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Supply Chain Analysis of Cross Border Importing E-Commerce Considering with Bonded Warehouse and Direct Mailing

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Abstract: In this paper, we consider a cross-border supply chain system that has an import e-commerce company and an overseas supplier. We first considered a pure bonded warehouse mode in which the e-commerce company makes bulk purchase from an overseas supplier to a bonded warehouse and will deliver goods to customers from the bonded warehouse when customers order online. We constructed a Stackelberg model to obtain the equilibrium solution by using backward induction, and then properties of equilibrium strategy and equilibrium profit is discussed. We then studied the combined bonded warehouse and direct mailing mode in which the e-commerce company will purchase a single piece and mail to the customer directly if the bonded warehouse is out of stock. Analytical results demonstrate that the combined bonded warehouse and direct mailing mode may increase the profit of suppliers and decrease the profit of e-commerce companies.

Keywords: cross-border importing e-commerce; supply chain; bonded warehouse; direct mailing; Stackelberg model

1. Introduction

Cross-border e-commerce import in China has gradually emerged since 2013 and the amount of cross-border online shopping users has increased drastically. On August 1, 2014, the General Administration of Customs (GAC) of China announced “on the supervision of the import and export of goods and goods in cross-border trade in electronic commerce.” The Chinese government has promulgated more than ten policies to encourage and standardize the import cross-border e-commerce, and the scale of the cross-border import e-commerce market has increased rapidly. Two policies in 2015, “on the related issues of the bonded import model for the pilot network purchase of e-commerce services in cross-border trade” by the General Administration of Customs and “reducing the import tariffs on consumer goods” by the China State Council, have fueled the cross-border import business growth. In the first half of 2017, the scale of cross-border e-commerce transactions in China reached 862.4 billion Chinese Yuan (about \$127 billion USD), a 66.3% increase over the previous year [1].

Commonly, there are two main logistics modes in cross-border e-commerce: Bonded warehouse mode and direct mail mode. In the bonded warehouse mode, the e-commerce company purchases goods from overseas suppliers and transports them to bonded warehouses. When customers order online, the goods will be extracted from bonded warehouses. After the import goods clear the custom procedures, they will be sent to customers via local express delivery. In the direct mail mode, goods will be delivered directly from overseas procurement after customers order online. Bonded warehouse model has been the mainstream mode in contemporary import e-commerce. Many

e-commerce companies are adopting bonded warehouse as their main method and using direct mail as a supplementary method. These companies include NetEase Kola shopping, Tmall International, Su Ninghai foreign purchase, jumei.com, Jingdong global purchase, Amazon overseas purchase, etc.

Our study attempts to answer the following questions: 1. Can combined bonded warehouse and direct mail mode get more profits than the pure bonded warehouse mode? 2. What are the supply chain decisions under the pure bonded warehouse mode and combined bonded warehouse and direct mail mode, respectively?; 3. What are key decision-making problems for the cross-border e-commerce company?

There is a number of studies on cross-border e-commerce from various aspects. Chen and Yang (2017) [2] considered the impact of government policies on cross-border e-commerce providers in an empirical study. Wang et al. (2017) [3] utilized the transaction cost analysis to study the impact of cross-border e-commerce on China's international trade. Deng and Wang (2016) [4] used the panel data model to analyze the advantage of the cross-border e-commerce portal. Lu and Wang (2016) [5] and Wang et al. (2017) [6] studied the effects of the cross-border e-commerce comprehensive Pilot Area based on different modes. Lin et al. (2018) [7] conducted research on dysfunctional customer behavior in cross-border e-commerce. Zhang et al. (2017) [8] proposed a BP neural network model to assess credit risk in cross-border electricity providers.

In the area of logistics and supply chain of cross-border e-commerce research, Li and Miao (2017) [9] discussed the logistics status and operation mode of China's cross-border e-commerce. Maria et al. (2017) [10] summarized the role of cross-border B2C providers in logistics in greater China region. Kawa and Zrordka (2016) [11] proposed the concept of integrator to solve the logistics problem of cross-border e-commerce. Hsiao et al. (2017) [12] studied the feelings of customers and designed a logistics service of cross-border e-commerce by using Kansei Engineering. Feng et al. (2017) [13] adopted the L-COPRAS method to assess the strategic cost of the downstream supply chain of cross-border e-commerce.

Mikalef et al. (2013, 2014, 2015) [14–16] empirically investigated alignment of internal resources with strategy and reviewed the literature on business-IT alignment from broad range of domains. They identified the antecedents such as procurement structure and organization size to show the positive impact of IT adoption on the supply chain improvement. They also used configuration theory approach to study the casual relationship of contingency elements between purchasing strategy and IT. While our work is focusing on cross-border e-commerce, the investment in technology of e-commerce and various factors such as government regulation and policies, tariff, and even politico environment all affect the supply chain performance. The alignment of the supply chain strategy with investment and resources is critical to the success of the e-commerce company.

So far, although there have been many studies on cross-border e-commerce and the supply chain theory, there are few theoretical studies on cross-border e-commerce from the perspective of the supply chain model. Zhang and Cao (2017) [17] built a price competition model on cross-border e-commerce companies and regulators and traditional trade enterprises. Wang et al. (2017) [18] studied price competition between cross-border e-commerce companies and upstream suppliers that own both online and offline sales. However, their papers do not consider the features of the logistics mode in the cross-border e-commerce and cross-border e-commerce company's procurement decision.

In this paper, we consider a supply chain system consisting of an import cross-border e-commerce company and an overseas supplier. In this model, the overseas supplier first determines the bulk purchase price, and then the e-commerce company will make purchasing decisions according to the price. We consider both the pure bonded warehouse mode and combined bonded warehouse and direct mail mode.

2. Assumptions and Notations

- p : the retail price of import e-commerce company (including tax and postal charge);
- c_0 : set-up cost of bonded warehouse mode;

c_1 : unit logistics cost of bulk purchase to the bonded warehouse (including transportation fee and bonded warehouse storage costs, etc.);

c_2 : delivery fee per commodity from the bonded warehouse to the customer (including import tariff);

c_3 : delivery fee in the direct mail mode (including import tariff);

w_2 : purchase price per commodity in the direct mail mode, $C \leq w_2 \leq p - c_3$;

C : unit production cost of the overseas supplier;

c_r : unit price of the overseas supplier in the direct mail mode;

v : the salvage value of unsold commodities in the bonded warehouse, $v < C + c_1$;

D : random continuous demand on interval $[0, \infty)$, with a probability density, $f(\cdot)$, and distribution function, $F(\cdot)$;

w_1 : bulk purchase price in the bonded warehouse mode, the overseas supplier's decision variable, where $C \leq w_1 \leq p - c_1 - c_2$;

Q : bulk purchase quantity, the import cross-border e-commerce company's decision variable.

Without loss of generality, we utilize the following widely used assumption in supply chain, revenue management, queuing theory, and other models (Ziya et al., 2004 [19]; Wei et al., 2013 [20]).

Assumption 1. General failure rate function $e(x) = \frac{xf(x)}{1-F(x)}$ is strictly increasing.

3. Mode 1: Pure Bonded Warehouse Mode

In the pure bonded warehouse mode, the overseas supplier first decides the bulk purchase price, w_1 , and then the e-commerce company makes a purchase decision with quantity, Q , according to w_1 . We build the mathematical model to solve the problem using backward induction.

3.1. The E-Commerce Company Decision

The expected profit for the e-commerce company with purchase price w_1 and purchase quantity, $Q > 0$, is

$$\begin{aligned}\pi_r(Q, w_1) &= (p - c_2) \cdot E\min(Q, D) + v \cdot E(Q - D)^+ - (c_0 + c_1 Q + w_1 Q) \\ &= (p - c_2 - v) \cdot E\min(Q, D) - (c_1 + w_1 - v)Q - c_0\end{aligned}\quad (1)$$

where $y^+ = \max\{y, 0\}$.

Similar to the newsvendor model, we can get

$$\begin{aligned}\frac{\partial \pi_r(Q, w_1)}{\partial Q} &= (p - c_2 - v)[1 - F(Q)] - (c_1 + w_1 - v) \\ \frac{\partial^2 \pi_r(Q, w_1)}{\partial Q^2} &= -(p - c_2 - v)f(Q) < 0\end{aligned}\quad (2)$$

So $\pi_r(Q, w_1)$ is concave in Q , and let

$$\frac{\partial \pi_r(Q, w_1)}{\partial Q} = (p - c_2 - v)[1 - F(Q)] - (c_1 + w_1 - v) = 0 \quad (3)$$

According to formula (3), we can obtain the optimal purchase quantity,

$$Q'(w_1) = F^{-1}\left(\frac{p - c_2 - c_1 - w_1}{p - c_2 - v}\right) \quad (4)$$

Therefore, the expected profit of the e-commerce company becomes

$$\begin{aligned}\pi_r(w_1) &= \pi_r(Q'(w_1), w_1) \\ &= (p - c_2 - v) \cdot E_{\min}(Q'(w_1), D) - (c_1 + w_1 - v)Q'(w_1) - c_0 \\ &= (p - c_2 - v) \int_0^{Q'(w_1)} [1 - F(x)] dx - (c_1 + w_1 - v)Q'(w_1) - c_0\end{aligned}\quad (5)$$

To avoid triviality, the optimal purchase quantity of the e-commerce company is $Q'(w_1)$ only when $\pi_r(w_1) > c_0$, and the optimal purchase quantity is 0 when $\pi_r(w_1) \leq c_0$.

Theorem 1. (1) $Q'(w_1)$ is a strictly decreasing function of w_1 , and has the minimum value 0 when $w_1 = p - c_2 - c_1$.

(2) $\pi_r(w_1)$ is a strictly decreasing function of w_1 , and has the minimum value $-c_0$ when $w_1 = p - c_2 - c_1$.

Proof. (1) According to formula (3), we can obtain

$$\frac{dQ'(w_1)}{dw_1} = -\frac{1}{(p - c_2 - v)f(Q'(w_1))} < 0,$$

So $Q'(w_1)$ is a strictly decreasing function of w_1 , and

$$Q'(p - c_1 - c_2) = F^{-1}\left(\frac{0}{p - c_2 - v}\right) = 0$$

(2) According to formula (4) we can obtain

$$\frac{d\pi_r(w_1)}{dw_1} = \frac{\partial \pi_r(Q'(w_1), w_1)}{\partial Q'(w_1)} \cdot \frac{dQ'(w_1)}{dw_1} + \frac{\partial \pi_r(Q'(w_1), w_1)}{\partial w_1} = -Q'(w_1) < 0$$

Therefore, $\pi_r(w_1)$ is a strictly decreasing in w_1 , and

$$\pi_r(p - c_1 - c_2) = \pi_r(Q'(p - c_1 - c_2), p - c_1 - c_2) = \pi_r(0, p - c_1 - c_2) = -c_0$$

□

The optimal purchase strategy of the e-commerce company can be given by the following proposition:

Proposition 1. (1) If $\pi_r(C) \leq 0$, the optimal decision for the e-commerce company is not to purchase;

(2) If $\pi_r(C) > 0$, then there exists a $w'_1 \in (C, p - c_1 - c_2)$, which makes $\pi_r(w'_1) = 0$. At this time, the optimal purchase quantity for the e-commerce company is:

$$Q^*(w_1) = \begin{cases} Q'(w_1) & w_1 < w'_1 \\ 0 & w_1 \geq w'_1 \end{cases} \quad (6)$$

Proof. (1) According to Theorem 1, $\pi_r(w_1)$ is a strictly decreasing function of w_1 , so if $\pi_r(C) \leq 0$, then for any $w_1 > C$, $\pi_r(w_1)$ is less than 0, and the optimal decision of the e-commerce company is to make no purchase;

(2) Because $\pi_r(w_1)$ is a strictly decreasing function of w_1 , and $\pi_r(C) > 0$, $\pi_r(p - c_1 - c_2) = -c_0 < 0$, so there is definitely $w'_1 \in (C, p - c_1 - c_2)$ to make $\pi_r(w'_1) = 0$, and $\pi_r(w_1) > 0$ when $w_1 < w'_1$,

meanwhile $\pi_r(w_1) < 0$ when $w_1 > w'_1$. Thus, the optimal purchase quantity for the e-commerce company is

$$Q^*(w_1) = \begin{cases} Q'(w_1) & w_1 < w'_1 \\ 0 & w_1 \geq w'_1 \end{cases}$$

□

3.2. The Overseas Supplier Decision

In this section, we discuss the bulk purchase price strategy of the overseas supplier in two situations base on the follower's decision, $Q^*(w_1)$.

(1) When $\pi_r(C) \leq 0$, regardless of the supplier's purchase price, the e-commerce company will not purchase, so both sides will have zero profit.

(2) When $\pi_r(C) > 0$, then the decision for the supplier is to find w_1 , that

$$\max_{w_1} \pi_s(w_1) = \begin{cases} (w_1 - C) \cdot Q'(w_1) & C \leq w_1 < w'_1 \\ 0 & w'_1 \leq w_1 \leq p - c_1 - c_2 \end{cases} \quad (7)$$

Denote $\phi(w_1) = (w_1 - C) \cdot Q'(w_1)$.

Theorem 2. (1) $\phi(w_1)$ is a strict concave in w_1 , and there is a unique maximum point, w_1^* , in the interval of $[C, p - c_1 - c_2]$;

(2) If $w_1^* < w'_1$, then the optimal bulk price of the supplier is w_1^* , and the equilibrium strategy of both sides of the game is $(w_1^*, Q'(w_1^*))$; and if $w_1^* > w'_1$, then the optimal bulk price of the supplier is less than but as close as possible to w'_1 (denoted as $w_1'^{-}$), and the equilibrium strategy of the game is $(w_1'^{-}, Q'(w_1'^{-}))$.

Proof. (1) According to Assumption 1 and Proposition 5.1 (Ziya et al. 2004), it can be easily proved;

(2) Because of $\phi(C) = 0$, the maximum point of $\pi_s(w_1)$ must be in interval $[C, w'_1]$, at this time $\pi_s(w_1) = \phi(w_1)$. Because $\phi(w_1)$ is a strictly concave function of w_1 , so if $w_1 \leq w_1^*$, then $\phi(w_1)$ is strictly increased in w_1 ; else $\phi(w_1)$ is strictly decreased in w_1 . So that:

If $w_1^* < w'_1$, then $\pi_s(w_1) = \phi(w_1)$ takes the maximum point w_1^* in interval $[C, w'_1]$. And then the optimal bulk price of the supplier is w_1^* , and the equilibrium strategy of the game is $(w_1^*, Q'(w_1^*))$.

If $w_1^* > w'_1$, because $\pi_s(w_1) = \phi(w_1)$ is nonnegative and strictly monotonically increasing in interval $[C, w'_1]$, so that the optimal bulk price of the supplier is $w_1'^{-}$, and the equilibrium strategy of the game is $(w_1'^{-}, Q'(w_1'^{-}))$. □

4. Mode 2: Combined Bonded Warehouse and Direct Mail Mode

In this mode, when the stock in the bonded warehouse is not enough to meet the demand, the e-commerce company can directly purchase commodities from the overseas supplier and deliver them by the direct mail mode.

4.1. The E-Commerce Company Decision

In the case that the bulk purchase price w_1 is given, we discuss in two situations:

- a. If the e-commerce company does not choose bulk purchase, and all commodities are sold by direct mail, i.e., $Q = 0$, then the expected profit is

$$\Pi_r^1 = (p - w_2 - c_3) \cdot ED \quad (8)$$

- b. If the bulk purchase quantity $Q > 0$, when the demand exceeds Q , the demand of beyond Q will be met by direct mail mode, and then the expected profit is

$$\begin{aligned} & \Pi_r^2(Q, w_1) \\ &= (p - c_2) \cdot \text{Emin}(Q, D) + v \cdot E(Q - D)^+ + (p - w_2 - c_3)E(D - Q)^+ - (c_1 + w_1)Q - c_0 \quad (9) \\ &= (w_2 + c_3 - c_2 - v) \cdot \text{Emin}(Q, D) - (c_1 + w_1 - v)Q - c_0 + (p - w_2 - c_3) \cdot ED \end{aligned}$$

It can be shown that

$$\frac{\partial \Pi_r^2(Q, w_1)}{\partial Q} = w_2 + c_3 - c_2 - c_1 - w_1 - (w_2 + c_3 - c_2 - v)F(Q) \quad (10)$$

If $w_1 \geq w_2 + c_3 - c_2 - c_1$, then $\frac{\partial \Pi_r^2(Q, w_1)}{\partial Q} \leq 0$, and $\Pi_r^2(Q, w_1)$ is maximized when $Q = 0$. Therefore,

$$\Pi_r^2(0, w_1) = (p - w_2 - c_3) \cdot ED - c_0 < \Pi_r^1 \quad (11)$$

Accordingly, the optimal strategy of the e-commerce company is not to make a bulk purchase.

If $w_1 \leq w_2 + c_3 - c_2 - c_1$, then

$$\frac{\partial^2 \Pi_r^2(Q, w_1)}{\partial Q^2} = -(w_2 + c_3 - c_2 - v)f(Q) < 0 \quad (12)$$

So $\Pi_r^2(Q, w_1)$ is strictly concave in Q , and there is a unique maximum point

$$Q''(w_1) = F^{-1}\left(\frac{w_2 + c_3 - c_2 - c_1 - w_1}{w_2 + c_3 - c_2 - v}\right) \quad (13)$$

The corresponding maximized expected profit is

$$\begin{aligned} & \Pi_r^2(w_1) = \Pi_r^2(Q''(w_1), w_1) \\ &= (w_2 + c_3 - c_2 - v) \cdot \text{Emin}(Q''(w_1), D) - (c_1 + w_1 - v)Q''(w_1) - c_0 + (p - w_2 - c_3) \cdot ED \quad (14) \\ &= (w_2 + c_3 - c_2 - v) \int_0^{Q''(w_1)} [1 - F(x)]dx - (c_1 + w_1 - v)Q''(w_1) - c_0 + (p - w_2 - c_3) \cdot ED \end{aligned}$$

Let

$$\psi(w_1) = (w_2 + c_3 - c_2 - v) \int_0^{Q''(w_1)} [1 - F(x)]dx - (c_1 + w_1 - v)Q''(w_1) - c_0 \quad (15)$$

represents the difference of the e-commerce company between the maximum profit for bulk purchase and not bulk purchase. According to (8), (14), if $\psi(w_1) \leq 0$, then the optimal strategy of the e-commerce company is not to bulk purchase, and if $\psi(w_1) > 0$, then the optimal purchase quantity of e-commerce company is $Q''(w_1)$.

Proposition 2. (1) $Q''(w_1) < Q'(w_1)$, i.e., given the same bulk purchase price, the bulk purchase quantity of the e-commerce company in mode 2 is less than that in mode 1;

(2) $\psi(w_1) < \pi_r(w_1)$, i.e., given the same bulk purchase price, the profit difference for bulk purchase and not bulk purchase in mode 2 is less than that in mode 1.

Proof. (1) Given that $w_2 + c_3 \leq p$,

$$Q''(w_1) = F^{-1}\left(1 - \frac{c_1 + w_1 - v}{w_2 + c_3 - c_2 - v}\right) \leq F^{-1}\left(1 - \frac{c_1 + w_1 - v}{p - c_2 - v}\right) = Q'(w_1)$$

(2) Similarly, we have

$$\begin{aligned}\psi(w_1) &= (w_2 + c_3 - c_2 - v) \int_0^{Q''(w_1)} [1 - F(x)] dx - (c_1 + w_1 - v) Q''(w_1) - c_0 \\ &\leq (p - c_2 - v) \int_0^{Q''(w_1)} [1 - F(x)] dx - (c_1 + w_1 - v) Q''(w_1) \\ &\leq (p - c_2 - v) \int_0^{Q'(w_1)} [1 - F(x)] dx - (c_1 + w_1 - v) Q'(w_1) = \pi_r(w_1)\end{aligned}$$

The proposition is proved. \square

Combine all the analysis above, we can obtain

Theorem 3. (1) The purchase quantity $Q''(w_1)$ is strictly decreasing in purchase price w_1 , and has the minimum value 0 when $w_1 = w_2 + c_3 - c_2 - c_1$;

(2) $\psi(w_1)$ is strictly decreasing in purchase price w_1 , and has the minimum value $-c_0$ when $w_1 = w_2 + c_3 - c_2 - c_1$.

Proof. Similar to the proof of Theorem 1. \square

Proposition 3. (1) If $\psi(C) \leq 0$ or $w_1 \geq w_2 + c_3 - c_2 - c_1$, then the e-commerce company will not bulk purchase;

(2) If $\psi(C) > 0$ and $w_1 \leq w_2 + c_3 - c_2 - c_1$, then there exists $w_1'' \in (C, w_2 + c_3 - c_2 - c_1)$ such that $\psi(w_1'') = 0$ and the optimal purchase quantity for the e-commerce company is

$$Q^{**}(w_1) = \begin{cases} Q''(w_1) & w_1 < w_1'' \\ 0 & w_1 \geq w_1'' \end{cases} \quad (16)$$

Proof. Similar to the proof of Proposition 1. \square

4.2. The Overseas Supplier Decision

We proceed our discussion in the following two cases:

(1) If $\psi(C) \leq 0$, then the e-commerce company will not bulk purchase, and all the demand will be met by the direct mail mode, in which the expected profit for the supplier is

$$\Pi_s^1 = (w_2 - C - c_r) \cdot ED.$$

(2) If $\psi(C) > 0$, according to Proposition 3, the expected profit for the supplier is

$$\Pi_s^2(w_1) = \begin{cases} (w_1 - C)Q''(w_1) + (w_2 - C - c_r)E[D - \min(D, Q''(w_1))] & C \leq w_1 < w_1'' \\ (w_2 - C - c_r) \cdot ED & w_1'' \leq w_1 \leq p - c_1 - c_2 \end{cases} \quad (17)$$

Denote $\Phi(w_1) = (w_1 - C)Q''(w_1) - (w_2 - C - c_r)E\min(D, Q''(w_1))$.

Theorem 4. (1) $\Phi(w_1)$ is a strict concave function in w_1 , and there is a unique maximum, w_1^{**} , in the interval of $[C, w_2 + c_3 - c_2 - c_1]$;

(2) If $w_1^{**} < w_1''$, then the optimal bulk price for the supplier is w_1^{**} , and the equilibrium strategy of the game is $(w_1^{**}, Q''(w_1^{**}))$; if $w_1^{**} > w_1''$, then the optimal bulk price is less than but as close as possible to w_1'' (denoted as $w_1''^-$), and the equilibrium strategy of the game is $(w_1''^-, Q''(w_1''^-))$.

Proof. Similar to the proof of Theorem 3. \square

A numerical example is presented in the next section to demonstrate our results and some interesting managerial insights are also provided.

5. Numerical Analysis

Consider an e-commerce company to import some commodities abroad to sell in the domestic market. The retail price p of the commodity is four thousand USD/ unit, the residual value v of unsold commodities is 0.6 thousand USD/ unit, the set-up cost c_0 in bonded warehouse mode is 0.5 thousand USD, the bulk purchase logistics cost c_1 is 0.3 thousand USD/unit, the delivery fee c_2 from the bonded warehouse to the customer (import tax included) is 0.6 thousand USD/unit, the delivery fee c_3 in the direct mail mode (import tax included) is 1.1 thousand USD/unit, the unit production cost C of the overseas supplier is 1 thousand USD/unit, the unit purchase price w_2 is equal to the overseas retail price 2.8 thousand USD/unit, and the unit retail fee c_r of the overseas supplier in the direct mail mode is 0.6 thousand USD. The demand follows a truncated normal distribution with a mean value of 10 and a standard deviation of 4, i.e.,

$$F(x) = \frac{1}{A} \int_0^x \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx \quad (18)$$

in which,

$$A = \int_0^\infty \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}} dx, \mu = 10, \sigma = 4$$

5.1. Comparison of Mode 1 and Mode 2

Intuitively, the e-commerce company can sell more commodities and bring more profit in the combined bonded warehouse and direct mail mode than that in the pure bonded warehouse mode. But the results of Table 1 show that the retailer's expected profit will indeed increase from 2.39 thousand USD to 2.77 thousand USD if the bulk price of the supplier is unchanged in the combined bonded warehouse and direct mail mode, comparing with the pure bonded warehouse mode. However, if the supplier adjusts its bulk price from 2.48 USD to 2.72 USD, the expected profit of the e-commerce company will drop from 2.39 USD to 1.38 thousand USD in equilibrium. In other words, the increase of the direct mail mode on the basis of the bonded warehouses increases the expected profit of the supplier and the total supply chain profit, but reduces the expected profit of the e-commerce company.

Table 1. Comparison of mode 1 and mode 2.

	Bulk Price	Purchase Quantity of the E-Commerce Company	Expected Profit of the Supplier	Expected Profit of the E-Commerce Company	Total Expected Profit of the Supply Chain
Equilibrium results of mode 1	2.48	7.00	10.35	2.39	12.75
Results of mode 2 use the equilibrium bulk price of mode 1	2.48	6.60	14.45	2.77	17.22
Equilibrium results of mode 2	2.72	5.08	14.97	1.38	16.35

5.2. Influence of Mean Value of Demand μ

Tables 2 and 3 show respectively the equilibrium results of mode 1 and mode 2 where the mean value of demand is {6, 7, 8, 9, 10, 11, 12, 13, and 14}. In the two modes, the equilibrium price, the equilibrium purchase quantity, and the equilibrium expected profit of the supplier and the e-commerce company all increase with the increase of the mean value of demand. And for each mean value of

demand, the equilibrium price, the equilibrium expected profit of the supplier and the total expected profit of the supply chain in the combined bonded warehouse and direct mail mode are greater than those in the pure bonded warehouse mode; the equilibrium purchase quantity and the equilibrium expected profit of e-commerce company in the combined bonded warehouse and direct mail mode are less than those in the pure bonded warehouse mode.

Table 2. Influence of mean value of demand μ on mode 1.

Mean Value of Demand	Equilibrium Price	Equilibrium Purchase Quantity	Equilibrium Expected Profit of the Supplier	Equilibrium Expected Profit of the E-Commerce Company	Total Expected Profit of the Supply Chain
6	2.25	4.46	5.57	0.98	6.55
7	2.30	5.07	6.59	1.46	8.05
8	2.36	5.68	7.73	1.85	9.57
9	2.42	6.33	8.99	2.16	11.15
10	2.48	7.00	10.35	2.39	12.75
11	2.53	7.72	11.81	2.61	14.42
12	2.58	8.44	13.34	2.75	16.08
13	2.63	9.16	14.93	2.80	17.73
14	2.66	9.98	16.56	2.97	19.53

Table 3. Influence of mean value of demand μ on mode 2.

Mean Value of Demand	Equilibrium Price	Equilibrium Purchase Quantity	Equilibrium Expected Profit of the Supplier	Equilibrium Expected Profit of the E-Commerce Company	Total Expected Profit of the Supply Chain
6	2.45	3.39	9.31	0.67	9.98
7	2.58	3.48	10.58	0.75	11.32
8	2.65	3.84	11.93	0.92	12.85
9	2.68	4.48	13.40	1.19	14.59
10	2.72	5.08	14.97	1.38	16.35
11	2.75	5.76	16.62	1.57	18.20
12	2.78	6.45	18.34	1.72	20.06
13	2.80	7.23	20.11	1.89	22.00
14	2.80	8.22	21.90	2.19	24.08

5.3. Influence of Standard Deviation of Demand σ

Tables 4 and 5 show respectively the equilibrium results in two modes in which the standard deviation of demand is {3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7}. The greater the standard deviation of demand, the greater the fluctuation of demand. In the pure bonded warehouse mode, the equilibrium price, the equilibrium expected profit of the supplier and the total expected profit of the supply chain decrease with the increase of demand fluctuation; the equilibrium purchase quantity decreases first and then increases with the increase of demand fluctuation, and the equilibrium profit of the e-commerce company increases first and then decreases with the increase of demand fluctuation.

In the combined bonded warehouse and direct mail mode, the equilibrium price decreases with the increase of demand fluctuation; the equilibrium purchase quantity, the equilibrium expected profit of the supplier and the total expected profit of the supply chain decrease first and then increase with the increase of demand fluctuation; and the equilibrium expected profit of the e-commerce company increases first and then decreases with the increase of demand fluctuation.

Table 4. Influence of standard deviation of demand σ on mode 1.

Standard Deviation of Demand.	Equilibrium Price	Equilibrium Purchase Quantity	Equilibrium Expected Profit of the Supplier	Equilibrium Expected Profit of the E-Commerce Company	Total Expected Profit of the Supply Chain
3.0	2.64	7.07	11.60	2.02	13.62
3.5	2.56	6.9	10.90	2.22	13.12
4.0	2.48	7.00	10.35	2.39	12.75
4.5	2.42	7.00	9.95	2.41	12.36
5.0	2.36	7.10	9.66	2.43	12.09
5.5	2.32	7.17	9.47	2.33	11.79
6.0	2.28	7.30	9.35	2.23	11.58
6.5	2.25	7.44	9.30	2.08	11.38
7.0	2.23	7.56	9.29	1.88	11.17

Table 5. Influence of standard deviation of demand σ on mode 2.

Standard Deviation of Demand	Equilibrium Price	Equilibrium Purchase Quantity	Equilibrium Expected Profit of the Supplier	Equilibrium Expected Profit of the E-Commerce Company	Total Expected Profit of the Supply Chain
3.0	2.80	5.67	15.53	1.37	16.89
3.5	2.76	5.33	15.19	1.39	16.57
4.0	2.72	5.08	14.97	1.38	16.35
4.5	2.68	4.93	14.88	1.36	16.24
5.0	2.65	4.81	14.91	1.28	16.19
5.5	2.62	4.76	15.03	1.20	16.24
6.0	2.59	4.79	15.24	1.12	16.37
6.5	2.55	4.94	15.51	1.09	16.60
7.0	2.49	5.30	15.82	1.13	16.94

6. Conclusions

This paper discusses an import cross-border e-commerce supply chain system consisting of a retail e-commerce company and an overseas supplier, both the pure bonded warehouse mode (mode 1) and combined bonded warehouse and direct mail mode (mode 2) are discussed respectively.

In mode 1, we obtain two critical purchase prices, w_1^* and w_1' . If $w_1^* < w_1'$, then the equilibrium bulk price of the supplier is w_1^* with the equilibrium purchase quantity of the e-commerce company $Q'(w_1^*)$; otherwise the equilibrium bulk price of the supplier is $w_1'^-$ with the equilibrium purchase quantity of the e-commerce company $Q'(w_1'^-)$.

In mode 2, we obtain two critical purchase prices w_1^{**} and w_1'' . If $w_1^{**} < w_1''$, then the equilibrium bulk price of the supplier is w_1^{**} with the equilibrium purchase quantity of the e-commerce company is $Q''(w_1^{**})$; otherwise the equilibrium bulk price of the supplier is $w_1''^-$ with the equilibrium purchase quantity of the e-commerce company $Q''(w_1''^-)$.

Our numerical results show that: (i) Adding direct mail to the bonded warehouse mode will increase the equilibrium profit of the supplier and the total supply chain, but will reduce the equilibrium profit of the e-commerce company, this means that mode 2 will be detrimental to cross-border e-commerce companies if there is no profit redistribution agreement with suppliers; (ii) for both modes, the equilibrium price, the equilibrium purchase quantity, and the equilibrium expected profit of the supplier and the e-commerce company are all increasing when the mean value of demand increases; (iii) in mode 1, when the variance of the demand increases, the equilibrium price, the equilibrium expected profit of the supplier and the total expected profit of the supply chain decrease, but the equilibrium purchase quantity first decreases and then increases, and the equilibrium profit of

the e-commerce company increases first and then decreases; (iv) in mode 2, when the variance of the demand increases, the equilibrium price decreases, the equilibrium purchase quantity, the equilibrium expected profit of the supplier and the total expected profit of the supply chain first decrease and then increase, and the equilibrium expected profit of the e-commerce company first increases and then decreases.

This research could be further extended to the following two cases: (i) We consider that the domestic retail price p and the unit purchase price w_2 (overseas retail price) are uncontrollable. In further research we could consider p as the decision variable for the e-commerce company and w_2 as the decision variable for the supplier. (ii) One may consider the impact of changes in import e-commerce policies (such as import tariff, bonded warehouse, etc.) on the supply chain.

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