Cooperation Strategy of Retailer Drop-Shipping in Dual-Channel Supply Chain under Non-Cooperative Game

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Abstract: Focusing on dual-channel supply chain involving both traditional channel and e-commerce channel, this paper analyses the supply chain decision in retailer drop shipping and manufacturer drop shipping, explores the conditions for the manufacturer and the retailer to select retailer drop shipping, and identifies their cooperative strategies in retailer drop shipping. The results show that the cooperative interval of drop shipping commission will expand with the increase in the market share of e-commerce channel, and vice versa. However, the expansion or shrink of the market capacity does not necessarily lead to increase or decrease in the drop shipping commission.

1. Introduction
With the rapid development of e-commerce and information technology, many manufacturers have opened their own online malls. The manufacturer’s e-commerce channel and the retailer’s physical distribution channel form a dual-channel supply chain. Facing the growing consumer demand for express delivery, online sellers are wracking their brains to improve the delivery of commodities in a timely manner (Li et al., 2014). Against this backdrop, retailer drop shipping emerges as an effective means to fulfill orders. In retailer drop shipping, the manufacturer consigns the delivery of online orders to a traditional retailer in the local region of consumers, and pays an agreed percentage of the sales in commission to the retailer. Retailer drop shipping has been extensively implemented in the dual-channel supply chain of appliance, furniture and other sectors. For example, Haier Group has assigned local retailers in Tier-3 or Tier-4 cities and the rural areas with the delivery of online orders of electrical appliances, and transferred to them some revenue in the form of rebates.

From the perspective of manufacturer, retailer drop shipping is a preferred option for delivering online orders of large, perishable commodities, especially in places out of its own distribution scope. After all, the strategy can greatly reduce the cost and improve the response speed of the supply chain system. From the perspective of retailer, however, retailer drop shipping is a mixed blessing. On the one hand, it might boost the demand for e-commerce sales, and suppress the demand in the physical market; on the other hand, the strategy helps to mobilize its idle delivery capacity. Owing to the effect of channel conflict and double marginalization on the selection of online order delivery mode, it is necessary to study the mutual cooperative strategy of retailer drop shipping by the manufacturer and the retailer under non-cooperative game.

2. Literature Review
In a dual-channel supply chain, there are two kinds of drop shipping: supplier drop shipping and retailer drop shipping. The former refers to that the supplier delivers goods to final consumers at the
request of the online seller according to its agreement with the seller (Liu and Wang, 2008). In recent years, some domestic and foreign scholars have examined the supplier drop shipping in the dual-channel supply chain.

Netessine and Rudi (2006) analysed the effect of changing environmental parameters (e.g. consumer demand, wholesale price, and transport cost) on retailer’s and supplier’s revenues under supplier drop shipping, retailer drop shipping, and the mixed delivery mode, and put forward the suggestions on alternative delivery mode in each scenario. Chiang and Feng (2010) compared the difference between the traditional delivery mode and supplier drop shipping in manufacturer’s and retailer’s revenues, and concluded that supplier drop shipping is better than the traditional mode. Based on the assumption of information symmetry, the two references agree that supplier drop shipping benefits all parties in the supply chain under certain circumstances.

Gan et al. (2010) and Zhao et al. (2012) studied the coordination of drop shipping supply chain with asymmetric demand information, particularly the problems arising from the retailer-supplier transmission of overestimated demand information, and designed the commitment contract to maximize the expected return of the supplier and the total profits of the supply chain. Zhao et al. (2013) examined the coordination and optimization strategy of the drop shipping supply chain including commitment cost, and found that the overall profit level of the supplier-dominated supply chain is higher than that of the retailer-dominated supply chain. Li (2011) constructed a drop shipping supply chain model, in which the demand is affected by the retail price, investigated the optimal solution for the model under three different right structures, and found that the profits of both sides under retailer-dominated supply chain tend to be higher than that in the case of equal power. Focusing on the supply chain contract under drop shipping, these four references conclude that supply chain information and dominant right have a critical impact on the profits of all parties in the drop shipping supply chain.

In addition, Liu and Wang (2008) and Deng and Yu (2014) investigated the optimal inventory strategy in the dual-channel drop shipping supply chain in view of different consumer demand features.

Compared with the studies on supplier drop shipping, only a few scholars have explored retailer drop shipping in the dual-channel supply chain. Probing into contract coordination problems under retailer drop shipping, Zhang and Zhao (2015, 2014) pointed out that reverse revenue sharing contract can effectively coordinate the retailer drop shipping supply chain, and the retail price of manufacturer’s e-commerce channel is positively related to the drop shipping commission. To sum up, the current studies on dual-channel supply chain of retailer drop shipping mainly emphasizes on contract coordination, failing to highlight cooperative strategy and cooperative interval of retailer drop shipping.

In light of the features of the dual-channel supply chain, this paper considers the effect of two shipping modes in the e-commerce channel on manufacturer’s and retailer’s revenues, recommends the cooperative strategy for the manufacturer and the retailer to perform retailer drop shipping under non-cooperative game, and advise on the effective performance of retailer drop shipping in the non-cooperative state.

3. Model Hypothesis
Suppose the manufacturer has dominance over the retailer in a supply chain. In addition to the traditional distribution channel, the manufacturer also engages in e-commerce. By contrast, the trailer is only involved in traditional sales. The manufacturer can either deliver the online orders itself, or consign the retailer to ship such orders (Figure 1).
The manufacturer determines the wholesale price \( w \) and distributes the product at unit production cost \( c \) to the physical retailer. Setting the order quantity as \( d_r \), the retailer sells the product to its consumer at the sales price \( p_r \). The same product is sold by the manufacturer at the price \( p_m \) on the online mall. For simplification, it is assumed that there is no significant difference of logistics service between retailer drop shipping and manufacturer drop shipping (or the difference does not constitute an impact on market demand). In reference to Li and Cui (2013), Cattani and Gilland (2006), the demand functions of the two delivery modes can be expressed as:

\[
d_m = \rho a - p_m + b p_r \\
d_r = (1-\rho)a - p_r + b p_m
\]

where \( m \) is the e-commerce channel (or manufacturer drop shipping); \( r \) is the traditional channel (or retailer drop shipping); \( a \) is the total market demand; \( \rho \) is the market share of e-commerce channel in the two channels \((0<\rho<1)\); \( b \) is the coefficient of cross-price elasticity between the two channels \((0<b<1)\). To guarantee there is a demand in the two channels, it is required that \( \rho a - p_m > 0 \) and \((1-\rho)a - p_r > 0 \).

4. Supply Chain Decisions

4.1. Supply chain decision in retailer drop shipping

In retailer drop shipping, the manufacturer consigns the retailer to ship the order quantity \( d_m \) from the e-commerce channel to the final consumers, and pays the retailer the drop shipping cost per unit goods \( c_i (0 \leq c_i \leq \rho a - c) \). Since \( \rho a - p_m > 0 \) and \( p_m \geq c + s \), so \( 0 \leq s \leq \rho a - c \).

The profit functions for the manufacturer, the retailer and the whole supply chain are:

\[
\pi_m = (p_m - c - s)d_m + (w - c)d_r \\
\pi_r = (p_r - w)d_r + (s - c_i)d_m \\
\pi_{sc} = \pi_m + \pi_r = (p_m - c - c_i)d_m + (p_r - c)d_r
\]

Given the manufacturer’s dominance in the supply chain and the involvement of the manufacturer and the retailer in Stackelberg competition, the optimal decision of the supply chain was solved by backward induction.

According to formulas (1), (2), (3), (4) and (5), the profit functions of manufacturer and retailer can be deduced as:

\[
U_m = (p_m - c - s)(\rho a - p_m + b p_r) + (w - c)[(1-\rho)a - p_r + b p_m] \\
U_r = (p_r - w)[(1-\rho)a - p_r + b p_m] + (s - c_i)(\rho a - p_m + b p_r)
\]

Following backward induction, the second-order derivative of \( p_r \) in relation to formula (7) was...
solved in the first place. The result \((-2<0)\) satisfies the second-order condition of maximization problem; then, the first-order derivative of \(p_r\) in relation to formula (7) was solved and taken as 0. Hence, the response function of retailer to the manufacturers obtained as:

\[
p_r = \frac{1}{2} b(s - c_1 + p_m) + \frac{1}{2} (1 - \rho) a + \frac{1}{2} w
\]  

(8)

Substituting formula (8) into the profit function of manufacturer (6), the second-order derivatives of \(w\) and \(p_m\) in relation to manufacturer’s profit function were solved in the first place. The results, both of which were less than 0, satisfies the second-order condition of maximization problem; then, the first-order derivatives of \(w\) and \(p_m\) to formula (6) were solved and taken as zero. Thus, formulas (9) and (10) were obtained:

\[
w = \frac{1}{2} [(1 - \rho) a + c + b(2p_m + c_1 - c - 2s)]
\]  

(9)

\[
p_m = \frac{(\rho - 1)ab + bc - 2bw + b^2(c_1 + c) - 2(pa + s + c)}{2(b^2 - 2)}
\]  

(10)

According to formulas (8), (9) and (10), it is possible to derive formulas (11), (12) and (13):

\[
w = \frac{1}{2} [(1 - \rho) a + c + b(s - c_1 - c - 2s)]
\]  

(11)

\[
p_m = \frac{1}{2} (s + c) + \frac{pa + ba - bpa}{2(1 - b^2)}
\]  

(12)

\[
p_r = \frac{b'(2s + c - c_1) + b^2 c + b^2 a(\rho - 1) + b(c_1 - c - 2s - 2pa) + 3(\rho - 1)a - c}{4(b^2 - 1)}
\]  

(13)

The profits of the manufacturer and the retailer in retailer drop shipping can be obtained as follows:

\[
\pi_{m} = \frac{1}{8(1 - b^2)} \left[3c^2 + 4xc + 2x^2 + \left[c^2 + 2(2s - c_1)c - c_1^2 + 2s^2\right]b^4 + \left[2(1 - \rho)(2s + c - c_1)a + 2c(c_1 + c)\right]b^3
\]

\[
+ \left[(\rho - 1) a^2 + 2(1 + \rho)a + 4pas + 2(c_1 - 4x)c + c_1^2 - 4(s^2 + c^2)\right]b^2 + \left[3\rho^2 - 2\rho + 1\right]a^2
\]

\[
- 2\left[(1 + \rho)c + 2px\right]a + \left[4\rho(1 - \rho)a^2 - 2(1 - \rho)(2s + c - c_1)a - 2c(c_1 + c)\right]b\right]
\]

\[
\pi_{r} = \frac{1}{16} \left[c^2 + 2(4s - 3c_1)c + c_1^2 - 8s(c_1 - s)\right]b^2 + \frac{1}{16} \left[(1 - \rho)(4s + c - 3c_1)a - c(c_1 + c)\right]b
\]

\[
+ \frac{1}{16} \left[(1 - \rho)^2 a^2 + \frac{1}{8} \left[4 \rho(s - c_1) - (1 - \rho)c\right]a + \frac{1}{16} c_1^2 - \frac{1}{2} (s - c_1)(c + s)\right]
\]  

(14)

(15)

4.2. Supply chain decision in manufacturer drop shipping

In manufacturer drop dripping, the manufacturer handles the order quantity \(d_m\) solicited from the e-commerce channel, and ships goods to the final consumers at the cost per unit goods \(c_0(c_1 \leq c_1 \leq \rho a - c)\).

The profit functions for the manufacturer, the retailer and the whole supply chain are:

\[
\pi_m = (p_m - c - c_2)d_m + (w - c)d_r
\]  

(16)

\[
\pi_r = (p_r - w)d_r
\]  

(17)

\[
\pi_{sc} = \pi_m + \pi_r = (p_m - c - c_2)d_m + (p_r - c)d_r
\]  

(18)

Similar to the solving process in Section 4.1, the profits of the manufacturer and the retailer in manufacturer drop shipping can be obtained as follows:

\[
\pi_{m} = \frac{1}{8}(\rho - 1)c + \frac{1}{8}(\rho + 1)c + \frac{1}{8}c_2 + \frac{2c_1}{8} + \frac{2c_2}{8} + \frac{c_0}{8} + \frac{c_2}{8} + \frac{c_0}{8} + \frac{c_2}{8} + \frac{c_0}{8}
\]  

(19)

\[
\pi_{r} = \frac{(1 - \rho) a + (c + c_2) b - c}{16}
\]  

(20)
5. Cooperative Condition in Retailer Drop Shipping

5.1. Conditions for the manufacturer to adopt retailer drop shipping

The manufacturer always selects the shipping mode with higher profit in the dual-channel supply chain. In other words, the manufacturer favours the retailer drop shipping only if the mode generates more profit than the manufacturer drop shipping.

Let $\pi_{\text{obj}}$ be the manufacturer’s decision variable, which reflects the profit difference between retailer and manufacturer drop shipping modes:

$$\pi_{\text{obj}} = \pi_{\text{ml}}^* - \pi_{\text{rc}}^*$$  \hspace{1cm} (21)

Substitute formulas (14) and (19) into formula (21) to obtain formula (22):

$$\pi_{\text{obj}} = b \left[2c_z + a(1 - \rho)\right] - 2a(1 - \rho)(2s - c_z) - 2c_z / 8 - (s - c_z)(2\rho a - 2c - c_z - s)/4$$

$$+ b^2 \left[c^2 + 2c_a + 2c(c - s) + c_z^2 - 2s^2\right]/8$$  \hspace{1cm} (22)

Thus, formula (22)$\geq 0$ ($\pi_{\text{obj}} \geq 0$) is the condition for the manufacturer to select retailer drop shipping.

Furthermore, there is: $\pi_{\text{obj}}(0) = b\left[c_z + a(1 - \rho)\right] + a(1 - \rho)c_z - c_z / 4 + c_z(2\rho a - 2c - c_z)/4 + b^2 \left(c_z^2 + 2c_a + 2c(c - s) + c_z^2 - 2s^2\right)/8$.

Since $c_z \leq \rho a - c$, it is easy to prove that $\pi_{\text{obj}}(0) \geq 0$.

Find the first-order derivative of $\pi_{\text{obj}}$ in relation to $s$:

$$\pi_{\text{obj}}(s)' = (s + c)(1 - b^2) - \rho a - ab(1 - \rho)/2$$  \hspace{1cm} (23)

The sign of the derivative is uncertain and $\pi_{\text{obj}}(0)' < 0$; then, find the second-order derivative:

$$\pi_{\text{obj}}(s)' = 1 - b^2 \geq 0$$

Let formula (22) $\leq 0$, and then the decision boundary for the manufacturer to select a shipping mode is:

$$s_{\text{ml}} = \rho a + ab / (1 - b^2) - c + 1 / (2(1 - b^2)) z_n; \quad s_{\text{rc}} = \rho a + ab / (1 - b^2) - c + 1 / (2(1 - b^2)) z_m$$  \hspace{1cm} (24)

Note: $z_n = \begin{bmatrix} 2(2c(c_z + c_a) + (c_z^2 + 2c_a^2 + c_z^2))b^2 + 4[(c_z + 2c_a + c_z(1 - \rho)a + c(c_z - c_z)]b + 2[2(1 - \rho)^3 a^2 + 4\rho(c + c_z)a$$

$$- 2(c_z + 3c_a) - (4c^2 + 3c_z^2 + c_z^2)]b^2 + 4(2(1 - \rho)a(1 - (1 - \rho)c_z + 2c_z + c_z - c_z)]b + 4(\rho a - c - c_z)^2$$

Since $\pi_{\text{obj}}(s)' \geq 0$, the condition for the manufacturer to adopt retailer drop shipping is $0 \leq s \leq s_{\text{ml}}$, or $s \geq s_{\text{ml}}$.

Meanwhile, it can be proved that $s_{\text{ml}} \geq \rho a - c$, so that $s \geq s_{\text{ml}}$. This condition does not fall in the range $s \in [0, \rho a - c]$, indicating that the condition for the manufacturer to adopt retailer drop shipping is $0 \leq s \leq s_{\text{ml}}$. Considering that $s_{\text{ml}}$ is the key to the manufacturer’s decision, $s_{\text{ml}}$ was defined as the “maximum acceptable price to the manufacturer” in the following sections.

Where $s_{\text{ml}} \leq s \leq s_{\text{ml}}$, it is clear that $\pi_{\text{obj}}'(s) < 0$, i.e. the manufacturer tends to give up retail drop shipping at a high drop shipping commission. Then, the manufacturer’s decision was explored when drop shipping commission increases to the unit cost of manufacturer drop shipping $c_z$. Substitute $s = c_z$ into formula (22) to obtain:

$$\pi_{\text{obj}}(c_z) = -b\left[(c_z + c_z)/2 - c(1 - b) + (1 - \rho)a\right]c_z - c_z]/4$$. It can be deduced that $\pi_{\text{obj}}(c_z) < 0$. Therefore, the manufacturer is willing to pay a drop shipping commission less than $c_z$, namely $s < c_z$.

Proposition 1: During the cooperation of retailer drop shipping, if the market share of e-commerce channel is expanded, the maximum acceptable price to the manufacturer $s_{\text{ml}}$ will increase, and vice versa.

Proof: Assuming that the manufacturer and the retailer have already entered into the cooperation in drop shipping, $\pi_{\text{obj}}(s, \rho a) \geq 0$ must be valid if both sides have agreed on the drop shipping
commission $s_j$. With the deepening of cooperation, the market share of e-commerce channel gradually increases to a certain level $\rho'$, when both sides start to renegotiate the drop shipping commission. Then, the manufacturer’s willingness to adjust the drop shipping commission obviously depends on the magnitude of $\pi_{mbj}(s_j, \rho')$.

The first-order derivative of $\pi_{mbj}$ in relation to $\rho$ was solved to get $\pi_{mbj}'(\rho) = a((s - c_j/2 - c_j/2)b - s + c_j)/2$. Since $s < c_j$, it is easy to deduce that $\pi_{mbj}'(\rho) > 0$.

Since $\pi_{mbj}'(\rho) > 0$, the profit difference between retailer and manufacturer drop shipping modes will increase with the market share of e-commerce channel, leading to the increase in $s_{ml}$, and vice versa.

Q.E.D.

**Proposition 2:** During the cooperation of retailer drop shipping, if the market capacity is expanded and the initial drop shipping commission is lower than $s_{an}$, then the maximum acceptable price to manufacturer $s_{ml}$ will increase; if the initial drop shipping commission is higher than $s_{an}$, the $s_{ml}$ will decrease. If the market capacity shrinks, the $s_{ml}$ will move in the opposite direction. (Note: $s_{an} = (c_1 + c_j)/2$). (Note: $s_{an} = (c_1 + c_j)/2$)

Proof: Assuming that the manufacturer and the retailer have already entered into the cooperation in drop shipping, $\pi_{mbj}(s_j, \rho) \geq 0$ must be valid if both sides have agreed on the drop shipping commission $s_j$. With the deepening of cooperation, the total market capacity gradually expands to a certain level $\rho'$, when both sides renegotiate the drop shipping commission. Then, the manufacturer’s willingness to adjust the drop shipping commission obviously depends on the magnitude of $\pi_{mbj}(s_j, \rho')$.

The first-order derivative of $\pi_{mbj}$ in relation to $a$ was solved to get $\pi_{mbj}'(a) = (c_1 - 2s + c_j)b/4$.

Through further analysis, it is found that $\pi_{mbj}'(a) \leq 0$ if $s_j \geq s_{an}$, and $\pi_{mbj}'(a) > 0$ if $s_j < s_{an}$.

Therefore, if the initial drop shipping commission is higher than $s_{an}$, then the profit difference between retailer and manufacturer drop shipping modes will decrease with the expansion of market capacity, leading to the decrease in the maximum acceptable price to the manufacturer $s_{ml}$, and vice versa.

Similarly, if the initial drop shipping commission is lower than $s_{an}$, then the profit difference between retailer and manufacturer drop shipping modes will increase with the shrink of market capacity, leading to the increase in the maximum acceptable price to the manufacturer $s_{ml}$, and vice versa.

Q.E.D.

5.2. **Conditions for the retailer to provide drop shipping service**

The retailer always makes the decision with higher profit on drop shipping service. In other words, the retailer is willing to provide drop shipping service only if doing so generates more profit than not doing so (non-drop shipping).

Let $\pi_{sjo}$ be the retailer’s decision variable, which reflects the profit difference between retailer drop shipping and non-drop shipping:

$$\pi_{sjo} = \pi_{sjo}^* - \pi_{sjo}^*$$

Substitute formulas (15) and (20) into formula (25) to obtain

$$\pi_{sjo} = b^2[c_1^2 - c_j^2 - 2c_2 + 8s(s + c_j) - 2c_j(3c_j + 4s)]/16 + b(c_1 - c_j) + (1 - \rho)a(4s - c_j - 3c_j)]/8$$

Let Formula (26) =0, then the decision boundary for the retailer to select shipping mode is:

$$s_j = \frac{pa + ab}{2(1+b)} + c_j - c - \frac{1}{4(1-b')}$$

$$s_{an} = \frac{pa + ab}{2(1+b)} + c_j - c + \frac{1}{4(1-b')}$$

(27)
Through further analysis, it was found that if $s_{rl} > s_{ml}$, then the minimum price acceptable to the retailer was solved to $s_{ml} \leq s \leq s_{rl}$, and $s \geq 0$. Whereas the condition for the manufacturer to adopt retailer drop shipping $0 \leq s \leq s_{ml}$, it is clear that $s_{rl}$ is the key to the retailer’s decision. Hence, $s_{rl}$ was defined as the “maximum acceptable price to the retailer” in the following sections.

The first-order derivative of $\pi_{rl}$ in relation to $s$ was solved to get $\pi_{rl} (s) = [\rho a + (1 - \rho) ab - (1 - b') (c + 2 s - c_{l})] / 2$. The sign of the derivative is uncertain. Then, the second-order derivative of $\pi_{rl}$ in relation to $s$ was solved as $\pi_{rl} (s) = b' - 1 \leq 0$. Meanwhile, substitute $s = 0$ and $s = c_{l}$ into the above formula, and then $\pi_{rl} (s) > 0$.

Through further analysis, it is found that $\pi_{rl} (c_{l}) = -b [b (c_{l} + c_{l}) / 2 - c (1 - b) (1 - \rho) a] (c_{l} - c_{l}) / 8 = \pi_{rl} (c_{l}) / 2 < 0$ if $s = c_{l}$. This means the retailer is not willing to provide drop shipping service if $s \in [0, c_{l}]$, i.e. $s > c_{l}$.

**Proposition 3:** During the cooperation of retailer drop shipping, if the market share of e-commerce channel is expanded, the maximum acceptable price to the retailer $s_{rl}$ will decrease, and vice versa.

The proof is similar to that of Proposition 1.

**Proposition 4:** During the cooperation of retailer drop shipping, if the market capacity is expanded and the initial drop shipping commission $s_{rl}$ is higher than the threshold $s_{ml}$, then the minimum price acceptable to the retailer $s_{ml}$ will increase; If the market capacity shrinks, the $s_{ml}$ will move in the opposite direction. (Note: $s_{ml} = (3 c_{l} + c_{l}) / 4 - [\rho (c_{l} - c_{l})] / [4 (1 - \rho) b + 4 \rho]$)

Proof: The first-order derivative of $\pi_{ml}$ in relation to $a$ was solved to get $\pi_{ml} (a) = (1 - \rho) (4 s - 3 c_{l} - c_{l}) b / 8 + (s - c_{l}) \rho / 2$. Through further analysis, it was found that if $s \geq s_{ml}$, then $\pi_{ml} (a) > 0$; if $s < s_{ml}$, then $\pi_{ml} (a) < 0$.

The rest of the proof is similar to that of Proposition 2.

Q.E.D.

6. Game Results and Cooperative Strategies

In the dual-channel supply chain, both the manufacturer and the retailer pursue the maximum profit in decision-making. Considering the difference in such factors as drop shipping commission, market share of e-commerce channel and market environment, the two sides select the shipping mode with the higher optimal equilibrium profit out of the two available modes.

6.1. Analysis of game results

With the deepening of cooperation between the manufacturer and the retailer, the environmental factors like market capacity and market share of e-commerce channel are under constant changes. To seek continued cooperation, it is necessary to disclose the variation in environmental factors on game results, and explore the two sides’ strategy for further cooperation.

**Inference 1:** During the cooperation of retailer drop shipping, if the market share of e-commerce channel is expanded, the cooperative interval of the drop shipping commission will expand, and vice versa.

Proof: According to Propositions 1 and 3, it can be seen that $\pi_{ml} (\rho) > 0$ and $\pi_{rl} (\rho) > 0$ in the cooperative interval $(c_{l}, c_{l})$. Then, Inference 1 is obviously true.

Q.E.D.

**Inference 2:** During the cooperation of retailer drop shipping, if the market capacity is expanded
and the initial drop shipping commission is higher than \( s_{nm} \), then the drop shipping commission will decrease; if the initial drop shipping commission is less than \( s_{n} \), then the drop shipping commission will increase; if the initial drop shipping commission falls between \( s_{nm} \) and \( s_{n} \), the cooperative interval of both sides in drop shipping commission will widen. If the market capacity shrinks, then the initial drop shipping commission will move in the opposite direction. (Note: \( s_{nm}=(c_i+c_j)/2 + s_n=(3c_i+c_j)/4-\left[\rho(c_j-c_i)\right]/\left[4(1-\rho)b+4\rho\right] \))

Proof: According to Propositions 2 and 4, it can be seen that \( c_1<s_{m}<s_{nm}<c_4 \) through further analysis. In this case, there are three possible scenarios.

1. If the initial drop shipping commission \( s_n \) is higher than \( s_{nm} \), then \( \pi_{nm}^{'a}(a) \leq 0 \) and \( \pi_{m}^{'a}(a) > 0 \); if the market capacity is expanded, then both \( s_{nm} \) and \( s_n \) will decline, and the drop shipping commission will tend to decline; if the market capacity shrinks, both \( s_{nm} \) and \( s_n \) will increase, and the drop shipping commission will tend to increase.

2. If \( s_n \) is lower than \( s_{nm} \) and greater than \( s_n \), then \( \pi_{nm}^{'a}(a) > 0 \) and \( \pi_{m}^{'a}(a) > 0 \); if the market capacity expands, the \( s_{nm} \) will increase and the \( s_n \) will reduce, leading to the widening of the cooperative interval of their drop shipping commission. Hence, the drop shipping commission may remain the same, increase or decrease; if the market capacity shrinks, the cooperative interval will also get narrow.

3. If \( s_n \) is lower than \( s_n \), then \( \pi_{nm}^{'a}(a) > 0 \) and \( \pi_{m}^{'a}(a) \leq 0 \); if the market capacity expands, both \( s_{nm} \) and \( s_n \) will increase, and the drop shipping commission will tend to increase; if the market capacity shrinks, the drop shipping commission will tend to decline.

Q.E.D.

6.2. Cooperation strategies and management suggestions

Based on the above analysis, the following management suggestions were presented to the manufacturer and the retailer during the operation of retailer drop shipping in the dual-channel supply chain.

6.2.1. Manufacturer’s strategies

**Strategy 1: The manufacturer’s cooperation strategy at the expansion of the market share of e-commerce channel**

If the market share of e-commerce channel expands after the mutual cooperation in drop shipping, the manufacturer may seek a lower drop shipping commission through negotiation, or propose any cooperation condition other than price, based on the evaluation of demand features.

From Inference 1, if the market share of e-commerce channel expands, both sides will be willing to make concessions in drop shipping commission. In this case, the manufacturer should evaluate the demand features of e-commerce channel before deciding on whether to suppress the commission by leveraging its dominance in the supply chain. If the demand is insensitive to logistics service or it is easy to meet logistics requirement, the manufacturer should negotiate for a low commission by reason of the increase in market share; if the demand is sensitive to logistics service or it is difficult to meet the logistics requirement, the manufacturer should stress on the service quality in further cooperation, and even ask for better delivery service at the same or slightly higher commission. In addition, the manufacturer may consider a more flexible way of cooperation in response to the growth in the market share of e-commerce channel, e.g. concluding a contract on logistics investment compensation plus unit drop shipping fee.

**Strategy 2: The manufacturer’s price negotiation strategy facing the shrink of the market share of e-commerce channel**

If the market share of e-commerce channel shrinks during the drop shipping cooperation, the manufacturer may renegotiate with the retailer to adjust the commission based on the root cause of the
Facing the shrink of the market share of e-commerce channel, the manufacturer tries to reduce the commission, while the retailer attempts to increase the commission. In this scenario, the manufacturer should not blindly request substantial commission reduction, but renegotiate with the retailer to adjust the commission based on the root cause of the shrink: (1) If the decrease of $\rho$ is irrelevant to the logistics service, the manufacturer may adjust the fee at the request of the retailer: maintain or properly increase the original commission without touching the bottom line price; if there is no possibility of cooperation, the two sides should consider adjusting the shipping mode. (2) If the decrease of $\rho$ is attributable to the fact that logistics service level fails to meet the user demand, the manufacturer should ask for better drop shipping logistics service, and properly increase the commission; otherwise, the manufacturer has to be ready to accept certain economic loss. (3) If the decrease of $\rho$ happens because the retailer does not reach the logistics service level specified in the contract, the manufacturer should take some punitive measures in the short term, and look for a new drop shipping cooperator in the medium or long term.

**Strategy 3: The manufacturer’s cooperation and pricing strategy at the expansion of market capacity**

If the market capacity expands during the drop shipping cooperation, the manufacturer should seek a fee reduction at a high initial drop shipping commission, properly increase the fee at a low initial drop shipping commission, and look to reduce the fee or propose any cooperation condition other than price if the initial drop shipping commission falls in the medium range.

From Inference 2, if the market capacity expands and the initial drop shipping commission surpasses the average shipping cost of both sides, then the drop shipping commission should be reduced. If the initial fee is lower than $s_l$, the commission should be properly increased. If the initial drop shipping commission falls between the average shipping cost and $s_l$, the cooperative interval of drop shipping commission for both sides should be widened. Similar to Strategy 2, the manufacturer should evaluate the demand features of e-commerce channel before decision-making.

**Strategy 4: The manufacturer’s price negotiation strategy facing the shrink of market capacity**

If the market capacity shrinks during the drop shipping cooperation, the manufacturer should properly increase the fee at a high initial drop shipping commission, seek a fee reduction at a low initial drop shipping commission, and renegotiate a price with the retailer if the initial drop shipping commission falls in the medium range.

From Inference 2, if the market capacity shrinks and the initial drop shipping commission surpasses the average shipping cost of both sides, then the drop shipping commission should be increased. If the initial fee is lower than $s_u$, the commission should be reduced. If the initial drop shipping commission falls between the average shipping cost and $s_u$, the cooperative interval of drop shipping commission for both sides should be narrowed down. The manufacturer should evaluate the demand features of e-commerce channel before selecting a proper cooperation strategy and renegotiating a price with the retailer. However, both sides may be confronted with the possibility of the loss of cooperation.

**6.2.2. Retailer’s strategies**

**Strategy 1: The retailer’s cooperation strategy at the expansion of market share of e-commerce channel**

If the market share of e-commerce channel expands after the mutual cooperation in drop shipping, the retailer may propose a cooperation condition other than price, or evaluate the scarcity of its own service before seeking a higher drop shipping commission through negotiation.

From Inference 1, if the market share of e-commerce channel expands, both sides will be willing to make concessions in drop shipping commission. In this case, the retailer should evaluate the scarcity of its own service before making a decision rather than blindly seek substantial price increase; if the logistics service is relatively scarce and it is difficult to provide the service specified in the contract,
the retailer may look for a higher drop shipping commission through negotiation; if it is easy to meet
the logistics requirement, the retailer may maintain or slightly reduce the original drop shipping
commission. In addition, the retailer may consider a more flexible way of cooperation or proposing a
cooperation condition other than price, e.g. concluding a contract with better flow of funds.

**Strategy 2: The retailer’s price negotiation strategy facing the shrink of the market share of
e-commerce channel**

If the market share of e-commerce channel shrinks during the drop shipping cooperation, the
retailer should renegotiate the price with the manufacturer and may be subject to the loss of cooperation.

Facing the shrink of the market share of e-commerce channel, the manufacturer tries to reduce the
commission, while the retailer attempts to increase the commission. In this scenario, the retailer should
not blindly request substantial commission increase, but renegotiate the price with the manufacturer:
(1) If the decrease of is irrelevant to the logistics service, the retailer may adjust the fee at the request
of manufacturer: maintain or properly increase the original commission without touching the bottom
line price; if the price request from the other side constitutes an economic loss to the retailer, the
retailer should fully communicate with the manufacturer and reconsider the necessity of further cooperation.
(2) If the decrease of \( \rho \) is attributable to the fact that logistics service level fails to meet
the user demand, the manufacturer may ask for better drop shipping logistics service level, and the
retailer should take this opportunity to negotiate a higher drop shipping commission. (3) If the
decrease of \( \rho \) happens because the retailer does not reach the logistics service level specified in the
contract, the retailer should fully communicate with the other side, make self-check and inspection,
and take proper measures against the problem in logistics service as soon as possible. Otherwise, the
retailer has to accept necessary punishment.

**Strategy 3: The retailer’s cooperation and pricing strategy at the expansion of market
capacity**

If the market capacity expands during the drop shipping cooperation, the retailer should properly
reduce the fee at a high initial drop shipping commission, seek a fee increase at a low initial drop
shipping commission, and look to increase the fee or propose any cooperation condition other than price if the initial drop shipping commission falls in the medium range.

From Inference 2, if the market capacity expands and the initial drop shipping commission
surpasses the average shipping cost of both sides, then the retailer should reduce the drop shipping
commission. If the initial fee is lower than \( s_{w} \), the commission should be properly increased. If the
initial drop shipping commission falls between the average shipping cost and \( s_{w} \), then the cooperative
interval of drop shipping commission for both sides should be widened. Similar to Strategy 1, the
retailer evaluate the scarcity of its own service before seeking a higher drop shipping commission, or
propose a cooperation condition other than price.

**Strategy 4: The retailer’s price negotiation strategy facing the shrink of market capacity**

If the market capacity shrinks during the drop shipping cooperation, the retailer should seek a fee
increase at a high initial drop shipping commission, reduce the fee at a low initial drop shipping
commission, and renegotiate a price with the manufacturer if the initial drop shipping commission falls in the medium range.

From Inference 2, if the market capacity shrinks and the initial drop shipping commission surpasses
the average shipping cost of both sides, then the retailer should seek to increase the drop shipping
commission. If the initial fee is lower than \( s_{w} \), the commission should be reduced. If the initial drop
shipping commission falls between the average shipping cost and \( s_{w} \), the cooperative interval of drop
shipping commission for both sides should be narrowed down. Similar to Strategy 2, the retailer
should renegotiate a price with the manufacturer and may be confronted with the loss of cooperation.

7. Conclusion

Focusing on the decision results in the dual-channel supply chain involving both manufacturer drop
shipping and retailer drop shipping, this paper analyses the applicable conditions for the manufacturer and the retailer to select the retailer drop shipping, identifies the commission interval for mutual cooperation in drop shipping, and determines the cooperative strategies for both sides in retailer drop shipping that change with the environmental factors.

The findings are as follows. (1) The mutual cooperative interval of drop shipping commission will change in the same direction as the market share of e-commerce. (2) With the expansion of market capacity, the drop shipping commission will reduce if it is high at the beginning, and vice versa. (3) With the expansion of market capacity, the drop shipping commission will increase if it is low at the beginning. (4) The cooperative interval of drop shipping commission will change in the same direction as the market share if it falls in the medium range at the beginning.

For simplification, the demand functions were considered as simple linear functions. In subsequent research, the cooperative strategy of retailer drop shipping in the dual-channel supply chain will be investigated, provided that the dual-channel market demand is a non-linear function (if the demand obeys the normal distribution or exponential distribution). Furthermore, it is assumed that the market demand is mainly affected by the commission of the two channels. In practice, however, the drop shipping commission has a certain impact on the drop shipping service level, and even market demand. Therefore, it is necessary to study the retailer drop shipping cooperative strategy in the dual-channel supply chain when the market demand is affected by the drop shipping commission.

REFERENCES

[1] Cattani K., Gilland W. (2006). Boiling frogs: Pricing strategies for a manufacturer adding a direct channel that competes with the traditional channel [J]. Production and Operations Management, Vol. 15, No. 1, pp.40-56.
[2] Chen J, Chen Y, Parlar M. and Xiao Y.B. (2011). Optimal inventory and admission policies for drop-shipping retailers serving in-store and online customers. IIE Transactions, Vol. 43, No. 5, pp.332-347.
[3] Chen J.X., Liang L., Yao D.Q., Sun S.N. (2017). Price and quality decisions in dual-channel supply chains. European Journal of Operational Research, Vol. 259, No. 3, pp.935-948.
[4] Chiang W K, Feng Y. (2010). Retailer or e-tailer? Strategic pricing and economic-lot-size decisions in a competitive supply chain with drop-shipping, Journal of the Operational Research Society, Vol. 61, No. 11, pp.1645-1653.
[5] Deng M.R., Yu Shan. (2014). Inventory Strategy in Dual—channel Drop—shipping Supply Chain Based on Customer Channel Preference, Science and Technology Management Research, Vol. 34, No. 6, pp.182-187.
[6] Fehr E, Schmidt K. M. (1999). A theory of fairness, competition and co-operation, Quarterly Journal of Economics, Vol. 114, No. 3, pp.817-868.
[7] Gan X., Sethi S. P., Zhou J. (2010). Commitment-penalty contracts in drop-shipping supply chains with asymmetric demand information, European Journal of Operational Research. Vol. 204, No. 3, pp.449-462.
[8] Li Hai, Cui N.F. (2013). Study on pricing scheme decision in dual channel supply chain under bargaining power, Application Research of Computers, Vol. 30, No. 8, pp.2323-2326.
[9] Li Ming. (2011). Coordinate the Drop-shipping supply chain with price-dependent stochastic demand, M.S. thesis, University of Science and Technology of China, Hefei of Anhui province, China.
[10] Li Z., Stephen M.G., Lai G. (2014). Supplier Encroachment Under Asymmetric Information, Management Science, Vol. 60, No. 2, pp.449-462.
[11] Li Q., and Ma J. (2016). Research on price Stackelberg game model with probabilistic selling based on complex system theory. Communications in Nonlinear Science and Numerical Simulation, Vol. 30, No. 1-3, pp.387-400.
[12] Liu L.W., Wang X.Y. (2008). Threshold level inventory rationing Policies with drop-shipping for internet retailers, Journal of Systems Engineering, Vol. 23, No. 6, pp.650-658.

[13] Lu Q, Liu N. (2015) Effects of e-commerce channel entry in a two-echelon supply chain: A comparative analysis of single- and dual-channel distribution systems, International Journal of Production Economics, Vol. 165, No. 6, pp.100-111.

[14] Netessine S., Rudi N. (2006). Supply Chain Choice on the Internet, Management Science, Vol. 52, No. 6, pp.844-864.

[15] Pu, X., L. Gong and X. Han. (2017). Consumer free riding: Coordinating sales effort in a dual-channel supply chain, Electronic Commerce Research and Applications, Vol. 22, No. 2, pp.12.

[16] Raaïd B., Mohamad Y.J., Simone Z. (2016). Dual-channel supply chain: A strategy to maximize profit. Applied Mathematical Modelling, Vol. 40, No. 21–22, pp.9454-9473.

[17] Wu D. (2013). The impact of repeated interactions on supply chain contracts: A laboratory study, International Journal of Production Economics, Vol. 142, No. 1, pp. 3-15.

[18] Zhang G.M., Zhao S.N. (2014). Study on Dual-Channel Supply Chain Coordination of Drop Shipping by the E-tailer, Industrial Engineering Journal, Vol. 17, No. 6, pp.77-82.

[19] Zhang G.M., Zhao S.N. (2015). Research on Dual-Channel Supply Chain Coordination of Drop Shipping by the Retailer, Industrial Engineering and Management, Vol. 20, No. 1, pp.108-114.

[20] Zhang L.L., Yao Zhong. (2015). Optimal strategy of risk-averse dual-channel supply chain with consumer returns, Computer Integrated Manufacturing Systems, Vol. 21, No. 3, pp. 766-775.

[21] Zhao J., Duan Y., Wang S., et al. (2012). Coordinated Drop Shipping Commitment Contract in Dual-Distribution Channel Supply Chain, Journal of Electronic Commerce in Organizations, Vol. 10, No. 4, pp.19-30.

[22] Zhao J.S., Duan Y.R., Wang S.J., Huo J. Z. (2013). Performance Comparative Study in Dual-Distribution Channel Drop Shipping Supply Chain Based on Different Dominant Positions, Journal of Industrial Engineering / Engineering Management, Vol. 27, No. 1, pp.171-177.

[23] Zhao J., Hou X.R., Guo Y.L., Wei J. (2017). Pricing policies for complementary products in a dual-channel supply chain. Applied Mathematical Modelling, Vol. 49, No. 18, pp.437-451.