Cross-border E-commerce Competitive Strategy Based on the Survey of Product Differentiation

Jun Chen, Shiyan Xu(✉), Chenyang Zhao, and Hui Chen

SILC Business School, Shanghai University, Shanghai 218000, China

Abstract. With the development of international trade and information technology, cross-border e-commerce is booming globally. It involves the movement of goods between domestic and foreign markets, domestic warehouses, and consumers. However, as cross-border e-commerce products often need long-distance transport, the commodities suitable for sale through cross-border e-commerce are limited. Therefore, merchants are increasingly facing fiercer competition. In this paper, a game model was built to analyze how differentiation of products affects the competitive strategy making in the cross-border dual-channel supply chain. The optimal pricing and service level under centralized and decentralized decisions were formulated. The relationship between multiple variables and service levels and profits were interpreted in combination with spatial geography. The equilibrium solution revealed that a centralized supply chain can generate more profits. And merchants should increase the degree of product differentiation and strive to improve service levels.

Keywords: Cross-border e-commerce · Product differentiation · Supply chain coordination · Dual-channel

1 Introduction

Cross-border E-commerce (CBE) is an electronic and information zed form of international trade. Buyers and sellers are in different countries or regions; they realize online transactions through information technology such as the Internet and complete the transportation of goods through international logistics (Wang 2014, Liu et al. 2015). Today, it is equivalent to cross-border e-retail, a business to consumer (B2C) model (iResearch 2014).

Advanced technology, growing demand and favorable policies have led to the explosive growth of global cross-border e-commerce. In 2014, the global cross-border e-commerce market exceeded $230 billion and is expected to grow further to $1 trillion by 2020 (Alizila 2015). In the same year, nearly one billion people worldwide will engage in cross-border online shopping, and their transaction volume will account for one-third of global B2C transactions (AliResearch 2015).

In the short term, due to the superior infrastructure and advanced technical conditions, the development of CBE will be concentrated in developed countries. In Germany,

© ICST Institute for Computer Sciences, Social Informatics and Telecommunications Engineering 2021
Published by Springer Nature Switzerland AG 2021. All Rights Reserved
H. Song and D. Jiang (Eds.): SIMUtools 2020, LNICST 370, pp. 659–678, 2021.
https://doi.org/10.1007/978-3-030-72795-6_53

for example, more than half of online merchants are selling their products to multiple foreign markets (Research and Markets 2015). However, in the long run, developing countries expect a leap-forward development after overcoming some of the limitations of information technology. China is expected to become the largest market for CBE by 2020 (iResearch 2016).

Since July 2014, including Announcement on Regulating Issues Concerning Import and Export Goods and Articles of Cross-border Trade E-Commerce, Announcement on Adding Customs Supervision Method Codes (i.e. Announcement No. 56 and No. 57) of the General Administration of Customs, various favorable policies have been introduced continuously, involving customs, commodity inspection, logistics, and payment, which have stimulated the development of cross-border e-commerce.

So far, cross-border e-commerce companies have emerged and gradually entered the track of normal development. They have various business models, mainly platform-based or self-operated, vertical or integrated.

Platform-based cross-border e-commerce companies develop and operate third-party e-commerce websites. They earn profit from providing related services and get commissions from settled businesses. Some of them directly their products. Self-operated cross-border e-commerce companies develop and operate e-commerce websites by themselves, and they are also responsible for a series of services such as procurement, warehousing, transportation and sales.

Integrated cross-border e-commerce has a wide range of goods while vertical cross-border e-commerce focuses on specific markets. According to this, it can be subdivided into four types.

Representative enterprises of integrated platform-based cross-border e-commerce include Jingdong Global, Tmall.HK, Taobao Global, ymatou.com and others. Representative enterprises of integrated self-operated cross-border e-commerce include Amazon Global, Wal-Mart Global e-shop, Net Ease Koala, Red, Lightinthebox and any others.

There are fewer vertical platform-based cross-border e-commerce businesses, with the focus of clothing, beauty and other products, such as Meilishuo, haimi.com. Vertical self-operated cross-border e-commerce is also rare. Representative companies include VIPSHOP, womai.com, mia.com, and JUMEI.COM.

However, no matter which kind of business model the company adopts, cross-border products often need long-distance transportation; the types of products suitable for cross-border e-commerce are limited. Cross-border e-commerce has to face increasingly severe channel competition, and how to set up the price to ensure maximum revenue is the current focus of cross-border supply chain competition strategy.

There has been a lot of academic research on the issue of channel competition. Among them, the channel coordination problem in the supply chain under the e-commerce environment is particularly prominent.

Huang et al. (2012) built a dual-channel supply-chain model consisting of a single manufacturer and retailer, discussing how to adjust prices and production plans in the event of an outage to achieve the maximum potential profit. They found that whether centralized or decentralized dual-channel supply chain, the optimal pricing is affected by the customer's channel preferences and market size changes (Huang et al. 2012).

Based on the distribution efficiency of different channels and the online channel acceptance of products, Liu Hanging et al. (2015) explored the effects of different pricing strategies on channels introduced by manufacturers when introducing online channels. The results show that the introduction of online channels is beneficial to manufacturers and the overall channel, and whether it is beneficial to retailers depends on the distribution efficiency of online channels relative to traditional channels (Hostelling 1929).

Deng Mingrong et al. (2016) constructed a signal game model between retailers and manufacturers under the condition of asymmetric demand information and analyzed the influence of market share and channel substitution coefficient on the dual-channel supply chain. It was found that the retailer would send the wrong market demand information to the manufacturer according to the wholesale price, and the manufacturer's wholesale price decision was related to the sales cost of the direct sales channel (Chamberlin 1965).

Compared with the traditional e-commerce market, cross-border e-commerce has a more serious homogenization competition trend. A simplistic and specialized business strategy will not bring excess profits to the company; in contrast, it will reduce the company's living space. Therefore, to reduce the degree of homogenization competition in the market, the implementation of the differentiation strategy is inevitable, which can help enterprises gain advantages and improve sales performance in the cross-border e-commerce market (Porter 1980).

This paper study the problem of how differentiation of product affects the competitive strategy making in the cross-border dual-channel supply chain which is significantly important in service levels. With the development of international trade and information technology, cross-border e-commerce is booming globally. However, as cross-border e-commerce products often need long-distance transport, the commodities suitable for sale through cross-border e-commerce are limited. Therefore, this paper formulates the optimal pricing and service level under the centralized and decentralized decision. The relationship between multiple variables and service levels and profits were interpreted in combination with spatial geography. Finally, the equilibrium solution revealed that a centralized supply chain can generate more profits.

2 Summary of Related Research

2.1 Differentiation Strategy

Differentiation has received extensive attention from scholars in early research, especially product differentiation.

The research by Hotelling (2015) and Chamberlin (2014) reveals how companies choose their position in the product space to cushion the impact of direct price competition.

Michael Porter (Xizheng et al. 2016) makes the concept of product differentiation more and more widely accepted by scholars. He believes there are two forms of competitive advantage: one is cost advantage and the other is differentiated operation. The company's generic competitive strategy includes Cost leadership, Differentiation, and Focus.

The three competitive strategies are not isolated. For example, Cost leadership can also realize the differentiation of the company's product performance, price, brand, and

any aspects in the competition; and differentiation can also control and reduce the cost to achieve the cost by providing different levels of products or services. Focus is the specific implementation of these two strategies. Therefore, in a sense, Cost leadership and Focus can also be regarded as a broader Differentiation.

Diao Xinjun et al. (2014) studied Bertrand price competition or Cournot quantity competition strategy for vertically differentiated products with asymmetric network externalities. The results show that the market profits and social welfare of the two products in the Cournot quantity competition are greater than that in the Bertrand price competition.

In the Bertrand price competition and Cournot quantity competition, when the network externality of low-quality products is large and certain conditions are met, low-quality products can also obtain large market profits. When high-quality products have large network externalities, or although the network externalities are small but meet certain conditions, the network externalities are equal or the products do not have network externalities, high-quality products gain greater market profit.

Xiao Di et al. (2013) studied the coordinated operation strategy of supply chain members under the influence of quality competition and price competition in a supply chain system consisting of two suppliers and one manufacturer. Furthermore, the effects of price competition and quality competition on the equilibrium solution of the supply chain in different scenarios are discussed separately.

Research shows that supplier cooperation can help improve the quality efforts of suppliers, but it will lead to a decline in the overall profit of the supply chain. The more intense the quality competition, the higher the quality of the suppliers in most scenarios. However, the intensity of price competition has a limited impact on the degree of supplier effort and can even be ignored in the context of supplier cooperation (Di et al. 2013).

Zhang Xizheng et al. (2016) extended the model of Salop's circular city, studied the dual-channel supply chain pricing strategy of alternative products in the e-commerce environment, and proposed an improved revenue-sharing contract coordination strategy, which can implement Pareto improvement of supply chain members to alleviate channel conflicts.

The study finds that the degree of product substitution has a positive impact on the pricing of various channels of alternative products and the demand for retail channels, while the impact on the demand and pricing of existing products is negative. The efficiency of the supply chain increases with the degree of product substitution while the coordination effect becomes better with the degree of product substitution first and then worse.

2.2 Consumer Utility

The market demand function in the above studies is derived by the manufacturer or retailer. The difference between products and services is essentially the difference in the eyes of consumers. When consumers perceive different prices or services from other competitive products, the differentiation strategy can be realized. Therefore, differentiation should be expressed as a function of consumer preferences, and research on

differentiation can be carried out at the level of consumer utility. With the utility function, the demand function can be derived from it, so the utility function is the key to model building.

The product brings benefits to consumers because the specific needs of consumers can be met through the product. However, consumers' demand for products is not limited to the products themselves but also includes the services provided by the merchants. The products sold in the market are broadly a binary combination containing the products themselves and merchant services. Providing perfect services can add value to customers and also bring a good reputation to the company, thereby enhancing the brand and market competitiveness of the company.

The research literature on services has long shown that consumers are often willing to pay for the promotion of services such that consumers who willing to pay a higher price do not have to wait anymore. As one of the product portfolios, the service level will inevitably become an important way for enterprises to obtain differentiated competitive advantages. Especially in the case that the quality of similar products is close and relatively fixed, the slight changes in the provision of services sometimes leads to a higher willingness to pay. For example, JD Logistics can achieve next-day delivery, and consumers usually choose JD as a shopping platform to meet the demand for timeliness of goods regardless of the higher price (Meng and Wang 2015).

Consumers make purchase decisions based on the principle of maximum utility when purchasing products. Whether consumers have a willingness to buy depends on the sum of the positive effects of products and services. Thus, the consumer will only be willing to purchase the product if and only if the total utility of the merchant's products and services is greater than the negative utility of the consumer's payment.

However, providing high-quality products or high-level services to consumers requires additional costs, that is, the higher the product quality or service quality, the higher the production cost of the merchants.

Under the restriction of market price competition, the excessive pursuit of high-quality products or services will bring the risk that the final profit will not rise and fall. So in real business activities, the merchants must balance the creation of added value and the corresponding cost increase. When designing a product portfolio, they must weigh the product differentiation competition and the differentiated competition strategy. The utility of the same product or service to different consumers is different, so there should be a parameter representing the type of consumer in the utility function.

Besides, products or services are different, different products or services have different effects for the same consumer, so there should be a parameter in the utility function that reflects the degree of differentiation of products and services.

To study the situation that the electronic direct selling channel and the traditional retail channel separately sell heterogeneous products in the dual-channel supply chain, Wang Yao et al. (2014) constructed a consumer utility function that characterizes product differences and service spillover effects and established a demand model and a profit model for a dual-channel supply chain.

The research results show that the differentiation strategy is beneficial to both manufacturers and retailers. Under decentralized decision-making, although the service has a negative spillover effect, within the appropriate scope, the improvement of service level is beneficial to the manufacturer. Therefore, manufacturers have the incentive to motivate retailers to work together to improve both sides' benefits (Diyun and Yaozhong 2015). But the assumption that manufacturers dominate in the game model does not match the facts.

Wang Chunping et al. (2016) introduced the differentiated network effect into the Hotelling model under linear cost. Based on the pricing strategy selection of basic information products and additional services, a game model of two companies' bundled sales and separate sales strategies in the duopoly market was established. They analyzed the impact of heterogeneous consumers on the duopoly market and the maximization of pricing strategies (Wujun et al. 2019). However, the products and services considered in the study are homogeneous.

Previous studies have achieved many results in channel competition or differentiation strategies or consumer utility. However, the cross-border e-commerce competition strategy is the result of comprehensive integration of the above aspects. So far, no relevant research has systematically combined them. Therefore, this paper aims to fill this gap and study the cross-border e-commerce supply chain coordination problem based on the differentiation strategy and consumer utility theory. It provides guidelines for merchants to develop cross-border e-commerce competition strategies.

3 Competitive Strategy Based on Product Differentiation

3.1 Model Parameters and Assumptions

Suppose there are one overseas supplier and two cross-border e-commerce in the cross-border supply chain. Merchant 1 is platform-based e-commerce, and merchant 2 is self-operated e-commerce. The products that the supplier provides to the merchants with a certain degree of difference, that is, the products sold through the two merchants, have a certain degree of substitutability.

There are two types of consumers in the market: price-sensitive and service-sensitive. The preferences of different types of consumers are reflected in the perception of product prices and service levels. For the price, price-sensitive consumers are more sensitive than service-sensitive consumers, and product price changes have a greater impact on their utility. On the contrary, for services, service-sensitive consumers are more sensitive than price-sensitive consumers, and service level changes have a greater impact on their utility.

Consumers are rational; they consider the benefits they get when purchasing products, so they will buy products from merchants with greater perceived utility. In order not to lose the generality, it is assumed that the demand faced by the two merchants is the unit market demand, and only the cost required to provide the logistics service is considered, the other costs are assumed to be zero.

The variables used in the model and their definitions are as follows (Table 1):

Table 1. Product differentiation model parameters

Parameters	Explanation
p_i	The price of the product, p_1 is the price of merchant 1, p_2 is the price of merchant 2
v	Valuation of the product, $v \in [0, 1]$
s_i	The level of logistics services provided by the merchant.s_1 is the level of logistics services provided by merchant 1, s_2 is the level of logistics services provided by merchant 2
$C(s_i)$	The cost functions of logistics services. Refer to the definition of the cost function in the *Principle of economics*, $C(s_i) = (\eta/2)s_i^2$, C_1 is the cost of logistics services of merchant 1, C_2 is the cost of logistics services of merchant 2
θ	The degree of difference between the products sold by merchant 2 and merchant 1. $\theta \in [0, 1]$, When $\theta = 0$, it means the product sold by merchant 2 is completely different from merchant 1 and there is no substitutability. When $\theta = 1$, it means there is no difference between the product sold by Merchant 2 and Merchant 1 and they are completely homogeneous
α	Consumer sensitivity to product prices, $\alpha \in [0, 1]$
β	Consumer sensitivity to service levels, $\beta \in [0, 1]$
D_i	Market demand function. D_1 is market demand faced by merchant 1; D_2 is market demand faced by merchant 2
π_i	Profit function π_1 is profit for merchant 1; π_2 is profit for merchant 2
U_i	The utility consumers get when they purchase the product.U_1 is the utility when they purchase the product from merchant 1, U_2 is the utility when they purchase the product from merchant 2

The cross-border e-commerce supply chain system relationship at this time is shown in Fig. 1:

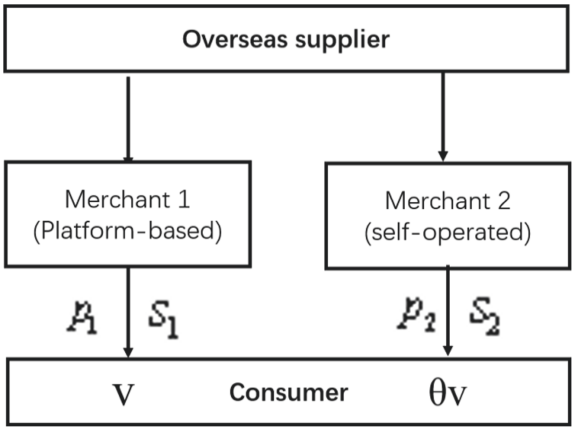

Fig. 1. Cross-border e-commerce product differentiation model

For the supply chain of cross-border e-commerce, the overseas suppliers transport the commodities to the self-operated or third-party platform for the next step of the sales according to the information of the consumers.

Referring to the model of Chen and Yang (Xizheng et al. 2016), the utility of the consumer to purchase items from merchant 1 is:

$$U_1 = v - \alpha p_1 + \beta s_1 \tag{1}$$

The utility of the consumer to purchase items from merchant 2 is:

$$U_2 = \theta v - \alpha p_2 + \beta s_2 \tag{2}$$

Consumers are rational. When the utility obtained is greater than or equal to zero, they will choose to purchase. When faced with two different channel choices, they will choose a channel with a large utility to purchase products, that is, consumers choose to follow max $(U_1, U_2, 0)$.

We define product valuations v_1 , v_2 , v_3 under three critical conditions $U_1 = 0$, $U_2 = 0$, $U_1 = U_2$; we can get:

$$\begin{aligned} v_1 &= \alpha p_1 - \beta s_1 \\ v_2 &= \frac{\alpha p_2 - \beta s_2}{\theta} \\ v_3 &= \frac{\alpha(p_1 - p_2) - \beta(s_1 - s_2)}{1 - \theta} \end{aligned} \tag{3}$$

The difference between the critical values is defined as:

$$\begin{aligned} \Delta v_1 = v_1 - v_2 &= \frac{\alpha(\theta p_1 - p_2) - \beta(\theta s_1 - s_2)}{\theta} \\ \Delta v_2 = v_3 - v_1 &= \frac{\alpha(\theta p_1 - p_2) - \beta(\theta s_1 - s_2)}{1 - \theta} \end{aligned} \tag{4}$$

When $v_1 \geq v_2$, there is $\Delta v_1 \geq 0$, so $\alpha(\theta p_1 - p_2) - \beta(\theta s_1 - s_2) \geq 0$ and $\Delta v_2 \geq 0$, at this time, $v_3 \geq v_1 \geq v_2$; When $v_1 \leq v_2$, there is $\Delta v_1 \leq 0$, so $\alpha(\theta p_1 - p_2) - \beta(\theta s_1 - s_2) \leq 0$ and $\Delta v_2 \leq 0$, at this time, $v_3 \leq v_1 \leq v_2$.

There are four cases as follows:

When $U_1 < 0$ or $U_2 < 0$, that is when $v < v_1$ or $v < v_2$, - The consumer's utility in purchasing the product at the merchant is negative, at which point the consumer will not have a purchase behavior;

When $U_1 > U_2$ and $U_1 \geq 0$, that is when $v > v_3$ and $v \geq v_1$; because consumers can obtain higher utility when purchasing products in merchant 1, consumers are inclined to purchase at merchant 1;

When $U_1 < U_2$ and $U_2 \geq 0$, that is when $v < v_3$ and $v \geq v_2$; because consumers can get higher utility when they purchase products in merchant 2, consumers tend to buy at merchant 2;

- When $U_1 = U_2 \geq 0$, that is when $v = v_3$ and $v \geq \max\{v_1, v_2\}$, the utility obtained by the consumer purchasing the product from merchant 1 is equal to that of purchasing from merchant 2, at which time the two merchants have no difference to the consumer.

This allows different product valuations in different product price ranges:

If $v_1 \leq v_2$, then $v_3 \leq v_1$, at this time, no one is buying in merchant 2, that is, the demand of merchant 2 is $D_2 = 0$. When $v \in [v_1, 1]$, the consumer purchases the product in merchant 1, the demand of merchant 1 is $D_1 = 1 - v_1$. When $v \in [0, v_1]$, consumers will not have purchase behavior. The price of this interval satisfies the conditions:

$$p_1 \leq \frac{\alpha p_2 + \beta(\theta s_1 - s_2)}{\alpha\theta} \tag{5}$$

If $v_1 \geq v_2$ and $v_3 \geq 1$, no one is buying in merchant 1, that is, the demand of merchant 1 is $D_1 = 0$. When $v \in [v_2, 1]$, the consumer purchases the product in merchant 2, the demand of merchant 2 is $D_2 = 1 - v_2$. When $v \in [0, v_2]$, consumers will not have purchase behavior. The price of this interval satisfies the conditions:

$$p_1 \geq p_2 + \frac{1 - \theta + \beta(s_1 - s_2)}{\alpha} \tag{6}$$

If $v_1 \geq v_2$ and $v_3 \leq 1$, when $v \in [v_3, 1]$, the consumer purchases the product in merchant 1, the demand of merchant 1 is $D_1 = 1 - v_3$; when $v \in [v_2, v_3]$, the consumer purchases the product in merchant 2, the demand of merchant 2 is $D_2 = v_3 - v_2$. The price of this interval satisfies the conditions:

$$\frac{\alpha p_2 + \beta(\theta s_1 - s_2)}{\alpha\theta} \leq p_1 \leq p_2 + \frac{1 - \theta + \beta(s_1 - s_2)}{\alpha} \tag{7}$$

This study aims to analyze the cross-border e-commerce competition strategy under differentiation. Since the first two cases are single-channel issues, they are not included in the following discussion. In summary, in the third case, the demand functions of merchant 1 and merchant 2 are, respectively:

$$\begin{aligned} D_1 &= 1 - \frac{\alpha(p_1 - p_2) - \beta(s_1 - s_2)}{1 - \theta} \\ D_2 &= \frac{\alpha(\theta p_1 - p_2) - \beta(\theta s_1 - s_2)}{\theta(1 - \theta)} \end{aligned} \tag{8}$$

To explore the impact of product differentiation on competitive strategies more clearly, assume that merchant 1 and merchant 2 provide the same level of logistics services, including delivery time, reliability, flexibility, after-sales service and others, that is $s_1 = s_2 = s$, at this time, the utility obtained by the consumer in merchant 1 and merchant 2 is:

$$U_{1s} = v - \alpha p_1 + \beta s \quad , \quad U_{2s} = \theta v - \alpha p_2 + \beta s \tag{9}$$

The demand functions of merchant 1 and merchant 2 are:

$$D_{1s} = 1 - \frac{\alpha(p_1 - p_2)}{1 - \theta} \quad , \quad D_{2s} = \frac{\alpha(\theta p_1 - p_2) + \beta s(1 - \theta)}{\theta(1 - \theta)} \tag{10}$$

The profits obtained are:

$$\begin{aligned}\pi_{1s} &= p_1 D_{1s} - C_1 = p_1 - \frac{\alpha p_1(p_1 - p_2)}{1-\theta} - \frac{1}{2}\eta s^2 \\ \pi_{2s} &= p_2 D_{2s} - C_2 = \frac{\alpha p_1(\theta p_1 - p_2) + \beta p_1 s(1-\theta)}{\theta(1-\theta)} - \frac{1}{2}\eta s^2\end{aligned} \tag{11}$$

The total profit of cross-border e-commerce is:

$$\pi_s = \pi_{1s} + \pi_{2s} = \frac{p_1(1-\theta-\alpha p_1+\alpha p_2)}{1-\theta} + \frac{\alpha p_1(\theta p_1 - p_2) + \beta p_1 s(1-\theta)}{\theta(1-\theta)} - \eta s^2 \tag{12}$$

3.2 Optimal Strategy Under the Centralized Model

Under the centralized decision-making, cross-border e-commerce closely cooperates to develop product prices and sales strategies jointly, and both parties aim at maximizing the total profit of cross-border e-commerce π_s.

$$\begin{aligned}\frac{\partial \pi_s}{\partial p_1} &= 1 - \frac{2\alpha(p_1 - p_2)}{1-\theta} \\ \frac{\partial \pi_s}{\partial p_2} &= \frac{2\alpha(\theta p_1 - p_2)}{\theta(1-\theta)} + \frac{\beta s}{\theta}\end{aligned} \tag{13}$$

The Hessian matrix of the optimization problem according to its second-order condition is:

$$H = \begin{pmatrix} \frac{-2\alpha}{1-\theta} & \frac{2\alpha}{1-\theta} \\ \frac{2\alpha}{1-\theta} & \frac{-2\alpha}{\theta(1-\theta)} \end{pmatrix} \tag{14}$$

$$|H_1| = \frac{-2\alpha}{1-\theta} \quad , \quad |H_2| = \frac{4\alpha^2}{\theta(1-\theta)} \tag{15}$$

Because $\theta \in [0, 1]$, we can get $|H_1| < 0$, $|H_1| > 0$; the Heather matrix is negative, so there is an optimal pricing strategy $(p_1^*\ ,\ p_2^*)$. It can maximize the total profit of cross-border e-commerce and can be calculated simultaneously $\partial \pi_s \big/ \partial p_1 = 0$, $\partial \pi_s \big/ \partial p_2 = 0$.

In the case of providing homogeneous services, the optimal pricing strategies for merchant 1 and merchant 2 are:

$$\begin{aligned} p_1^* &= \frac{1+\beta s}{2\alpha} \\ p_2^* &= \frac{\theta+\beta s}{2\alpha}\end{aligned} \tag{16}$$

Bring p_1^* , p_2^* into π_{1s}, π_{2s}, π_s, we can get under the homogenous service concentration strategy, the profit of merchant 1, merchant 2 and the total profit of cross-border

e-commerce are:

$$\begin{aligned}\pi_{1s}^{c} &= \frac{1+\beta s-2\alpha\eta s^{2}}{4\alpha}\\ \pi_{2s}^{c} &= \frac{\theta\beta s+(\beta^{2}-2\alpha\eta\theta)s^{2}}{4\alpha\theta}\\ \pi_{s}^{c} &= \frac{\theta(1+2\beta s)+(\beta^{2}-4\alpha\eta\theta)s^{2}}{4\alpha\theta}\end{aligned} \tag{17}$$

Let $\partial\pi_s^c \big/ \partial s = 0$, the service level provided by the merchants under the homogeneous service concentration strategy is:

$$s^{c} = \frac{\beta\theta}{4\alpha\eta\theta-\beta^{2}} \tag{18}$$

3.3 Optimal Strategy Under the Decentralized Model

In the decentralized decision-making strategy, the merchants each make decisions based on their profit maximization principle. This is a dynamic oligopolistic game model, namely the Stackelberg game.

Because the platform-based merchants have more abundant resources, it is assumed that the platform-based merchant 1 in the distributed model is the leader of the game, and the self-operated merchant 2 is the follower.

The decision order is that merchant 1 first formulates the product price to maximize its profit; merchant 2 then sets its income level according to the pricing of merchant 1. Merchant 1 knows that merchant 2 will make such a decision, so merchant 1 will utilize the response function of merchant 2 to itself as the basis for the final price decision. We use the inverse inductive method to calculate the optimal solution of the model.

Merchant 2 sets the price to maximize its profits, that is $\partial\pi_{2s} \big/ \partial p_2 = 0$, the price of the product of merchant 2 can be determined as:

$$p_{2} = \frac{\alpha\theta p_{1}+\beta s(1-\theta)}{2\alpha} \tag{19}$$

Bringing p_2 into the profit function of merchant 1, we can get:

$$\pi_{1s} = \frac{\alpha p_{1}^{2}(\theta-2)+p_{1}(2+\beta s)(1-\theta)}{2(1-\theta)} - \frac{1}{2}\eta s^{2} \tag{20}$$

Let $\partial\pi_{1s} \big/ \partial p_1 = 0$, get the best product pricing p_1^* that maximizes the profit of merchant 1:

$$p_{1}^{*} = \frac{(2+\beta s)(1-\theta)}{2\alpha(2-\theta)} \tag{21}$$

Bring p_1^* into p_2^*, get the best product pricing p_2^* that maximizes the profit of merchant 2:

$$p_{2}^{*} = \frac{[\beta s(4-\theta)+2\theta](1-\theta)}{4\alpha(2-\theta)} \tag{22}$$

Bring p_1^* , p_2^* into π_{1s}, π_{2s}, π_s, under the homogenous service decentralization strategy, the profits of merchant 1, merchant 2 and the total profits of cross-border e-commerce are:

$$\begin{aligned}
\pi_{1s}^d &= \frac{8\theta(1+s\beta)A_1 + s^2(2\beta\theta A_1 - \alpha\eta A_5)]}{2\alpha A_5} \\
\pi_{2s}^d &= \frac{4\theta^2(1-\theta) + 4s\beta\theta A_2 + s^2[\beta^2(4-\theta)A_2 - \alpha\eta A_5]}{2\alpha A_5} \\
\pi_s^d &= \frac{4\theta A_2 + 4s\beta\theta A_3 + s^2[\beta^2 A_4 - 2\eta\alpha A_5]}{2\alpha A_5}
\end{aligned} \tag{23}$$

Among them:

$$\begin{aligned}
A_1 &= (1-\theta)(2-\theta) \\
A_2 &= (1-\theta)(4-\theta) \\
A_3 &= (1-\theta)(8-3\theta) \\
A_4 &= (1-\theta)(16-4\theta-\theta^2) \\
A_5 &= 8\theta(2-\theta)^2
\end{aligned} \tag{24}$$

Because $\theta \in [0, 1]$, A_1–A_5 are all positive.

Let $\partial\pi_s^d \big/ \partial s = 0$, the level of service provided by merchants under the homogeneous service decentralization strategy is:

$$s^d = \frac{2\beta\theta A_3}{2\alpha\eta A_5 - \beta^2 A_4} \tag{25}$$

3.4 Comparative Analysis

3.4.1 Impact on Service Levels

First, we compare the level of service under centralized decision-making and decentralized decision-making. When merchants provide homogeneous services, the difference between their service level in centralized and decentralized decision-making is:

$$\Delta s = s^c - s^d = \frac{\beta\theta^2[8\alpha\eta\theta(3-\theta) - \beta^2 A_1]}{(4\alpha\eta\theta - \beta^2)(2\alpha\eta A_5 - \beta^2 A_4)} \tag{26}$$

Because $\theta \in [0, 1]$, $s^c > 0$, $s^d > 0$, $4\alpha\eta\theta - \beta^2 > 0$, $2\alpha\eta A_5 - \beta^2 A_4 > 0$, and weather Δs is negative or positive is depends on $8\alpha\eta\theta(3-\theta) - \beta^2 A_1$. When $8\alpha\eta\theta(3-\theta) - \beta^2 A_1 > 0$, $s^c > s^d$, the level of service under centralized decision is greater than that under decentralized decision-making, and vice versa.

That is, when merchants in a cross-border e-commerce supply chain provide the same service, the service level is affected by consumer behavior (α, β), operating costs (η), and product attributes (θ). Therefore, merchants should consider these influencing factors when formulating service strategies.

Second, we analyze in detail the impact of variables $\alpha,\ \beta,\ \eta,\ \theta$ on service levels. Under centralized decision:

$$\begin{aligned}\frac{\partial s^c}{\partial \alpha} &= \frac{-4\beta\eta\theta^2}{(4\alpha\eta\theta-\beta^2)^2}\\ \frac{\partial s^c}{\partial \beta} &= \frac{\theta(4\alpha\eta\theta+\beta^2)}{(4\alpha\eta\theta-\beta^2)^2}\\ \frac{\partial s^c}{\partial \eta} &= \frac{-4\beta\eta\theta^2}{(4\alpha\eta\theta-\beta^2)^2}\\ \frac{\partial s^c}{\partial \theta} &= \frac{-\beta^3}{(4\alpha\eta\theta-\beta^2)^2}\end{aligned} \tag{27}$$

Under decentralized decision:

$$\begin{aligned}\frac{\partial s^d}{\partial \alpha} &= \frac{-4\beta\eta\theta A_3A_5}{(2\alpha\eta A_5-\beta^2A_4)^2}\\ \frac{\partial s^d}{\partial \beta} &= \frac{2\theta A_3(\beta^2A_4+2\alpha\eta A_5)}{(2\alpha\eta A_5-\beta^2A_4)^2}\\ \frac{\partial s^d}{\partial \eta} &= \frac{-4\alpha\beta\theta A_3A_5}{(2\alpha\eta A_5-\beta^2A_4)^2}\\ \frac{\partial s^d}{\partial \theta} &= \frac{-8\beta(4\alpha\eta\theta^2A_6+\beta^2A_7)}{(2\alpha\eta A_5-\beta^2A_4)^2}\end{aligned} \tag{28}$$

Among them:

$$\begin{aligned}A_6 &= (2-\theta)(6-\theta)\\ A_7 &= (1-\theta)^2(32-24\theta+5\theta^2)\end{aligned} \tag{29}$$

Because $\theta \in [0, 1]$, so $A_6 > 0,\ A_7 > 0$ are all positive.

Conclusion as below:

(1) $\partial s^c \big/ \partial \alpha < 0,\ \ \partial s^d \big/ \partial \alpha < 0$

Whether centralized or decentralized, cross-border e-commerce service levels s will decrease as consumers become more sensitive to product prices. This is because, when consumers are more sensitive to product prices, they will be attracted by lower prices. At this time, both platform-based and self-operated companies tend to adopt low-cost competition strategies to attract more consumers. Merchants often transfer logistics costs to consumers, as they are reflected in the final price of the product. In the case of selling homogeneous products, the reduction in prices will inevitably lead to a reduction in logistics investment, which will eventually lead to a decline in service levels.

(2) $\partial s^c \big/ \partial \beta > 0,\ \ \partial s^d \big/ \partial \beta > 0$

Whether it is centralized or decentralized, the level of cross-border e-commerce services s will increase as consumers become more sensitive to service levels.

This is because, when consumers are more sensitive to service levels, they will pay more attention to the utility of services. At this time, both platform-based and self-operated enterprises tend to adopt competitive strategies to improve service levels and then attract more consumers.

(3) $\partial s^c / \partial \eta < 0,\ \partial s^d / \partial \eta < 0$

Whether it is centralized or decentralized, the level of cross-border e-commerce services s will decrease as the service cost factor η increases.

This is because when the service cost coefficient rises, or when the efficiency of service cost input and output is low, providing the same level of service requires more cost. The merchant is rational, and the pursuit of profit maximization is bound to the reduction of service costs, and ultimately leads to a decline in service levels.

(1) $\partial s^c / \partial \theta < 0,\ \partial s^d / \partial \theta < 0$

Whether it is centralized or decentralized, the level of cross-border e-commerce services s will decrease as the degree of product differentiation decreases.

When the products sold by different merchants tend to be the same, the needs of consumers are roughly the same. At this time, the warehouses will be placed close to the suppliers (because consumers are widely distributed), and the service level would then reduce. (The warehouse is far from the consumer, which means that the delivery time increases, the waiting time of consumers increases, and may not be punctual. If there are after-sales problems, the return and exchange problem may be difficult to solve, which affects reliability; long-distance transportation adopts a single form and is not flexible.) At the same time, the warehouse is far from consumers, which means that some consumers may not be in the delivery area, which is the low service level. Also, the reduction in the diversity of commodities means that there may be no more strict requirements for special logistics and distribution of different types of goods, the overall level of logistics will decline.

3.4.2 Impact on Cross-border E-commerce Total Profit

First, look at the comparison of cross-border e-commerce total profit under centralized- and decentralized decision-making. When the merchants provide homogeneous services, the difference between the total profit of cross-border e-commerce in centralized- and decentralized decision-making is:

$$\Delta\pi_s = \pi_s^c - \pi_s^d = \frac{4\theta + 4s\beta\theta(3-\theta) + s^2\beta^2(4+\theta-\theta^2)}{16\alpha(2-\theta)^2} \tag{30}$$

Because $\theta \in [0, 1]$, $\Delta\pi_s > 0$. This shows that the total profit of cross-border e-commerce under centralized decision-making is larger than that under decentralized decision-making, which means that if the merchants work closely together, conclude alliances, and formulate product prices and sales strategies jointly, they can bring greater benefits to the entire cross-border e-commerce.

Next, analyze in detail the impact of variables $\alpha,\ \beta,\ \eta,\ \theta$ on total profit.

Under centralized decision:

$$\begin{aligned}\frac{\partial \pi_s^c}{\partial \alpha} &= \frac{-(s^2\beta^2 + 2s\beta\theta + \theta)}{4\alpha^2\theta} \\ \frac{\partial \pi_s^c}{\partial \beta} &= \frac{s^2\beta + s\theta}{2\alpha\theta} \\ \frac{\partial \pi_s^c}{\partial \eta} &= -s^2 \\ \frac{\partial \pi_s^c}{\partial \theta} &= \frac{-s^2\beta^2}{4\alpha\theta^2}\end{aligned} \tag{31}$$

Under decentralized decision:

$$\begin{aligned}\frac{\partial \pi_s^d}{\partial \alpha} &= \frac{-(4\theta A_2 + 4s\beta\theta A_3 + s^2\beta^2 A_4)}{2\alpha^2 A_5} \\ \frac{\partial \pi_s^d}{\partial \beta} &= \frac{s(2\theta A_3 + s\beta A_4)}{\alpha A_5} \\ \frac{\partial \pi_s^d}{\partial \eta} &= -s^2 \\ \frac{\partial \pi_s^d}{\partial \theta} &= \frac{-4(4\theta^2 s\beta A_6 + 4\theta^2 A_8 + s^2\beta^2 A_9)}{\alpha A_5^2}\end{aligned} \tag{32}$$

Among them:

$$\begin{aligned}A_8 &= (2-\theta)(2+\theta) \\ A_9 &= (2-\theta)(32 - 48\theta + 34\theta^2 - 7\theta^3)\end{aligned} \tag{33}$$

Because $\theta \in [0, 1]$, $A_8 > 0$, $A_9 > 0$ are all positive.

Conclusion as below:

(1) $\partial \pi_s^c \big/ \partial \alpha < 0, \ \partial \pi_s^d \big/ \partial \alpha < 0$

Whether it is centralized or decentralized, the total profit of cross-border e-commerce π_s will decrease as consumers become more sensitive to product prices.

This is because, when consumers are more sensitive to product prices, they will be attracted by lower prices. At this time, both platform-based and self-operated companies tend to adopt a competitive strategy of lowering product prices to attract more consumers. This will result in a decline in the total profit of cross-border e-commerce. Therefore, price competition is not beneficial to the overall supply chain. Both enterprises and governments should actively guide consumers to pay more attention to the quality of products and services.

(2) $\partial \pi_s^c \big/ \partial \beta > 0, \ \partial \pi_s^d \big/ \partial \beta > 0$

Whether it is centralized or decentralized, the total profit of cross-border e-commerce π_s will increase as consumers become more sensitive to service levels.

This is because, when consumers are more sensitive to service levels, they will pay more attention to the utility of services. At this time, both platform-based and self-operated enterprises tend to adopt competitive strategies to improve service levels to attract more consumers, this will increase the total profit of cross-border e-commerce.

(3) $\partial \pi_s^c / \partial \eta = \partial \pi_s^d / \partial \eta < 0$

Whether it is centralized or decentralized, the total profit of cross-border e-commerce π_s will decrease as the service cost factor η increases.

This is because when the service cost coefficient rises, or when the efficiency of service cost input and output is low, providing the same level of service requires more cost, which will inevitably lead to a decline in the total profit of cross-border e-commerce. At this time, the government should give enterprises certain subsidies, improve the corresponding cross-border e-commerce infrastructure construction, reduce the service cost of enterprises, and promote the healthy development of cross-border e-commerce.

$\partial \pi_s^c / \partial \theta < 0$, $\partial \pi_s^d / \partial \theta < 0$

Whether it is centralized or decentralized, the total profit of cross-border e-commerce π_s will increase as the degree of difference in products sold by merchant's θ decreases. This means that to increase profits, companies should widen the differences between products, including differences in category and quality.

Under the circumstance of commodity convergence, large-scale platforms have certain advantages in the logistics service level because of their own logistics system. Small enterprises have to reduce the funds for maintaining the logistics service level due to the loss of consumers, and then their profits may be affected. At the same time, the profits of large enterprises will also be affected because of the decrease in service level caused by commodity convergence.

4 Numerical Analysis

To visualize the impact of the differentiation strategy on the cross-border e-commerce supply chain, this section does some simulation analysis with specific values.

Let $\alpha = 0.5$, $\beta = 0.5$, $\eta = 0.6$, $s = 1$, the impact of product differentiation on the total profit of cross-border e-commerce supply chain under centralized decision-making and decentralized decision-making is shown in Fig. 2. The red line refers to the centralized decision while the blue dotted line refers to the decentralized decision.

It can be seen from the figure that as the degree of product differentiation increases, the profit of cross-border e-commerce supply chain is decreasing under both centralized and decentralized strategies, and the profit attenuation under the centralized strategy is smaller than that under the decentralized strategy. When the product differentiation between cross-border e-commerce is certain, the supply chain that implements the centralized strategy can obtain more profits.

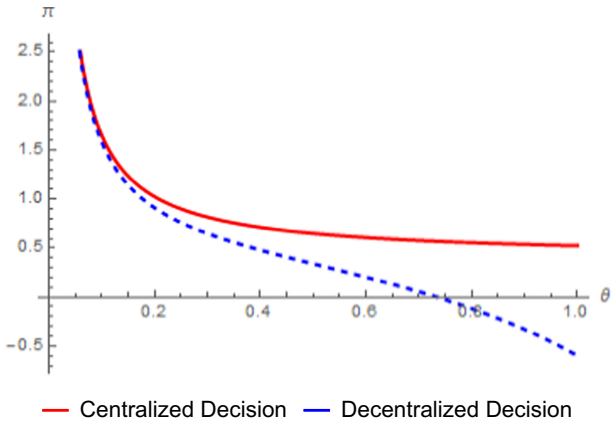

Fig. 2. Profit of cross-border e-commerce supply chain under centralized decision-making and decentralized decision-making (Color figure online)

(1) Let $\alpha = 0.5,\ \beta = 0.5,\ \eta = 0.6,\ s = \{0.3,\ 0.7\}$, when cross-border e-commerce centralized decision-making, the impact of product differentiation on the total profit of cross-border e-commerce supply chain under different service levels is shown in Fig. 3:

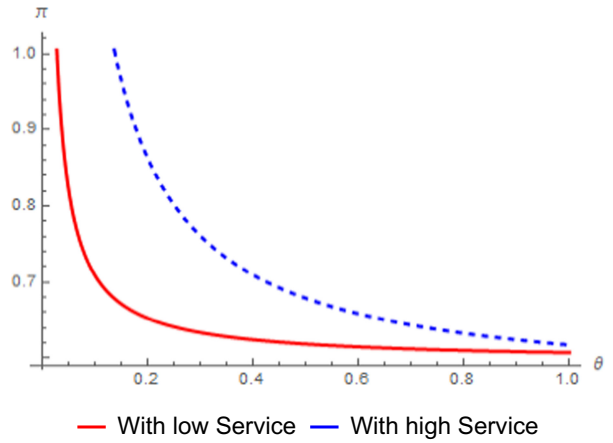

Fig. 3. Profit of cross-border e-commerce supply chain under different service level centralized decision (Color figure online)

It can be seen from the figure that, under the centralized decision, as the degree of product differentiation increases, the profit of the cross-border e-commerce supply chain decreases, and the profit attenuation under the low service level is less than that under the high service level. When the product differentiation between cross-border e-commerce is certain, the supply chain with a high service level can obtain more profits.

(2) Let $\alpha = 0.5,\ \beta = 0.5,\ \eta = 0.6,\ s = \{0.3,\ 0.7\}$, when cross-border e-commerce decentralized decision-making, the impact of product differentiation on the total profit of cross-border e-commerce supply chain under different service levels is shown in Fig. 4:

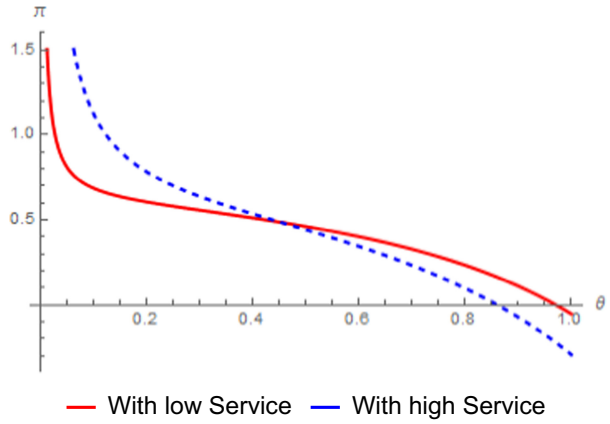

Fig. 4. Profit of cross-border e-commerce supply chain under different service level decentralized decision-making (Color figure online)

It can be seen from the figure that under the decentralized decision-making, as the degree of product differentiation increases, the profit of the cross-border e-commerce supply chain decreases, and the profit attenuation under the low service level is less than that under the high service level. The degree of product differentiation at the intersection of the two curves is set to θ^*. When $\theta \in [0, \theta^*]$, supply chain with a high service level can get more profit; when $\theta \in [\theta^*, 1]$, in contrast, a supply chain with a low service level can get more profit.

5 Conclusion

Cross-border e-commerce is booming around the world, but it is followed by fierce competition between vendors and channels for product quality and service levels. The "Blue Ocean" has changed to "Red Ocean". To maintain an advantage in this competition, the differentiation strategy is indispensable (Cao et al. 2019). This paper adopts the theoretical method of game theory analysis and the empirical research method of designing questionnaire interviews.

This paper considers a dual-channel cross-border supply chain that includes overseas suppliers, platform-based e-commerce, and self-operated e-commerce. The game model is used to analyze the impact of product differentiation on the competitive strategy of the merchants, and the optimal pricing and optimal service levels under centralized- and decentralized decision-making. According to the collection of effective questionnaires

and interview information, the correctness of the product differentiation analysis strategy model was verified.

From model equilibrium solutions and numerical analysis, the following practical guidance can be derived:

(1) As the degree of product differentiation increases, the profit of cross-border e-commerce supply chain increases. To increase profits, companies should actively expand the differences in sales products, including differences in quality and quality. Provide consumers with more choices and better services.

(2) When the product differentiation between cross-border e-commerce is certain, the cross-border supply chain that implements the centralized strategy can obtain more profits. For example, Wal-Mart's global store in JD.com has proven this (Zhang 2016). Wal-Mart has increased its customers and secured domestic supply chain support through the JD platform. JD.com has expanded its product offerings through Wal-Mart and gained stronger international supply chain support.

(3) When the products of the merchants tend to be the same, the role of service differentiation is highlighted, and enterprises that can provide better logistics service levels can gain a competitive advantage. Price competition is not beneficial to the overall supply chain. Both enterprises and governments should actively guide consumers to pay more attention to the quality of products and services.

Cross-border e-commerce companies focused on the construction of overseas warehouses is evidence of the importance of service differentiation. Cross-border e-commerce has experienced modes such as direct mail to overseas warehouse collection and domestic bonded area collection, aiming to improve the satisfaction of cross-border e-commerce customers and improve competitiveness. At this time, the government should give enterprises certain subsidies, improve the corresponding cross-border e-commerce infrastructure construction, and reduce the service cost of enterprises, which can promote the healthy development of cross-border e-commerce.

(4) Promote the transformation and upgrading of cross-border enterprises, accelerate the process of enterprise branding, foster international Internet brands, enhance the technological innovation capability and international competitiveness of enterprises, drive the development of high-end service industries, and foster new service formats. Enhance export competitive advantage and profit margin, master the international market to expand import scale and industry coverage and develop local service industry to drive domestic enterprises to participate in the global network division of labor and competition.

This paper is only the initial step in the study of the cross-border e-commerce operation strategy. It has a positive guiding role in the practical operation of modern Chinese cross-border e-commerce. Since cross-border e-commerce includes international supply chain and domestic supply chain, and the operation strategy is complex and extensive, we will further improve the competitive strategy in future research work, such as research on the risk of cross-border e-commerce operation mode, cross-border e-commerce warehousing, international trade transportation, and last-mile delivery management.

References

Wang, J.: Opportunities and challenges of international e-commerce in the pilot areas of China. Int. J. Mark. Stud. **6**(6), 141–149 (2014)

Liu, X.J., Chen, D.Y., Cai, J.S.: The Operation of the Cross-border e-commerce Logistics in China. Int. J. Intell. Inf. Syst. **4**(2), 15–18 (2015)

iResearch. 2014 China Cross-border E-commerce Report (Brief Edition) [EB/OL]. https://californiacenter.us/wp-content/uploads/2015/02/2014-China-Cross-border-E-commerce-Report-Brief-Edition.pdf. Accessed 05 Jan 2015

Alizila. Cross-border E-Commerce to Reach $1 Trillion in 2020 [EB/OL]. https://www.alizila.com/cross-border-e-commerce-to-reach-1-trillion-in-2020/. Accessed 11 Jun 2015

AliResearch. The prospect for the global cross-border B2C e-commerce market. Beijing, AliResearch (2015)

Research and Markets: Europe Cross-border B2C E-Commerce 2015. Business Wire, Dublin (2015)

iResearch. 2016 China Cross-border Online Shoppers Report [EB/OL]. https://californiacenter.us/wp-content/uploads/2015/01/2016-Chinas-Cross-border-Ecommerce-Report.pdf. Accessed 21 Mar 2016

Huang, S., Yang, C., Zhang, X.: Pricing and production decisions in dual-channel supply chains with demand disruptions. Comput. Ind. Eng. **62**, 70–83 (2012)

Hanjin, L., Xiaojun, F., Hongmin, C.: Research on dual channel pricing strategy under retailer price leadership structure. CMS **23**(6), 91–98 (2015)

Deng Mingrong, L., Xiujuan. : Research on dual channel supply chain based on signal game under demand information asymmetry. Oper. Res. Manage. **25**(4), 125–133 (2016)

Porter, M.E.: Competitive strategy: techniques for analyzing industries and competitors. Soc. Sci. Electron. Publishing **2**, 86–87 (1980)

Xinjun, D., Deli, Y., Bin, T.: Service cooperation policy in a dual-channel supply chain under service differentiation. Oper. Manage (2014)

Xiao, D., Yuan, J.X., Bao, X.: Analysis of supply chain coordination strategy under the double competition of quality and price. Chin. Manage. Sci (2013)

Zhang, X., Liu, C., Zhang, R.: Pricing and coordination of dual-channel supply chain based on alternative product competition. Soft Sci. **30**(3) (2016)

Diyun, M., Yaozhong, W.: Research on the sources of competitive advantages of online retail enterprises from the perspective of value networks-taking Jingdong as an example. Search **278**(10), 45–49 (2015)

Yao, W., Bin, D., Can, L.: Heterogeneous product dual channel supply chain improvement strategy with negative spillover effect. J. Manage (2014)

Cunping, W., Guofang, N., Minqiang, L.: Optimal pricing strategy for oligopolistic information products and services. J. Manage. Sci. (2016)

Chen, J., Yang, Y.: Service cooperation policy in a dual-channel supply chain under service differentiation. Am. J. Ind. Bus. Manag. **4**(6), 284–294 (2014)

Wujun, C., Mengna, Y., Chaogai, X.: Construction of a logistics enterprise-led cross-border e-commerce ecosystem-multi-case study. Sci. Technol. Manage. Res. **16** (2019)

Tao, Z.: Wal-Mart's JD alliance, the retail industry is brewing huge changes. Chin. Bus. **7**, 78–79 (2016)