such as resale, agency. Due to cooperate with the online platform retailer, the supplier is now able to sell their products through different channels of platform retailer in addition to the traditional retail channel. Some platform retailers provide reselling and agency channels, allowing the supplier with a traditional channel to sell their products through two online channels. Andema and Anker sell their products through traditional channels and Amazon's reselling and agency channels.

In reality, because of huge transaction volumes and close contact with consumers, the platform retailer can effectively obtain mass online shopping data from consumers, including purchase data, reviews, and product preferences. By analyzing the consumption data on the platform retailer, they can predict market demand. In addition, the offline retailer directly faces the consumer market and can collect consumers' information through direct interaction with consumers, thus obtaining market information and signaling market demand. However the supplier is far away from the market, so it is difficult for them to grasp consumers' consumption information. Although suppliers can approach consumers to get some information through the agent model of the platform retailer, compared with the platform retailer and offline retailer, their information is still lacking. Therefore, there is asymmetric demand information among the platform retailer, offline retailer, and supplier. The information asymmetry among supply chain members affects the overall efficiency of the supply chain.

The above background motivates us to further investigate the supplier's channel choice and the information-sharing strategy of the platform retailer and offline retailer. In this paper, we address the following research questions:

1. How should the supply chain members price under different channels?
2. Whether does the offline retailer and platform retailer have incentive to share information with the supplier? And whether benefit from sharing information with each other?

2. Literature Review

This paper focus on the information sharing problem of offline retailer and platform retailer. Hence, this paper is mainly related to the stream of literature: Demand information sharing in the supply chain.

This paper also related to the demand information sharing in different supply chain structures, including bilateral monopoly (e.g., Guan and Chen 2017, Guo and Iyer 2010; Guan et al. 2020; Ha et al 2022) [1-4], upstream competition (e.g., Li 2002, Li and Zhang 2008) [5, 6], and downstream competition (e.g., Jiang and Hao 2016; Hao et al. 2018; Wei and Daniel 2020; Xu et al. 2022) [7-8]. Some literature examines the vertical information sharing in bilateral monopoly supply chain. Guan et al. (2020) [4] examine information sharing from supplier. The intrusion of direct selling gives the supplier the opportunity to interact directly with consumers. The supplier is forced to disclose information about the quality of their products because if they do not, consumers will conclude that the products are of poor quality. Therefore, the offline retailer can obtain information from the supplier free of charge. The above-mentioned literature studies the contract selection of online channel, without considering the traditional offline channel. In addition, they do not consider the hybrid channel (i.e., wholesale and agency channel). Some papers examine the effect of horizontal information sharing under upstream and downstream competition. Jiang and Hao (2016) [7] investigate vertical and horizontal information sharing under downstream competition supply chain. They point that when offline retailers' horizontal competition is not intense, they have the motivation to share information, and when offline retailers and supplier place orders, horizontal information sharing and vertical information sharing can coexist. Hao et al. (2018) [8] analyze the impact of market competition mode and information sharing order on the optimal information-sharing strategy. Wei and Daniel (2020) [9] examine the impact of information leakage on supply chain performance. The study of Xu et al. (2022) [10] adds the information sharing between competing suppliers, studies two independent supply chains with one supplier and one offline retailer, and shows that horizontal competition hinders the information sharing. This part of the literature only studies the impact of information sharing on supply chain performance and members. They do not consider the reselling channel and agency channel. There is no paper to consider the case where the offline retailer and online platform retailer both have demand information, and hybrid channel exist on the platform retailer, which is the focus of our study.

3. Problem Description and Assumptions

This paper consider a supply chain consisting of a supplier, a platform retailer and an offline retailer. The supplier sells a product not only through a traditional channel but also through a reselling channel or/and an agency channel provided by the platform retailer. In the traditional channel (T), the supplier sells the product with a wholesale price w to the offline retailer who sells it with a retail price p_t. In the reselling channel (R), the supplier sells the product with the wholesale price w to the platform retailer who sells it with a retail price p_r to consumers. In the agency channel (A), the supplier sells the product directly to consumers with a sales price p_a and shares sales revenues with the platform retailer according to a commission rate λ. The commission rate λ is assumed to be exogenous (Geng et al. 2018; Chen et al. 2021) [11, 12]. Without loss of generality, we normalize the supplier's production cost to zero.

The supplier sells the product through traditional, reselling and agency channels (denoted as TRA structure), the representative consumer's utility function is $U(q_t, q_r, q_a) = \sum_{i=t,r,a}[aq_i - q_i^2/2 - p_i q_i] - \gamma_1 q_t q_r - \gamma_1 q_t q_a - \gamma_2 q_r q_a$. Maximization of the consumer's utility leads to the demand functions:

$$q_t = \alpha_1 a - \beta_1 p_t + \beta_2 p_r + \beta_2 p_a, \tag{1.}$$

$$q_r = \alpha_2 a - \beta_1 p_r + \beta_2 p_t + \beta_3 p_a, \tag{2}$$

$$q_a = \alpha_2 a - \beta_1 p_a + \beta_2 p_t + \beta_3 p_r, \tag{3}$$

where $\alpha_1 = \frac{1-2\gamma_1+\gamma_2}{1-2\gamma_1^2+\gamma_2}$, $\alpha_2 = \frac{1-\gamma_1}{1-2\gamma_1^2+\gamma_2}$, $\beta_1 = \frac{1+\gamma_2}{1-2\gamma_1^2+\gamma_2}$, $\beta_2 = \frac{\gamma_1}{1-2\gamma_1^2+\gamma_2}$. q_t, q_r, and q_a are the sales quantities in the traditional channel, reselling channel, and agency channel, respectively. Parameter a is potential market demand. Parameter γ_1 $(0 < \gamma_1 < 1)$ is the competition intensity of traditional channel and reselling channel. Parameter γ_2 is the competition intensity of the reselling channel and agency channel. We assume $\gamma_1^2 < \gamma_2 < 1$ to ensure the positive demand.

The platform retailer obtains a demand information f_p. Meanwhile, the offline retailer can also obtain a demand information f_t from the product's sales data. We assume that $f_i = e + \varepsilon_i (i = t, p)$ where the information error $\varepsilon_i \sim N(0, \sigma_i^2)$ and is independent of e Variance σ_i^2 can indicate the accuracy of information f_i.

Considering the advantage of the platform retailer in gathering and analyzing huge volumes of online consumer data, we assume that the accuracy of f_p is higher than that of f_t, i.e., $\sigma_p^2 < \sigma_t^2$. Due to the loyalty of consumer channel preference, consumers who choose to purchase the product through traditional channel will not purchase it through platform channel. So, we assume that demand signals f_p and f_t are not correlated, i.e., $Cov(\varepsilon_p, \varepsilon_t) = 0$. Similar to Mishra et al. (2009) [13], we apply the following linear-expectation information structures:

$$E[e|f_p] = E[f_t|f_p] = \frac{\sigma^2}{\sigma^2 + \sigma_p^2} f_p \triangleq k_p f_p, \tag{4}$$

$$E[e|f_t] = E[f_p|f_t] = \frac{\sigma^2}{\sigma^2 + \sigma_t^2} f_t \triangleq k_t f_t, \tag{5}$$

$$E[e|f_t, f_p] = \frac{k_t(1-k_p)}{1-k_p k_t} f_t + \frac{k_p(1-k_t)}{1-k_t k_p} f_p \triangleq I f_t + J f_p, \tag{6}$$

where $k_i (i = p, t)$ represents the accuracy of information f_i, which is inversely proportional to information variance σ_i^2. The platform retailer has more accurate demand information than the offline retailer means that $k_p > k_t$, which is equivalent that $\sigma_p^2 < \sigma_t^2$.

Noting that Eq. (6) characterizes a combined prediction on uncertain demand, which is the weighted average of two retailers' demand signals. Parameters I and J are the weights for demand signals f_t and f_p.

This paper consider the following three information-sharing strategies. (1) Strategy N: both the platform retailer and the offline retailer do not share their demand signals. (2) Strategy H: the platform retailer and the offline retailer share their demand signals only with each other, i.e., horizontal sharing. (3) Strategy B: the platform retailer and the offline retailer share their demand signals with other members, i.e., both horizontal and vertical sharing. We assume that the supplier and the two retailers play Stackelberg game in decision process. The supplier, as the leader of Stackelberg game, first makes pricing decision, and then the platform retailer and the offline retailer, as the followers, make their pricing decisions.

Under strategy N, the objective profit functions of the supplier, offline retailer, and platform are shown as follows:

$$\max_{(w,p_a)} \pi_s^N = E[wq_t + (1-\lambda)p_a q_a + wq_r], \tag{7}$$

$$\max_{p_r} \pi_p^N = E[\lambda p_a q_a + (p_r - w)q_r | f_p], \tag{8}$$

$$\max_{p_t} \pi_t^N = E[(p_t - w)q_t | f_t]. \tag{9}$$

4. Equilibrium Solutions and the Information Sharing Decision

In this section, this paper first derive the equilibrium solutions with three information-sharing strategies (N, H, and B) under TRA channel structure. Then, the optimal information strategies are discussed by analyzing the equilibrium solutions.

4.1. Equilibrium Solutions

Using the method of backward induction, this paper first derive the offline retailer's and platform's best response functions. After the offline retailer and the platform choose strategy $Y \in N, H, B$ (we only prove Table 1 under strategy N, the proof of other strategies is similar to strategy N), given the wholesale price w and the retail price p_a, the offline retailer and the platform respectively make the retail price p_t and p_r to maximize their expected profit. Substituting Eqs. (1)-(3) into Eqs. (8) and (9), respectively. Calculate the first-order and second-order derivatives of $E[\pi_t^N|f_t]$ and $E[\pi_p^N|f_p]$ as follows:

$$\frac{\partial E[\pi_t^N|f_t]}{\partial p_t} = (w - 2p_t)\beta_1 + (p_a + p_r)\beta_2 + a_0\alpha_1 + \alpha_1 E[e|f_t], \tag{10}$$

$$\frac{\partial E[\pi_p^N|f_p]}{\partial p_r} = (w - 2p_p)\beta_1 + p_t\beta_2 + (1+\lambda)p_a\beta_3 + a_0\alpha_2 + \alpha_2 E[e|f_p], \tag{11}$$

$$\frac{\partial^2 E[\pi_t^N|f_t]}{\partial p_t^2} = -2\beta_1 < 0, \tag{12}$$

$$\frac{\partial^2 E\left[\pi_p^N\middle|f_p\right]}{\partial p_r^2} = -2\beta_1 < 0, \tag{13}$$

Eqs. (12) and (13) means that the expected profit functions $E[\pi_t^N|f_t]$ and $E\left[\pi_p^N\middle|f_p\right]$ are concave in p_t and p_r, respectively. The retailer's and the platform's response function are derived by setting Eqs. (10) - (11) to zero and solving it

$$p_t(w, p_a) = \frac{2\beta_1^2 + \beta_1\beta_2}{4\beta_1^2 - \beta_2^2} w + \frac{2\beta_1\beta_2 + (1+\lambda)\beta_2\beta_3}{4\beta_1^2 - \beta_2^2} p_a + \frac{2\beta_1\alpha_1 + \beta_2\alpha_2}{4\beta_1^2 - \beta_2^2}(a_0 + E[e|f_t]), \tag{14}$$

$$p_r(w, p_a) = \frac{2\beta_1^2 + \beta_1\beta_2}{4\beta_1^2 - \beta_2^2} w + \frac{\beta_2^2 + 2(1+\lambda)\beta_1\beta_3}{4\beta_1^2 - \beta_2^2} p_a + \frac{2\beta_1\alpha_2 + \beta_2\alpha_1}{4\beta_1^2 - \beta_2^2}\left(a_0 + E\left[e\middle|f_p\right]\right). \tag{15}$$

Next, we derive the supplier's best-response functions. Substituting (14) and (15) into Eq. (7), we calculate the first-order partial derivatives of $E[\pi_s^N]$, i.e., Eq. (16):

$$\frac{\partial \pi_s^N}{\partial w} = \frac{(4\beta_1\beta_2 - 4\beta_1^2)}{2\beta_1 - \beta_2} w + \frac{\partial \pi_s^N}{\partial w} = \frac{(4\beta_1\beta_2 - 4\beta_1^2)}{2\beta_1 - \beta_2} w + \frac{\partial \pi_s^N}{\partial w} = \frac{(4\beta_1\beta_2 - 4\beta_1^2)}{2\beta_1 - \beta_2} w + \frac{\left(\beta_2\beta_3\lambda + \beta_1(2\beta_2 + 2\beta_3 - \beta_2\lambda - 2\beta_3\lambda)\right)}{2\beta_1 - \beta_2} p_a + \frac{(\alpha_1 + \alpha_2)\beta_1}{2\beta_1 - \beta_2} a_0,$$

(16) and Eq. (17): $\frac{\partial \pi_s^N}{\partial p_a} = \frac{\left(\beta_1\beta_2^2 - 4\beta_1^3 + 2\beta_1\beta_3^2(1+\lambda) + \beta_2^2\beta_3(2+\lambda)\right)p_a}{4\beta_1^2 - \beta_2^2} + \frac{(2\beta_1\beta_3(1-\lambda) + \beta_1\beta_2(2-\lambda) - \beta_2\beta_3\lambda)w}{4\beta_1^2 - \beta_2^2} + \frac{(2\alpha_2\beta_1 + \alpha_1\beta_2)(2\beta_1 + \beta_3)(1-\lambda)a_0}{4\beta_1^2 - \beta_2^2}$.

Next, we calculate the second-order partial derivatives with respect to w and p_a, and derive Hessian matrix of $E[\pi_s(w, p_a)^N]$

$$\frac{\partial^2 E[\pi_s(w, p_a)^N]}{\partial w^2} = \frac{4\beta_1(\beta_2 - \beta_1)}{2\beta_1 - \beta_2}$$

$$\frac{\partial^2 E[\pi_s(w, p_a)^N]}{\partial p_a^2} = \frac{2(1-\lambda)(3\beta_1\beta_2^2 - 4\beta_1^3 + (2+\lambda)\beta_2^2\beta_3 + 2(1+\lambda)\beta_1\beta_3^2)}{4\beta_1^2 - \beta_2^2},$$

$$\frac{\partial^2 E[\pi_s(w, p_a)^N]}{\partial w\,\partial p_a} = \frac{\partial^2 E[\pi_s(w, p_a)]}{\partial p_a\,\partial w} = \frac{(2-\lambda)\beta_1\beta_2 + 2(1-\lambda)\beta_1\beta_3 + \lambda\beta_2\beta_3}{2\beta_1 - \beta_2}.$$

The Hessian matrix of $E[\pi_s(w, p_a)^N]$ is

$$H = \begin{bmatrix} \frac{4\beta_1(\beta_2 - \beta_1)}{2\beta_1 - \beta_2} & \frac{(2-\lambda)\beta_1\beta_2 + 2(1-\lambda)\beta_1\beta_3 + \lambda\beta_2\beta_3}{2\beta_1 - \beta_2} \\ \frac{(2-\lambda)\beta_1\beta_2 + 2(1-\lambda)\beta_1\beta_3 + \lambda\beta_2\beta_3}{2\beta_1 - \beta_2} & \frac{2(1-\lambda)(3\beta_1\beta_2^2 - 4\beta_1^3 + (2+\lambda)\beta_2^2\beta_3 + 2(1+\lambda)\beta_1\beta_3^2)}{4\beta_1^2 - \beta_2^2} \end{bmatrix}$$

It is easy to verify that when the commission rate satisfies $\lambda < \lambda_0$, the ex-ante profit function of the supplier is concave. Here, $\lambda_0 = \Big(2\big(2\beta_1(2\beta_1^2 - 3\beta_1\beta_2 + \beta_2^2)(\beta_1 + \beta_3)^2(16\beta_1^5 - 8\beta_1^4(\beta_2 + 4\beta_3) - 8\beta_1^3(4\beta_2^2 - \beta_2\beta_3 - 2\beta_3^2) + 2\beta_1^2\beta_2^2(3\beta_2 + 16\beta_3) + \beta_1\beta_2^2(15\beta_2^2 + 2\beta_2\beta_3 + 2\beta_3^2) + 2\beta_2^4\beta_3)\big)^{\frac{1}{2}} - 2\beta_1(2\beta_1 - \beta_2)\big(\beta_1(4\beta_1^2 - 2\beta_1\beta_2 - 5\beta_2^2) - \beta_3^2(2\beta_1 + \beta_2) - 3\beta_2\beta_3(\beta_1 + \beta_2)\big)\Big) / (2\beta_1^3(\beta_2^2 + 4\beta_2\beta_3 - 4\beta_3^2) + \beta_1^2\beta_2(\beta_2 - 6\beta_3)(\beta_2 - 2\beta_3) + 2\beta_1\beta_2^2\beta_3(3\beta_2 - \beta_3) + \beta_2^3\beta_3^2)$.

Then setting equation system Eqs. (10) and (11) to zero, we derive the optimal wholesale price w^N and p_a^N of the supplier

$$w^N = A_1^N a_0, \tag{18}$$

$$p_a^N = A_2^N a_0. \tag{19}$$

Substituting Eqs. (18)-(19) into (18) and (19), we get the offline retailer's and platform's optimal retail price

$$p_t^N = A_3 a_0 + A_5 k_t f_t, \tag{20}$$

$$p_r^N = A_4 a_0 + A_6 k_p f_p. \tag{21}$$

Substituting Eqs. (18)-(21) into Eqs. (7)-(9), and taking expectation, the ex-ante profits of the supplier, the offline retailer, and the platform, i.e., Π_s^N, Π_t^N and Π_p^N are obtained $\Pi_s^N = B_1^N a_0^2$, $\Pi_t^N = B_2^N a_0^2 + B_4 F_1^2$, $\Pi_p^N = B_3^N a_0^2 + B_5 F_2^2$.

Similarly, we can obtain the equilibrium prices and the ex-ante profits under strategies H and B separately. The equilibrium prices and the ex-ante profits of supply chain members are summarized in Table 1.

Table 1. The equilibrium prices and ex-ante profits under three strategies

	Strategy *N*	**Strategy *H***	**Strategy *B***
$\boldsymbol{w^Y}$	$A_1 a_0$	$A_1 a_0$	$A_1(a_0 + If_t + Jf_p)$
$\boldsymbol{p_a^Y}$	$A_2 a_0$	$A_2 a_0$	$A_2(a_0 + If_t + Jf_p)$
$\boldsymbol{p_t^Y}$	$A_3 a_0 + A_5 k_t f_t$	$A_3 a_0 + A_5(If_t + Jf_p)$	$A_3(a_0 + If_t + Jf_p)$
$\boldsymbol{p_r^Y}$	$A_4 a_0 + A_6 k_p f_p$	$A_4 a_0 + A_6(If_t + Jf_p)$	$A_4(a_0 + If_t + Jf_p)$
$\boldsymbol{\Pi_s^Y}$	$B_1 a_0^2$	$B_1 a_0^2$	$B_1(a_0^2 + F_3^2)$
$\boldsymbol{\Pi_t^Y}$	$B_2 a_0^2 + B_4 F_1^2$	$B_2 a_0^2 + B_4 F_3^2$	$B_2(a_0^2 + F_3^2)$
$\boldsymbol{\Pi_p^Y}$	$B_3 a_0^2 + B_5 F_2^2$	$B_3 a_0^2 + B_5 F_3^2$	$B_3(a_0^2 + F_3^2)$

where $F_1^2 = k_t^2(\sigma^2 + \sigma_t^2)$, $F_2^2 = k_p^2(\sigma^2 + \sigma_p^2)$, $F_3^2 = (I + J)^2\sigma^2 + I^2\sigma_t^2 + J^2\sigma_p^2$. $A_1 - A_5$ and $B_1 - B_5$ are shown in Appendix 1.

4.2. Equilibrium Solutions

We define the values of information sharing for the supplier, platform retailer, offline retailer and the whole supply chain, as $V_s^Z = \Pi_s^Z - \Pi_s^N$, $V_p^Z = \Pi_p^Z - \Pi_p^N$, $V_t^Z = \Pi_t^Z - \Pi_t^N$, $V^Z = V_s^Z + V_t^Z + V_p^Z$, respectively, where $Z \in H, B$. By the calculation, the values of information sharing are obtained and listed in Table 2.

Table 2. The values of information sharing under different information-sharing strategies

Strategies *Z*	**Strategy *H***	**Strategy B**
$\boldsymbol{V_s^Z}$	0	$B_1 F_3^2$
$\boldsymbol{V_t^Z}$	$B_4(F_3^2 - F_1^2)$	$B_2 F_3^2 - B_4 F_1^2$
$\boldsymbol{V_p^Z}$	$B_5(F_3^2 - F_2^2)$	$B_3 F_3^2 - B_5 F_2^2$
$\boldsymbol{V^Z}$	$B_4(F_3^2 - F_1^2) + B_5(F_3^2 - F_2^2)$	$\left(\sum_{k=1}^{3} B_k\right) F_3^2 - B_4 F_1^2 - B_5 F_2^2$

Proposition 1.

(a) $V_s^H = 0$; $V_p^H > 0$; $V_t^H > 0$; $V^H > 0$.

(b) $V_s^B > 0$; $V_p^B > 0$, iff $\Phi_1 > 0$; $V_t^B > 0$, iff $\Phi_2 > 0$, $V^B > 0$, iff$\Phi_3 > 0$.

(c) $V^B > V^H$, iff $\Phi_3 > 0$.

where $\Phi_1 = B_3F_3^2 - \frac{\beta_1(\beta_2\alpha_1+2\beta_1\alpha_2)^2}{(4\beta_1^2-\beta_2^2)^2}F_2^2$, $\Phi_2 = B_2F_3^2 - \frac{\beta_1(2\beta_1\alpha_1+\beta_2\alpha_2)^2}{(4\beta_1^2-\beta_2^2)^2}F_2^2$, $\Phi_3 = (B_1 + B_2 + B_3)F_3^2 - \frac{\beta_1(2\beta_1\alpha_1+\beta_2\alpha_2)^2}{(4\beta_1^2-\beta_2^2)^2}F_1^2 - \frac{\beta_1(\beta_2\alpha_1+2\beta_1\alpha_2)^2}{(4\beta_1^2-\beta_2^2)^2}F_2^2$.

Proposition 1 (a) shows that the value of information sharing for the offline retailer and platform retailer are all positive under strategy H.

Proposition 1 (b) shows that strategy B benefits the supplier because the supplier can better adjust the pricing decisions with the demand information information. When the parameters satisfied the conditions $\Phi_1 > 0$ ($\Phi_2 > 0$), the platform retailer (offline retailer) would voluntarily share information with the supplier. Otherwise, sharing information is harmful to the platform retailer (offline retailer). The value of the whole supply chain may be positive or negative. The supplier can offer a payment m_1 and m_2 in compensation for the offline retailer when the value of information sharing is positive for the whole supply chain and is negative for the offline retailer and platform retailer. Note that $-V_t^B < m_1 < V_s^B$ and $-V_p^B < m_2 < V_s^B$. We call this scenario contract sharing.

Proposition 1 (c) shows that strategy B dominates strategy H, when the whole supply chain benefits from strategy \$B\$. In order to further explore the information sharing strategy influenced by the commission rate and the degree of substitution between offline retailer and platform retailer channel, we set $\sigma = 1, \sigma_t = 0.7, \sigma_p = 0.5, \gamma_1 = \gamma_2 = \gamma$.

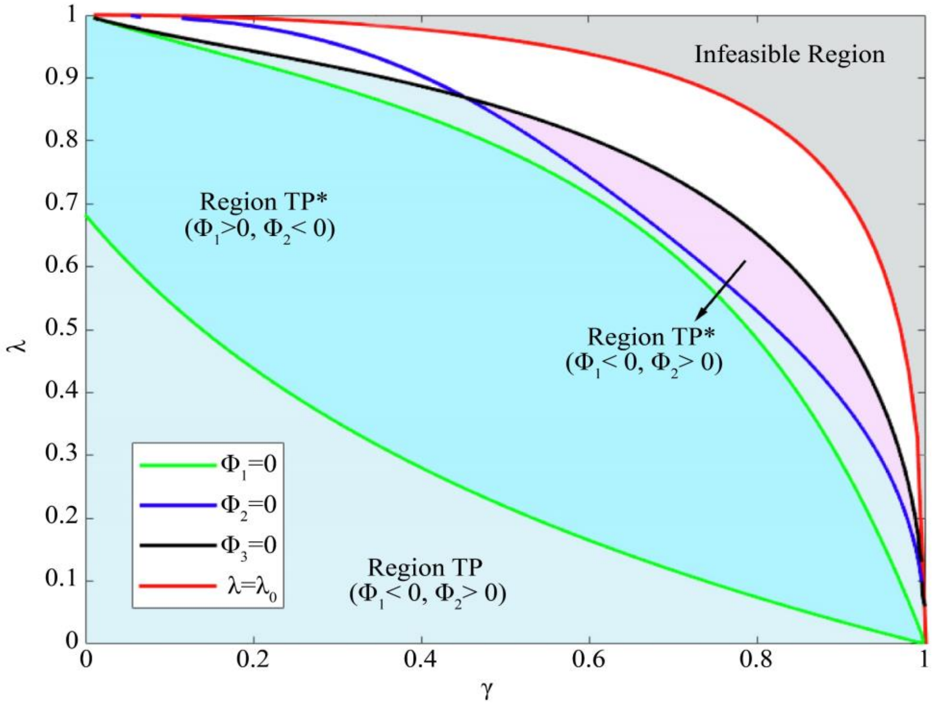

Fig. 1 Illustration of the optimal information sharing strategies of the offline retailer and platform retailer

From Fig.1, we can see that when the competition intensity and commission rate are low, strategy B harms the offline retailer and the platform retailer, the optimal strategy is contract sharing (Region TP). When the competition intensity and commission rate are moderate, the platform retailer can benefit from sharing information with the supplier while the offline retailer is impaired by information sharing (Region *TP**). When the commission rate and competition intensity are high, strategy B is harmful to the platform retailer, and the offline retailer can benefit from sharing information with the supplier (Region *T*P*). The reason is that the negative effect of double marginalization in the reselling channel exceeds the positive effect of the agency channel, which harms the platform retailer. When the competition intensity is high, the values of information sharing for the whole supply chain are negative, the strategy H is better than the strategy B.

To summarize, the strategy H always benefits the platform retailer and the offline retailer, but vertical share dominates the horizontal share. When the commission rate and competition intensity are low, the optimal strategy is B, which includes contract sharing. When the commission rate and competition intensity are high, the optimal strategy is strategy H.

5. Conclusion

This work examines the optimal information-sharing strategy in a supply chain consisting of a supplier, an offline retailer, and an online platform retailer. We have examined three information-sharing strategies: no information sharing, horizontal information sharing, and full information sharing. Through comparison and analysis, we obtain the optimal information-sharing strategy, which depends on the commission rate and competition intensity.

The numerical analysis shows the following findings. Firstly, horizontal information sharing is always beneficial to the offline retailer and platform retailer regardless of which channel structure is selected by the supplier. Secondly, the supplier always benefits from the offline retailer's and platform retailer's information sharing. Lastly, the optimal strategies also depend on the parameter condition of channel competition intensity and commission rate of the agency channel. These results are different from previous studies on information sharing in traditional supply chains, which provide a decision-making basis for demand information sharing in the supply chain.

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Appendix 1

$$A_1^{TRA} = \Big(\Big((1-\lambda)\left(\lambda\beta_2^2\beta_3^2\alpha_1 + 4\beta_1^3\big((2-\lambda)\beta_2 + 2(1-\lambda)\beta_3\big)\alpha_2 + 8\beta_1^4(\alpha_1+\alpha_2) + \beta_1\beta_2\beta_3\big(2(1-\lambda)\beta_3\alpha_1 + 2\lambda\beta_3\alpha_2 - (2+\lambda)\beta_2(\alpha_1+2\alpha_2)\big) - 2\beta_1^2\big(\beta_2^2(\alpha_1+\lambda\alpha_1+3\alpha_2) + 2\beta_3^2(\alpha_1+\lambda\alpha_1+2\lambda\alpha_2) - \beta_2\beta_3(2(1-\lambda)\alpha_1 + (2+\lambda)\alpha_2)\big)\right)\Big)\Big) / \Big(32(1-\lambda)\beta_1^4\beta_2 - 32(1-\lambda)\beta_1^5 + \lambda^2\beta_2^3\beta_3^2 - 2\beta_1\beta_2^2\beta_3\left(\big(8-3\lambda(2+\lambda)\big)\beta_2 - (2-\lambda)\lambda\beta_3\right) - 2\beta_1^3\big((16+(16-\lambda)\lambda)\beta_2^2 - 4(2-\lambda)(1-\lambda)\beta_2\beta_3 - 4(1-\lambda)(3+\lambda)\beta_3^2\big) - \beta_1^2\beta_2\left(\big(20-\lambda(20+\lambda)\big)\beta_2^2 - 4\big(6-\lambda(3+2\lambda)\big)\beta_2\beta_3 + 12(1-\lambda^2)\beta_3^2\right)\Big) \triangleq$$

C_1,

$A_2^{TRA} = (\beta_1 (16 \beta_1^3 \alpha_2(1-\lambda) + \beta_2^2 \beta_3 ((4-5\lambda) \alpha_1 - \lambda\alpha_2) + \beta_1 \beta_2 (2 \beta_3 ((3-2\lambda) \alpha_1 - (3-4\lambda) \alpha_2) - \beta_2 ((6-7\lambda) \alpha_1 + (2-\lambda) \alpha_2)) + 2 \beta_1^2 (2 (1-\lambda) \beta_3 (\alpha_1 + 3 \alpha_2) + \beta_2 (6 \alpha_1 - 5 \lambda\alpha_1 - 6 \alpha_2 + 7 \lambda\alpha_2))))/(32\beta_1^5 (1-\lambda) - 32\beta_1^4 \beta_2 (1-\lambda) - \lambda^2 \beta_2^3 \beta_3^2 + 2 \beta_1 \beta_2^2 \beta_3 ((8 - 3 \lambda(2+\lambda)) \beta_2 - (2-\lambda) \lambda\beta_3) + 2 \beta_1^3 ((16 + (16-\lambda) \lambda) \beta_2^2 - 4 (2-\lambda) (1-\lambda) \beta_2 \beta_3 - 4 (1-\lambda) (3+\lambda) \beta_3^2) + \beta_1^2 \beta_2 ((20 - \lambda(20+\lambda)) \beta_2^2 - 4 (6 - \lambda(3 + 2\lambda)) \beta_2 \beta_3 + 12 (1-\lambda^2) \beta_3^2))) \triangleq C_2$,

$A_3^{TRA} = (C_1\beta_1(2\beta_1 + \beta_2) + C_2\beta_2(2\beta_1 + (1+\lambda)\beta_3) + 2\beta_1\alpha_1 + \beta_2\alpha_2)/(4\beta_1^2 - \beta_2^2)$,

$A_4^{TRA} = (C_1\beta_1(2\beta_1 + \beta_2) + C_2(\beta_2^2 + 2(1+\lambda)\beta_1\beta_3) + 2\beta_1\alpha_2 + \beta_2\alpha_1)/(4\beta_1^2 - \beta_2^2)$,

$A_5^{TRA} = (2\beta_1\alpha_1 + \beta_2\alpha_2)/(4\beta_1^2 - \beta_2^2)$,

$A_6^{TRA} = (2\beta_1\alpha_2 + \beta_2\alpha_1)/(4\beta_1^2 - \beta_2^2)$,

$B_1^{TRA} = \Big(2C_1^2\beta_1(\beta_2 - \beta_1)(2\beta_1 + \beta_2) + C_1(2\beta_1 + \beta_2)\big(C_2(2-\lambda)\beta_1\beta_2 + C_2(2(1-\lambda)\beta_1 + \lambda\beta_2)\beta_3 + \beta_1(\alpha_1 + \alpha_2)\big) + C_2(1-\lambda)\big(C_2(3\beta_1\beta_2^2 - 4\beta_1^3 + (2+\lambda)\beta_2^2\beta_3 + 2(1+\lambda)\beta_1\beta_3^2) + (2\beta_1 + \beta_3)(\beta_2\alpha_1 + 2\beta_1\alpha_2)\big)\Big)/(4\beta_1^2 - \beta_2^2)$

$B_2^{TRA} = (C_1(\beta_2^2 - 2\beta_1^2 + \beta_1\beta_2) + C_2\beta_2(2\beta_1 + \beta_3 + \lambda\beta_3) + 2\beta_1\alpha_1 + \beta_2\alpha_2)^2/(4\beta_1^2 - \beta_2^2)^2$,

$B_3^{TRA} = \Bigg(C_1^2\beta_1(\beta_1\beta_2 + \beta_2^2 - 2\beta_1^2)^2 + C_2^2\big(\beta_1\big(\beta_2^4 + \lambda(16\beta_1^2\beta_2^2 - 3\beta_2^4 - 16\beta_1^4)\big) + (1+\lambda)\beta_2^2(4(1+\lambda)\beta_1^2 - \lambda\beta_2^2)\beta_3 + 4(1+\lambda)^2\beta_1^3\beta_3^2\big) + 2C_2\beta_1(4\lambda\beta_1^2 + \beta_2^2 - \lambda\beta_2^2 + 2(1+\lambda)\beta_1\beta_3)(\beta_2\alpha_1 + 2\beta_1\alpha_2) + \beta_1(\beta_2\alpha_1 + 2\beta_1\alpha_2)^2 + C_1(2\beta_1 + \beta_2)\Big(C_2\Big(2\beta_1(\beta_2 - \beta_1)(\beta_2^2 + 2\beta_1\beta_3) + \lambda\big(\beta_2^3\beta_3 + 4\beta_1^3(\beta_2 + \beta_3) - \beta_1\beta_2^2(\beta_2 + 2\beta_3)\big)\Big) + 2\beta_1(\beta_2 - \beta_1)(\beta_2\alpha_1 + 2\beta_1\alpha_2)\Big)\Bigg)/(4\beta_1^2 - \beta_2^2)^2$,

$B_4^{TRA} = (\beta_1(2\beta_1\alpha_1 + \beta_2\alpha_2)^2)/(4\beta_1^2 - \beta_2^2)^2$,

$B_5^{TRA} = (\beta_1(\beta_2\alpha_1 + 2\beta_1\alpha_2)^2)/(4\beta_1^2 - \beta_2^2)^2$.