Cross-border Supply Chain Decision Making based on O2O Dual Channel Retailing

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Abstract. The supply chain structure of single overseas supplier and single cross-border e-retailer is constructed. Based on the retail mode of cross-border e-retailer's O2O dual channel, the influence of consumers' preference for online and offline channels on price setting of members in cross-border supply chain is considered, and cross-border customs clearance cost factor is introduced. Through centralized decision-making and decentralized decision-making, the centralized decision-making model of differential pricing strategy and unified pricing strategy is analyzed. The pricing decision of cross-border supply chain under decentralized decision-making is studied from two aspects: Stackelberg game dominated by foreign suppliers and Stackelberg game dominated by cross-border electronic retailers.

Keywords: O2O; dual channel; cross-border e-commerce; supply chain decision making.

1. Introduction

With the introduction of a series of national policies supporting cross-border e-commerce development, China's cross-border e-commerce has developed rapidly. According to the monitoring data of China E-Commerce Research Center, the scale of cross-border e-commerce transactions in China in the first half of 2018 was 4.5 trillion yuan, a year-on-year increase of 25%. In the cross-border e-commerce import and export structure, China's cross-border e-commerce import and export structure accounted for 77.1% of exports, and the import ratio was 22.9%. At present, cross-border exports and cross-border import growth are relatively fast, but with the upgrade of domestic consumption, the market demand for cross-border imports is more urgent. In the cross-border e-commerce import and export structure, the proportion of imported e-commerce is gradually expanding. However, the problem has also followed. As the e-commerce platform can only realize the online purchase of overseas products, the user lacks the physical product experience, and the payment and distribution to the delivery takes a long time, and the procedures for returning and exchange are complicated, which seriously affects the Consumer shopping experience. In this context, the O2O dual-channel sales model has gained more cross-border e-commerce (the “cross-border e-commerce” mentioned in this article refers to “B2C import cross-border e-retailers”), which can make domestic consumers You can enjoy the same products and services without going abroad, and can drive the transformation and upgrading of the domestic manufacturing industry, leaving overseas consumption in the country, increasing income and generating income for domestic enterprises.

2. Literature Review

At present, there are many researches on O2O dual channels, which can be roughly divided into three categories. The first is to use an empirical research method to discuss the O2O dual channel based on the consumer's perspective[1]-[3]. The second is to use the modeling method to study the impact of the introduction of direct sales channels on distribution channels. Many research results show that the new self-built online direct sales channel is beneficial to manufacturers [4]. However, Yoo et al pointed out that the introduction of direct sales channels does not always lead to a reduction in retail prices and an increase in consumer welfare, and may even lead to a deterioration in the income of independent retailers in certain market environments [5]. Zheng et al. studied the optimal dual-channel strategy choices of manufacturers based on different service levels between channels [6]. Mukhopadhyay et al. discussed the impact of manufacturers' authorized retailers to increase product value and transfer payment on the dual-channel supply chain, and analyzed the problem of

coordinated contract design under the conditions of complete information symmetry and information asymmetry [7]. Yan proposed a dual-channel supply chain coordination strategy for brand differentiation and revenue sharing [8]. Pei et al. discussed a dual-channel supply chain coordination strategy that manufacturers provide funds to support retailers to improve service levels [9].

In the research of supply chain decision-making, the research on the influence of market game power on supply chain member pricing, demand and income mainly focuses on two aspects: First, the influence of market game power on traditional supply chain[10]-[12]. Gao et al. constructed a closed-loop supply chain consisting of a manufacturer and a retailer, and studied the effects of two types of Stackelberg games and Nash equilibrium game power structures on manufacturer recycling efforts, retail sales efforts, pricing and returns [13]. Cai et al. studied the impact of price discount contracts on the coordination of dual-channel supply chains under different game power structures. The results show that consistent pricing strategies can reduce channel conflicts and increase retailers' returns [14]. Lu et al. constructed a two-tier, two-channel supply chain consisting of a supplier and two retailers (a traditional retailer and an e-retailer), analyzing the two types of Stackelberg games and Nash equilibrium games for supply chain member pricing and returns.

The above research is based on the dual-channel supply chain structure formed by manufacturers to increase online direct sales channels, and analyzes the impact of dual-channel operation and management and different power structures on the pricing and benefits of each member in the dual-channel supply chain. Few documents from the perspective of cross-border e-retailers, based on the dual-channel retail model formed by cross-border e-retailers opening offline channels, to analyze and study different power structures in cross-border e-retailer dual-channel supply chains The impact of member pricing, demand and revenue. Therefore, from the perspective of consumers' preference on online and offline channels, this paper constructs channel demand function and income function, and studies the pricing decisions of offline and online dual channels under different power structures, while considering cross-border The impact of customs clearance costs on supply chain member prices, demand and earnings.

3. Problem Statement

At present, there are many modes of operation for cross-border e-commerce O2O dual-channel retailing in the market. The cross-border e-commerce researched in this paper focuses on online channel marketing, while opening offline stores or cooperating with offline merchants to transport imported goods to Sales are carried out in the physical stores of offline merchants, thus forming a dual-channel sales model for offline. The resulting decision-making question is how to price cross-border e-commerce with online and offline dual channels to maximize revenue. At the same time, the game between cross-border e-retailers and overseas suppliers will also affect the profit distribution of the supply chain. Therefore, this paper builds a two-tier cross-border supply chain structure based on a single overseas supplier and a single cross-border e-retailer, and cross-border e-retailers launch O2O dual-channel retail model, namely online channel sales and offline channel sales. Coexistence, the specific structure of the cross-border supply chain is shown in Figure 1.

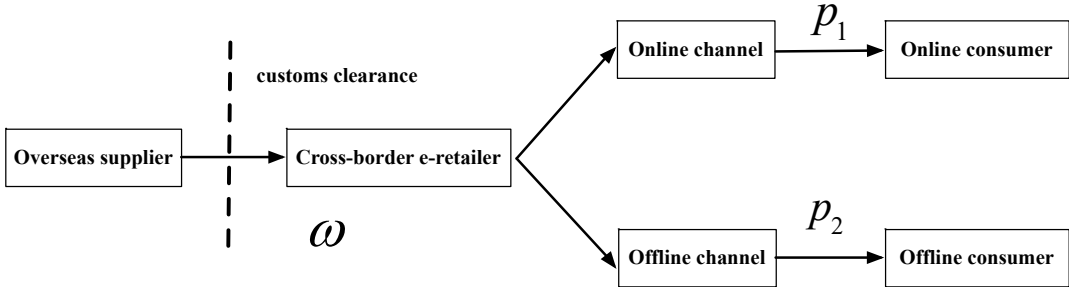

Fig. 1 Cross-border e-commerce O2O dual-channel retail model

D_1 and D_2 respectively represent the total product sales volume of online and offline channels of cross-border e-retailers. From the perspective of market size, once the total consumption demand

is met, the product will not continue to be sold. Parameter α represents the maximum demand in the potential market. Suppose $0 \le \theta \le 1$ is the consumer's preference for online channels, and $\alpha_1 = \alpha\theta$ is the basic sales volume of online channel products. Similarly, suppose $1-\theta$ is the degree of consumption preference of offline channels, $\alpha_2 = \alpha(1-\theta)$ is the basic sales volume of offline channel products, and the channel selection is different when the degree of consumption preference is different. The online and offline sales functions of cross-border e-retailers are as follows $D_1 = \alpha_1 - \beta p_1 + \gamma p_2$, $D_2 = \alpha_2 - \beta p_2 + \gamma p_1$. Parameters β and γ measure the price elasticity of demand and its own price and cross-price sensitivity, respectively. Assuming that parameters β and γ satisfy $\beta > \gamma > 0$, this means that product demand is more sensitive to changes in its own channel price than to other channel products.

This paper analyzes the cross-border e-commerce O2O dual-channel supply chain through centralized and decentralized decision-making models. The parameter symbols used in this document are described in Table 1.

Table 1. Parameter Description

Symbol	Description
D_1, D_2	Product demand for online and offline channels for cross-border e-retailers
$\alpha, \alpha_1, \alpha_2$	Total market demand, potential market demand for online and offline channels
θ	Consumer preferences for online travel
β, γ	Channel's own price and cross price sensitivity
ω	Wholesale price of overseas suppliers
p_1, p_2, p	Retail prices for online and offline channels, unified pricing for online and offline channels
c_s, k	Product unit cost of overseas suppliers, product clearance unit cost
c_1, c_2	Sales unit cost for online and offline channels
π, π_s, π_r	Total profit in the supply chain, profit from overseas suppliers, profit from cross-border e-retailers
π_{r1}, π_{r2}	Product sales profit of online and offline channels of cross-border e-retailers

4. Centralized Pricing Decision Model

In the centralized pricing decision model, overseas suppliers and cross-border e-retailers seek profit maximization from the overall interests of the supply chain, and the two parties determine the optimal pricing decision through cooperation. In pursuit of the largest total profit in the supply chain, cross-border e-retailers simultaneously determine online channel retail price p_1 and offline channel retail price p_2. The total supply chain profit function in the centralized pricing decision model can be modeled as:

$$\pi = (p_1 - c_s - k - c_1) D_1 + (p_2 - c_s - k - c_2) D_2 \tag{1}$$

The profit function can be further simplified to:

$$\pi = (p_1 - I) D_1 + (p_2 - J) D_2 = \left[REV_1^c \right] D_1 + \left[REV_2^c \right] D_2 \tag{2}$$

Among them, $I = c_s + k + c_1$, $J = c_s + k + c_2$, REV_1^c and REV_2^c respectively represent the income from sales of online channels and offline channels. In addition, $D_1 = \alpha_1 - \beta p_1 + \gamma p_2$, $D_2 = \alpha_2 - \beta p_2 + \gamma p_1$, and its constraints are $D_1 \geq 0$, $D_2 \geq 0$, $\left[REV_m^c\right] \geq 0$, $\left[REV_r^c\right] \geq 0$.

4.1 Differential Pricing Strategy

Zhang et al. argue that differential pricing is the best strategy for assigning the highest price to the highest operating cost channel, and needs to consider price-sensitive consumer behavior. The pricing strategy of the channel should be proportional to its consumer preferences and the services it provides. Therefore, this section discusses the use of differential pricing strategies for dual-channel cross-border supply chains, considering the impact of consumer preferences and customs clearance costs on pricing policies.

Proposition 1: Under the differential pricing strategy, the supply chain total profit function A is a strictly concave function for B and C. The optimal price D of the online channel of the cross-border e-retailer and the optimal price F of the offline channel are respectively:

$$p_1^{C*} = \frac{\alpha\theta\beta + \alpha(1-\theta)\gamma + (\beta^2 - \gamma^2)I}{2\beta^2 - 2\gamma^2} \tag{3}$$

$$p_2^{C*} = \frac{\alpha\theta\gamma + \alpha(1-\theta)\beta + (\beta^2 - \gamma^2)J}{2\beta^2 - 2\gamma^2} \tag{4}$$

Corollary 1: Under the differential pricing strategy of centralized decision making, when the total profit function of the supply chain is the largest, the optimal price of the online channel of the cross-border e-retailer is an increasing function of the consumer preference, and the optimal price of the offline channel is A reduction function on consumer preferences.

Corollary 2: Under the differential pricing strategy of centralized decision-making, the retail price of online and offline channels is an increasing function of customs clearance costs, and its retail price increases with the increase of customs clearance costs.

4.2 Unified Pricing Strategy

Webb et al. pointed out that differential pricing strategies lead to most conflicts between channels. Therefore, some dual-channel closed-loop supply chain options unify their pricing strategies across all channels. This section will examine the option to use a unified pricing strategy to consider the impact of consumer channel preferences and cross-border customs clearance costs on pricing policies. There is $p_1 = p_2 = p$ at this time.

Proposition 2: Under the unified pricing strategy, the total profit function π is a strictly concave function for p. Therefore, the optimal uniform price p^{U*} can be solved, and the optimal profit π^{U*} can be obtained.

$$p^{U*} = \frac{\alpha\theta + \alpha(1-\theta) + (\beta - \gamma)(2c_m - I + J)}{4(\beta - \gamma)} \tag{5}$$

Corollary 3: Under the unified pricing strategy of centralized decision making, when the total profit function π is the largest, the optimal unified price p^{U*} of the cross-border e-retailer is not affected by the consumption channel.

Corollary 4: Under the centralized decision-making unified pricing strategy, the optimal unified price p^{U*} of the cross-border e-retailer is an increasing function of the customs clearance cost k, and p^{U*} increases as the customs clearance cost k rises.

5. Closed-loop Supply Chain under Decentralized Decision Making

Under the decentralized decision-making, most of the direct sales channels and retail channels of enterprises tend to operate independently. Generally speaking, if centralized decision-making is accompanied by high costs, the supply chain cannot obtain the optimal profit. Decentralized decision making can be beneficial to supply chain operations management. In addition, cross-channel returns can increase the choice of consumer return channels, increase customer satisfaction, and increase sales, thus achieving a new retail concept combining online sales and offline sales.

5.1 The Stackelberg Game Driven by Overseas Suppliers

Under the Stackelberg game power structure dominated by overseas suppliers, it has the right to set prices, and can use the price response of cross-border e-retailers as the basis for its price decision. Under this dominant model, the two-stage game sequence between overseas suppliers and cross-border e-retailers is: overseas suppliers first determine the wholesale price of products ω, and retailers determine online channel retail prices p_1 and offline channels based on overseas supplier pricing retail price p_2. As overseas suppliers are in a dominant position, in order to reduce costs, customs clearance costs will be borne by subordinate cross-border e-tailers. Therefore, according to the assumption, the profit functions of overseas suppliers and cross-border e-retailers are expressed as:

$$\pi_s = (\omega - c_s)(D_1 + D_2) \tag{6}$$

$$\pi_{r1} = (p_1 - \omega - c_1 - k) D_1 \tag{7}$$

$$\pi_{r2} = (p_2 - \omega - c_2 - k) D_2 \tag{8}$$

Proposition 3: Under the Stackelberg game dominated by overseas suppliers, the manufacturer's wholesale price, the cross-border e-retailer's online and offline channels, the optimal equilibrium solutions for retail prices are ω^{S*}, ${p_1}^{S*}$ and ${p_2}^{S*}$:

$$\omega^{S*} = \frac{2\beta - \gamma}{4\beta(\beta - \gamma)}\alpha - \frac{\beta - \gamma}{2\beta^2}A - \frac{2\beta - \gamma}{4\beta}B + \frac{c_s}{2} \tag{9}$$

$${p_1}^{S*} = \left(\frac{1}{4\beta^2 - \gamma^2} + \frac{\beta - \gamma}{2\beta^2}\right)A + \frac{\alpha}{4(\beta - \gamma)} - \frac{B}{4} + \frac{\beta c_s}{2(2\beta - \gamma)} \tag{10}$$

$${p_2}^{S*} = \frac{3B}{4} + \frac{\gamma - (\beta - \gamma)(2\beta + \gamma)}{2\beta(4\beta^2 - \gamma^2)}A + \frac{\alpha}{4(\beta - \gamma)} + \frac{\beta c_s}{2(2\beta - \gamma)} \tag{11}$$

Corollary 5: Under the Stackelberg game dominated by overseas suppliers, the consumption channel preference has no effect on the wholesale price ω^{S*} of overseas suppliers. At this time, the wholesale price ω^{S*} depends on the size of β and γ. The retail price p_1^{S*} of the online channel of the cross-border e-retailer is an increasing function with respect to the consumption preference θ, and the retail price p_2^{S*} of the offline channel is a decreasing function with respect to the consumption preference θ.

Corollary 6: Under the overseas supplier-led Stackelberg game, the overseas supplier wholesale price ω^{S*} is a decreasing function of the customs clearance cost k, while the online and offline channels retail prices p_1^{S*} and p_1^{S*} are increasing functions of the customs clearance cost k.

5.2 Stackelberg Game Dominated by Cross-border E-retailers

Under the Stackelberg game structure dominated by cross-border e-retailers, cross-border e-retailers can use the wholesale price of overseas suppliers as the basis for decision making for their

own retail prices. Since overseas suppliers do not set their wholesale prices for a single online channel or offline channel retail price, they take into account the pricing of the two channels of cross-border e-retailers and then adopt corresponding pricing decisions. In the model, cross-border e-retailers will focus on online and offline channels, that is, the online channel price is equal to the offline channel price ($p_1=p_2$). The two-stage game sequence between overseas suppliers and cross-border e-retailers is: cross-border e-retailers first determine their online and offline channel retail price p , and overseas suppliers determine their wholesale based on the centralized pricing of cross-border e-retailers price ω. Since cross-border e-retailers are in a dominant position and have bargaining power for overseas suppliers, they will require overseas suppliers to bear customs clearance fees. Therefore, according to the assumptions, the profit functions of overseas suppliers and cross-border e-retailers are expressed as:

$$\pi_s = (\omega - c_s - k)(\alpha - 2(\beta - \gamma)p) \tag{12}$$

$$\pi_r = (p - \omega - c_1)D_1 + (p - \omega - c_2)D_2 \tag{13}$$

Proposition 4: Under the Stackelberg game dominated by cross-border e-retailers, the wholesale price of overseas suppliers, the optimal equilibrium solution for retail prices of online and offline channels of cross-border e-retailers are ω^{R*} and p^{R*} respectively.

$$\omega^{R*} = \frac{\alpha}{8(\beta - \gamma)} + \frac{c_s + k}{4} - \frac{c_1 + c_2}{8} \tag{14}$$

$$p^{R*} = \frac{3\alpha}{8(\beta - \gamma)} + \frac{c_1 + c_2}{8} - \frac{c_s + k}{4} \tag{15}$$

Corollary 7: Under the Stackelberg game dominated by cross-border e-retailers, consumer channel preferences do not affect the decision of wholesale price ω^{R*} and retail price p^{R*}.

Corollary 8: Under the Stackelberg game dominated by cross-border e-retailers, the overseas supplier wholesale price ω^{R*} is an increasing function of customs clearance cost k , while the cross-border e-retailer's online and offline channels have a uniform retail price p^{R*} for customs clearance. The decreasing function of cost k .

6. Conclusion

This paper builds a cross-border supply chain structure based on a single offshore supplier and a single cross-border e-retailer, and cross-border e-retailers have online and offline O2O dual sales channels, considering consumer channel preferences and customs clearance costs for cross-border supply The decision-making influence of the chain analyzes the pricing decision of the cross-border supply chain from the differential pricing strategy, the centralized decision-making of the unified pricing strategy and the external supplier-led, cross-border e-retailer-led distributed decision-making of the Stackelberg game. The research results show that cross-border customs clearance costs have different effects on the pricing decisions of closed-loop supply chains under different rights structures. The consumption preferences of online and offline channels of cross-border e-retailers also have an impact on supply chain decision-making.

The research in this paper is mainly based on market demand, consumer risk neutrality and other ideal conditions, while the actual O2O dual channel sales channel is more complicated, so in the future, we can study the cross-border of O2O dual channel sales under uncertain market demand. On the other hand, the supply chain built by a single overseas supplier and a single cross-border e-retailer can be expanded into a competitive multi-channel supply chain of multi-border suppliers and multi-cross-border e-retailers. The third-party sales channels, the design of the hybrid sales channel, and the in-depth study of this type of supply chain decision-making will have stronger theoretical and practical significance.

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