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Selection of Sales Mode for E-Commerce Platform Considering Corporate Social Responsibility

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Abstract: From the perspective of corporate social responsibility (CSR) of the e-commerce platform, this paper investigates the choice of e-commerce platform for wholesale sales, agency sales, and hybrid sales modes when the manufacturer has both an offline retail channel and an e-commerce platform channel. Taking the e-commerce platform as the dominant player and considering factors such as the potential market size of the e-commerce platform, consumers' sensitivity to CSR input level, and the CSR input cost coefficient, we constructed a Stackelberg game model under the wholesale sales, agency sales, and hybrid sales modes. We explored the impact of the e-commerce platform's CSR behavior on the choice of its sales modes as well as on the members of the supply chain. The findings indicate that, irrespective of the consumers' sensitivity to CSR level and CSR input cost coefficient, the e-commerce platform tends to adopt the hybrid sales mode when its potential market size is smaller. Moreover, when the potential market size is larger, the wholesale sales mode is preferred; only when the potential market size is moderate, and consumers are less sensitive to CSR input level or CSR input cost coefficient is higher, the e-commerce platform will choose the agency sales mode. The increase in the potential market size of the e-commerce platform and the consumers' sensitivity to CSR input level is conducive to the rise in the profits of the e-commerce platform, and the increase in the CSR input cost coefficient makes the profits of the e-commerce platform decrease. At the same time, the demand for the e-commerce platform increases as consumers become more sensitive to CSR input level or as the potential market size of the e-commerce platform increases. In contrast, the reduction in the CSR input cost coefficient negatively affects the demand for the e-commerce platform.

Keywords: corporate social responsibility; e-commerce platform; sales mode selection; Stackelberg game model

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1. Introduction

With the rapid development of information technology and logistics industry, people's use of e-commerce platforms is increasing, and online shopping is gradually becoming the primary mode of consumption. The selling price of online channels is generally lower than that of offline channels due to the difference in operating costs, and this has prompted a large number of consumers to switch from offline physical channels to online channels for shopping [1]. Moreover, it was pointed out earlier by CSA that 57% of people who visit offline physical shops will buy products online [2]. Therefore, faced with such a massive online shopping scale, manufacturers have chosen to open up online sales channels to form a dual-channel model where offline retail and online platform channels coexist. Simultaneously, manufacturers often produce multiple generations of a product as the level of technology continues to evolve. For example, Huawei mobile phones sell both the latest generation Mate 60 series and the previous generation Mate 50 series, and even the Nova and P series. It is observed that manufacturers also differ in their choice of sales channels for their products. Still taking Huawei as an example, Huawei's mobile phone series are all

sold through Huawei Jingdong's self-owned official flagship shop (shipped by Jingdong and providing after-sales service). The footwear and apparel brand Adidas has adopted a sales channel strategy different from Huawei's: opening an Adidas official flagship shop on Jingdong (with Adidas responsible for delivery and after-sales service). In addition, it is found that some of HP's products are sold both at the HP official flagship shop on Jingdong and at HP Jingdong's self-owned official flagship shop. Based on the manufacturer's multiproduct and multichannel operating structure, the e-commerce platforms typically have the following three sales modes available to manufacturers: wholesale sales, agency sales, and hybrid sales modes. In the wholesale sales mode, manufacturers wholesale their products to e-commerce platforms, and then the platforms sell them to consumers, such as Huawei mobile phones, which all use Huawei Jingdong's self-owned official flagship shop. In contrast, in the agency sales mode, manufacturers pay a commission to e-commerce platforms and then sell their products directly to consumers through the platforms themselves. For example, the sales channel strategy of footwear and apparel brand Adidas is completely different from that of Huawei, in which they set up an Adidas official flagship shop on the Jingdong platform. Finally, e-commerce platforms can use the above methods to sell products simultaneously, which is called the hybrid sales mode, e.g., some of HP's products are sold at both the HP Jingdong's self-owned official flagship shop and the HP official flagship shop.

Corporate social responsibility (CSR) has been a hot research topic recently. Cheng et al. [3] clarified that CSR requires enterprises to pay attention to the interests of other stakeholders while pursuing economic interests and to take the initiative to assume specific legal, economic, and moral responsibilities. Nowadays, although people rely on e-commerce platforms to buy products, there is a lack of intuitive understanding regarding product quality, and the willingness to pay for the products is different due to individual differences in their product requirements. Thus, people can only rely on public product information and the evaluation of the purchasers to decide whether to buy. However, complaints over product quality are still common. Therefore, some well-known platform enterprises, such as JD.com and Vipshop, have started to take the lead and have undertaken CSR to establish product quality identification centers. This behavior is responsible for consumers, provides the most direct proof of goods, and then wins the consumers' trust in the enterprises. Meanwhile, customers' needs are becoming more and more diversified. For example, Amazon has developed AWS cloud services and Alexa smart speakers to enhance the experience of customers [4]. The instrument used to authenticate goods and the investment in improving customers' satisfaction, however, also places enormous cost pressure on e-commerce platforms. As such, this requires e-commerce platforms to take on CSR while also taking into account the benefits and level of return on investment for the enterprises. Additionally, when platform enterprises undertake CSR, they also utilize it as a marketing and communication tool. This not only helps establish a positive corporate image [5] but also allows for the exploration of potential consumers. Ultimately, this leads to an increase in consumer purchasing intention, subsequently driving up product demand and achieving greater economic benefits [6].

Based on the above discussion, this paper focuses on the e-commerce platform considering undertaking CSR and aims to determine which sales mode is more beneficial for its own interests. The following research questions are posed:

(1) Under the three sales modes, what is the impact of CSR undertaken by the e-commerce platform on its market demand, CSR input level, and profits?
(2) Which sales mode (wholesale sales mode, agency sales mode, or hybrid sales mode) is most advantageous for the e-commerce platform when undertaking CSR? What conditions are met?
(3) Does the e-commerce platform's CSR behavior also impact the manufacturer and offline retailer? What kind of impact does it have?

The rest of this paper is organized as follows. Section 2 reviews the relevant literature. In Section 3, we introduce the problem and model hypothesis, and in Section 4, we build

and solve the model. In Section 5, we analyze the equilibrium of the solutions. Then, in Section 6, numerical simulation is carried out for the given values of relevant parameters. Finally, the conclusions, future research directions, and managerial insights are presented in Section 7.

2. Literature Review

This paper presents a review of the literature in three main areas: dual-channel sup-ply chains, sales modes, and CSR.

2.1. Dual-Channel Supply Chain

In recent years, many scholars have carried out in-depth research on various aspects of the dual-channel supply chain. Yang et al. [7], by constructing a Stackelberg game model of consumer utility, analyzed the complex mechanism of retailers' innovation input level affecting supply chain operation and designed a dual coordination mechanism to mitigate online and offline channel conflicts as well as to improve supply chain operation efficiency. Under a dual-channel supply chain, Liu et al. [8] explored how to set reasonable prices for different products and found that consumer acceptance of product networks can influence the impact of consumers' behavior on supply chain channel pricing and its mechanism. Zhang et al. [9] studied the impacts of different risk tolerances of supply chain members on supply chain operational decisions and designed a coordination contract. It was found that the reverse benefit-sharing and cost-sharing combination contract with transfer payments can achieve the coordination of a dual-channel green supply chain. Yu et al. [10] considered a dual-channel supply chain consisting of a manufacturer with an online direct sales channel and a physical retailer, and the dual-channel allows unidirectional transshipment from the physical retailer to the manufacturer's direct sales channel. The impact of unidirectional transshipment on the ordering decisions of both parties is investigated based on this. Pakdel et al. [11] studied the impact of consumers' preferences on pricing in a dual-channel supply chain led by the retailer. They identified a Pareto region of consumer channel preferences, where both the manufacturer and retailer benefit from the dual-channel supply chain. Different from the previous literature, which only considered offline and online dual channels, this paper focuses on wholesale sales, agency sales, and hybrid sales modes of online media based on dual channel.

2.2. Sales Mode

The above literature observed that manufacturers sell their products online and offline. However, with the development of e-commerce, some scholars have begun to study the issue of selecting sales modes for online channels of supply chain members within the e-commerce environment. Li et al. [12] found that under blockchain technology, the manufacturer should choose the online direct connection + commissioned sales mode to sell their products. Yang et al. [13] conducted a study on the selection strategy of e-commerce sales mode and information sharing strategy. They discovered that the selection of sales mode for an e-retailer mainly depends on the level of investment efficiency of the manufacturer. Lai et al. [14] investigated the effect of a manufacturer's risk neutrality or risk appetite on the choice of an e-commerce platform's sales mode. Tian et al. [15] analyzed the impact of competition between two upstream suppliers and order fulfillment costs on the optimal online sales mode choice of a manufacturer under three sales modes. Wu et al. [16] constructed a game model for the implementation of public welfare marketing by manufacturer brands and an e-commerce platform's own brands under the wholesale sales and agency sales modes. They investigated the public welfare marketing decision-making problem under the existence of competition between supply chain brands with the two sales modes. Tian et al. [17] constructed a supply chain model in which two manufacturers simultaneously adopt either wholesale sales or agency sales. They also considered whether the e-commerce platform provides logistics services and analyzed the impact of the platform's logistics service level on the platform sales mode selection of the

manufacturer. Nevertheless, all of the above research studied sales mode selection from the perspective of the manufacturer or supplier, and very few of them dealt with hybrid sales modes in which products are sold simultaneously in both wholesale sales and agency sales modes. Moreover, none of the above research considered the issue of product online sales mode selection from the perspective of the e-commerce platform.

2.3. Corporate Social Responsibility

In addition, although there are several studies on dual-channel supply chain and sales modes, the above literature needs to examine the impact of CSR assumed by e-commerce platforms on the choice of supply chain sales modes. Presently, some scholars view CSR as an exogenous variable and express CSR as a concern for consumers' interests [18–20]. Another group of scholars view CSR as an endogenous variable in order to enhance investment behavior for the benefit of supply chain members. Liu et al. [21] considered the asymmetry of retailer's information about supplier's CSR input level and analyzed decision-making outcomes when information is symmetric and asymmetric under a centralized and decentralized model. Zhao et al. [22], for a retailer-led closed-loop supply chain, found that CSR investments have to be moderate and in line with the company's development to be more effective. Liu et al. [23] considered a channel structure with a single or two recycling third parties based on CSR. It was found that the demand for new products, the recycling efficiency of used products, and the total profits of the supply chain increase with the increase in consumers' sensitivity to CSR, regardless of the channel structure. Liu et al. [24] explored the recycling and pricing decisions of a closed-loop supply chain of CSR investment and analyzed the impact of retailers undertaking CSR on their own decisions.

More studies have been conducted that consider manufacturers or retailers to undertake CSR, in contrast to very little research that considers e-commerce platforms to undertake CSR. Li et al. [25] constructed a game model under the CSR situation assumed by a food supplier and a third-party e-commerce platform. Ma et al. [26] constructed a three-way evolutionary game model between a government regulator, a manufacturer, and an e-commerce retailer. They found that the higher the fines imposed by the government on the e-commerce retailer, the more they are promoted to fulfill their CSR. Therefore, different from the previous literature, this paper examines the choice of sales mode of the e-commerce platform and considers the scenarios of the e-commerce platform assuming CSR simultaneously.

To sum up, the existing literature seldom considers multiple sales mode selection online from the perspective of the e-commerce platform, and few studies consider the impact of CSR assumed by an e-commerce platform on their sales mode selection. Therefore, under the situation that the manufacturer possesses both offline and online dual channels, this paper constructs a supply chain game model consisting of a manufacturer, an offline retailer, and an e-commerce platform, with the consideration of the e-commerce platform undertaking CSR. The research focuses on analyzing the effects of the potential market size of the e-commerce platform, consumers' sensitivity to CSR level, and CSR input cost coefficient on the optimal choice of sales mode of the e-commerce platform, as well as the effects on the members of the supply chain.

3. Problem Description and Model Hypothesis

This paper considers a supply chain system consisting of a manufacturer (m), an e-commerce platform (e), and an offline retailer (r) under the situation of the e-commerce platform undertaking CSR. The manufacturer can sell products not only through an offline retailer but also on an e-commerce platform, where the manufacturer wholesales to the offline retailer at the wholesale price, w_r, and the offline retailer sells to the consumers at the retail price, p_r. The e-commerce platform provides three sales modes for the manufacturer to sell products: (1) Wholesale sales mode: the e-commerce platform wholesales products from the manufacturer at the price of w_e, and then sells them to consumers at the retail price of p_e; (2) Agency sales mode: first, the e-commerce platform ought to determine the

product unit commission, T, to be paid by the manufacturer, and then the manufacturer can directly sell the products to consumers at the price of p_m through the platform. (3) Hybrid sales mode: the e-commerce platform uses both wholesale sales mode and agency sales mode to sell the manufacturer's products.

WS, AS, and HS represent that the e-commerce platform adopts wholesale sales mode, agency sales mode, and hybrid sales mode, respectively, to sell the manufacturer's products. The specific model structure is shown in Figure 1, and the symbols used in this paper and their relevant meanings are shown in Table 1. In addition, this paper makes the following assumptions: (1) We assume that the manufacturer's production cost, transportation cost, and transportation cost of the e-commerce platform are 0; (2) We assume that the information among the manufacturer, the offline retailer, and the e-commerce platform is entirely symmetric; (3) We assume that the market size is standardized to 1; (4) We assume that the influence of CSR undertaken by the e-commerce platform on its demand is greater than that of the offline retailer, that is, $\lambda > \beta$; (5) The cost of the e-commerce platform undertaking CSR is $\frac{1}{2}\varepsilon e^2$; the greater ε is, the higher the CSR input cost [23].

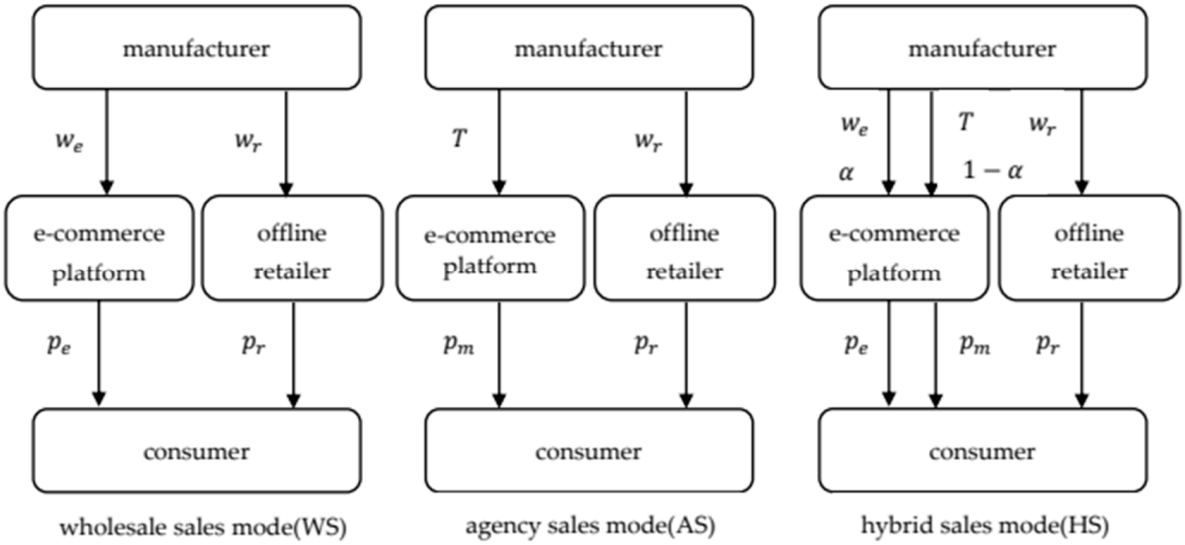


Figure 1. The structure of the three online sales modes on the e-commerce platform.

Table 1. Symbols and definitions.

n	Potential market size of e-commerce platform
$1-n$	Potential market size of offline retailer
p_r	Selling price for a product of offline retailer
p_e	Selling price for a product of e-commerce platform at the time of wholesale sales
p_m	Selling price for a product of the manufacturer at the time of agency sales
w_r	Wholesale prices for a product of manufacturer to offline retailer
w_e	Wholesale price for a product of manufacturer to the e-commerce platform at the time of wholesale sales
θ	Price elasticity coefficient
λ	Consumers' sensitivity to CSR input level
ε	CSR input cost coefficient
e	CSR input level
β	Coefficient of influence of CSR input level of e-commerce platform on retailer without CSR consideration [24]
T	Unit commission price of the e-commerce platform
α	The proportion of the market share under the wholesale sales mode, then $1-\alpha$ denotes the proportion of the market share under the agency sales mode

4. Model Construction and Solution

4.1. Wholesale Sales Mode (WS)

In this case, the e-commerce platform opts for the wholesale sales mode upon assuming CSR, and the sales mode is the same as that of the offline retailer. The manufacturer provides goods to the e-commerce platform and offline retailer at the price of w_e^{WS} and w_r^{WS}. Subsequently, the goods are sold to consumers at the price of p_e^{WS} and p_r^{WS}, respectively. The decision order of supply chain members is as follows: first, the e-commerce platform determines the CSR input level e^{WS}, then the manufacturer decides the wholesale price, w_r^{WS} and w_e^{WS}, and, finally, the e-commerce platform and offline retailer decide the sales price, p_e^{WS} and p_r^{WS}, respectively.

At this point, the linear demand function is constructed by referring to the relevant literature [21,24]. The demand functions of the e-commerce platform and offline retailer are as follows: $D_f^{WS} = n - p_e^{WS} + \theta p_r^{WS} + \lambda e^{WS}$, $D_r^{WS} = 1 - n - p_r^{WS} + \theta p_e^{WS} - \beta e^{WS}$. Accordingly, the profit functions of the manufacturer, offline retailer, and e-commerce platform are as follows: $\pi_m^{WS} = w_r^{WS} D_r^{WS} + w_e^{WS} D_f^{WS}$, $\pi_r^{WS} = \left(p_r^{WS} - w_r^{WS}\right) D_r^{WS}$, $\pi_e^{WS} = \left(p_e^{WS} - w_e^{WS}\right) D_f^{WS} - \frac{1}{2}\varepsilon {e^{WS}}^2$.

Under the consideration of CSR input, when $\varepsilon > \frac{(\beta\theta - 2\lambda)^2}{2\left(-4+\theta^2\right)^2}$, there exists a unique optimal solution of the model; then, the optimal equilibrium solutions of each supply chain member under the wholesale sales mode are

$$e^{WS*} = \frac{x_2(-\theta + nx_3)}{2\varepsilon x_1^2 - x_2^2},\ D_r^{WS*} = \frac{-2\varepsilon x_1(2 + nx_3) + x_2(\lambda + nx_4)}{2\left(2\varepsilon x_1^2 - x_2^2\right)},\ D_f^{WS*} = \frac{\varepsilon x_1(-\theta + nx_3)}{2\varepsilon x_1^2 - x_2^2}$$

Finally, the optimal profits of each member are

$$\pi_e^{WS*} = \frac{\varepsilon(\theta - nx_3)^2}{2\left(2\varepsilon x_1^2 - x_2^2\right)},\ \pi_r^{WS*} = \frac{\left(-2\varepsilon x_1(2 + nx_3) + x_2(\lambda + nx_4)\right)^2}{4\left(-2\varepsilon x_1^2 + x_2^2\right)^2}$$

$$\pi_m^{WS*} = \frac{4\varepsilon x_1^2\left(-x_2(\lambda + nx_4)(1 + nx_5) + \varepsilon x_1\left(2 + \theta^2 + 2(-1 + n)nx_3x_5\right)\right) + x_2^2(\lambda + nx_4)^2 x_6}{4\left(-2\varepsilon x_1^2 + x_2^2\right)^2 x_7}$$

The references to the relevant parameters are given in Appendix A.

4.2. Agency Sales Mode (AS)

In this model, the e-commerce platform selects the agency sales mode upon assuming CSR. Different from the sales mode of the offline retailer, the manufacturer sells independently on the e-commerce platform and needs to pay a certain commission to the platform, and then decides the retail price of the product. The decision order of supply chain members is as follows: after the e-commerce platform determines the CSR input level e^{AS}, the manufacturer determines the wholesale price, w_r^{AS}, to the offline retailer and the retail price, p_m^{AS}, to the platform for the unit commission T, and, finally, the offline retailer determines the retail price, p_r^{AS}, to the offline retailer.

In this case, the demand functions of the e-commerce platform and offline retailer are as follows: $D_d^{AS} = n - p_m^{AS} + \theta p_r^{AS} + \lambda e^{AS}$, $D_r^{AS} = 1 - n - p_r^{AS} + \theta p_m^{AS} - \beta e^{AS}$. Accordingly, the profit function of the manufacturer, offline retailer, and e-commerce platform are as follows: $\pi_m^{AS} = w_r^{AS} D_r^{AS} + \left(p_m^{AS} - T\right) D_d^{AS}$, $\pi_r^{AS} = \left(p_r^{AS} - w_r^{AS}\right) D_r^{AS}$, $\pi_e^{AS} = T D_d^{AS} - \frac{1}{2}\varepsilon {e^{AS}}^2$.

The optimal equilibrium solutions for each member of the supply chain system in the agency sales mode are, respectively, in the case of considering CSR input,

$$e^{AS*} = -\frac{Tx_2}{4\varepsilon},\ D_r^{AS*} = \frac{4\varepsilon(1 - n + T\theta) + T\beta x_2}{16\varepsilon},\ D_d^{AS*} = \frac{Tx_2^2 + 4\varepsilon(\theta + Tx_6 - nx_3)}{16\varepsilon}$$

Finally, the optimal profits of each member are

$$\pi_e^{AS*} = \frac{T\left(8\varepsilon(\theta + Tx_6) + Tx_2^2 - 8n\varepsilon x_3\right)}{32\varepsilon},\ \pi_r^{AS*} = \frac{(4\varepsilon x_{10} + T\beta x_2)^2}{256\varepsilon^2}$$

$$\pi_m^{AS*} = -\frac{16\varepsilon^2(X_1 + X_2) + 8T\varepsilon x_2 X_3 + T^2 x_2^2 X_4}{128\varepsilon^2 x_7}$$

The references to the relevant parameters are given in Appendix A.

4.3. Hybrid Sales Mode (HS)

The e-commerce platform adopts both wholesale sales and agency sales mode upon assuming CSR. The decision order of supply chain members is as follows: the CSR input level, e^{HS}, is determined by the e-commerce platform, and then the manufacturer decides the wholesale price, w_r^{HS}, w_e^{HS}, and the retail price, p_m^{HS}, under the agency sales mode for the unit commission, T. Finally, the offline retailer decides the retail price, p_r^{HS}, while the e-commerce platform decides the retail price, p_e^{HS}, under the wholesale sales mode.

Therefore, the demand functions of the wholesale sales mode, agency sales mode, and offline retailer are, respectively, $D_f^{HS} = \alpha n - p_e^{HS} + \theta\left(p_r^{HS} + p_m^{HS}\right) + \lambda e^{HS}$, $D_d^{HS} = (1-\alpha)n - p_m^{HS} + \theta\left(p_r^{HS} + p_e^{HS}\right) + \lambda e^{HS}$, $D_r^{HS} = 1 - n - p_r^{HS} + \theta\left(p_e^{HS} + p_m^{HS}\right) - \beta e^{HS}$. Accordingly, the profit functions of the manufacturer, offline retailer, and e-commerce platform are as follows: $\pi_m^{HS} = w_e^{HS} D_f^{HS} + \left(p_m^{HS} - T\right) D_d^{HS} + w_r^{HS} D_r^{HS}$, $\pi_r^{HS} = \left(p_r^{HS} - w_r^{HS}\right) D_r^{HS}$, $\pi_e^{HS} = \left(p_e^{HS} - w_e^{HS}\right) D_f^{HS} + T D_d^{HS} - \frac{1}{2}\varepsilon {e^{HS}}^2$.

When θ and ε satisfy the condition of $\theta < \frac{1}{2}$, $\varepsilon > \frac{(\beta\theta - 2\lambda)^2}{2\left(-4+\theta^2\right)^2}$ simultaneously, there exists a unique optimal solution, and the optimal equilibrium solutions for each member of the supply chain system under the hybrid sales mode are

$$e^{HS*} = \frac{x_2\left(\theta - T(1+\theta)\left(-8+\theta^2\right) + nx_8\right)}{-2\varepsilon x_1^2 + x_2^2},\ D_r^{HS*} = \frac{-2\varepsilon x_1 X_7 + x_2 X_8}{4\varepsilon x_1^2 - 2x_2^2}$$

$$D_f^{HS*} = \frac{T(1+\theta)x_2^2 - \varepsilon x_1\left(\theta + T\theta^2(1+\theta) + nx_8\right)}{2\varepsilon x_1^2 - x_2^2},\ D_d^{HS*} = \frac{2\varepsilon\theta(2+\theta)x_1 + nX_5 + T(1+\theta)X_6}{-4\varepsilon x_1^2 + 2x_2^2}$$

Finally, the optimal profits of each member are

$$\pi_e^{HS*} = \frac{X_9 + nX_{10} + T(T(1+\theta)X_{12} + 2n\varepsilon X_{11})}{-4\varepsilon x_1^2 + 2x_2^2},\ \pi_r^{HS*} = \frac{2\varepsilon x_1 X_7 - x_2 X_8}{-4\varepsilon x_1^2 + 2x_2^2}$$

$$\pi_m^{HS*} = \frac{X_{13}(X_{14} + x_2(-2\lambda X_{15} + TX_{16}))(-x_2 X_8 + 2X_7\varepsilon x_1) - 2x_1 x_9^2 X_{19}\left(2\varepsilon\theta x_1^2(1+Tx_9) + nX_{20} - x_2 X_{21}\right)}{4x_1\left(2\varepsilon x_1^2 - x_2^2\right)^2 x_9^3} -$$
$$\frac{\left((n-2n\alpha)x_2^2 + 2\varepsilon(2+\theta)x_1(\theta(2+\theta) + 2n(-1+\alpha)x_5) + T(1+\theta)X_6\right)X_{13}(-2\varepsilon\theta x_1 + \theta\lambda x_2 - TX_{17} + nX_{18}))}{4x_1\left(2\varepsilon x_1^2 - x_2^2\right)^2 x_9^3}$$

The references to the relevant parameters are given in Appendix A.

5. Analysis of Equilibrium Results

Proposition 1. The sensitivity analysis of the e-commerce platform's demand and the difference in demand with offline retailer under three sales modes with respect to λ: $\frac{\partial D_f^{WS*}}{\partial\lambda} > 0$, $\frac{\partial D_d^{AS*}}{\partial\lambda} > 0$, $\frac{\partial\left(D_f^{HS*} + D_d^{HS*}\right)}{\partial\lambda} > 0$; $\frac{\partial\left(D_f^{WS*} - D_r^{WS*}\right)}{\partial\lambda} > 0$, $\frac{\partial\left(D_d^{AS*} - D_r^{AS*}\right)}{\partial\lambda} > 0$, $\frac{\partial\left(D_f^{HS*} + D_d^{HS*} - D_r^{HS*}\right)}{\partial\lambda} > 0$.

According to Proposition 1, when the e-commerce platform undertakes CSR, the rise of the consumers' sensitivity to CSR level contributes to the increase in the demand for products on the e-commerce platform. Moreover, the gap between the product demand of the offline retailer and that of the e-commerce platform is becoming wider and wider under whichever mode. The reason is that the behavior of the e-commerce platform in undertaking CSR guarantees the authenticity of the products to a certain extent and improves the customers' satisfaction with the consumption experience. As a result, it attracts a larger number of consumers who are highly sensitive to the level of CSR. It also shows that increased consumers' sensitivity to CSR input level can effectively promote the market demand for e-commerce platform products and reduce the competitive pressure from offline retailers. Therefore, the e-commerce platform should fully utilize these core competitive advantages and seize the opportunity to expand its market size.

Proposition 2. The sensitivity analysis of the e-commerce platform's demand and the difference in demand with offline retailer under three sales modes with respect to ε: $\frac{\partial D_f^{WS*}}{\partial \varepsilon} < 0$, $\frac{\partial D_d^{AS*}}{\partial \varepsilon} < 0$, $\frac{\partial (D_f^{HS*} + D_d^{HS*})}{\partial \varepsilon} < 0$; $\frac{\partial (D_f^{WS*} - D_r^{WS*})}{\partial \varepsilon} < 0$, $\frac{\partial (D_d^{AS*} - D_r^{AS*})}{\partial \varepsilon} < 0$, $\frac{\partial (D_f^{HS*} + D_d^{HS*} - D_r^{HS*})}{\partial \varepsilon} < 0$.

From Proposition 2, when the CSR input cost coefficient of the e-commerce platform increases, the demand under either mode decreases subsequently. Also, the e-commerce platform channel brings less and less competitive pressure relative to offline retailer. This is straightforward because the increase in the CSR input cost coefficient indicates that the cost invested in selling products also rises. Then, the e-commerce platform may cut the CSR input level in order to obtain more profits, so as to reduce consumers' trust in the quality of the e-commerce platform's products as well as bring bad experiences to customers. Consequently, consumers may choose to shift towards offline retail channels to purchase products, and it also diminishes the purchase intention of certain potential consumers.

Proposition 3. The sensitivity analysis of the CSR input level and the e-commerce platform's profits under three sales modes with respect to λ: $\frac{\partial e^{WS*}}{\partial \lambda} > 0$, $\frac{\partial e^{AS*}}{\partial \lambda} > 0$, $\frac{\partial e^{HS*}}{\partial \lambda} > 0$; $\frac{\partial \pi_e^{WS*}}{\partial \lambda} > 0$, $\frac{\partial \pi_e^{AS*}}{\partial \lambda} > 0$, $\frac{\partial \pi_e^{HS*}}{\partial \lambda} > 0$.

Proposition 3 illustrates that the profits of the e-commerce platform increase as consumers' sensitivity to the CSR input level of the e-commerce platform increases, regardless of the sales mode. The reason for this is that when consumers are strongly sensitive to the CSR input level of the e-commerce platform, they will prefer the e-commerce platform with a higher CSR input level. As a result, the e-commerce platform will be more willing to make an increase in the level of CSR, thereby stimulating the amount of consumer demand and achieving an improvement in profits. It can be seen that taking responsibility for product quality problem detection and customer service is an indispensable investment for the e-commerce platform.

Proposition 4. The sensitivity analysis of the CSR input level and the e-commerce platform's profits under three sales modes with respect to ε: $\frac{\partial e^{WS*}}{\partial \varepsilon} < 0$, $\frac{\partial e^{AS*}}{\partial \varepsilon} < 0$, $\frac{\partial e^{HS*}}{\partial \varepsilon} < 0$; $\frac{\partial \pi_e^{WS*}}{\partial \varepsilon} < 0$, $\frac{\partial \pi_e^{AS*}}{\partial \varepsilon} < 0$, $\frac{\partial \pi_e^{HS*}}{\partial \varepsilon} < 0$.

The increase in CSR input cost coefficient makes the e-commerce platform's profits decrease in either mode, as shown in Proposition 4. This effect is due to the fact that the higher CSR input cost of the e-commerce platform reduces the CSR input level and then results in consumers who are sensitive to the CSR input level being reluctant to buy products from the e-commerce platform. In addition, this leads to the reduction in product demand and e-commerce platform's profits. It also suggests that if the e-commerce platform wants to achieve more profits, it has to enhance the level of its CSR input technology, make efforts to innovate, and optimize costs with the help of technological innovation.

6. Numerical Example

As the profit formulas are complex, this section discusses the impact of the above three modes on dual supply chain members through a numerical example, which is more concrete with the help of numerical values [27]. It further derives the optimal sales strategy under the situation of the e-commerce platform undertaking CSR. Referring to JD.com and Amazon e-commerce platforms, their platform commissions are distributed at 2–10% and 8–15%, based on category differences. According to the related literature [22–24,28], as well as the assumptions and ranges of values in the previous paper, it is assumed that n = 0.4, θ = 0.2, T = 0.1, α = 0.2, β = 0.5, λ = 1.5, and ε = 7.

6.1. Impact of the Potential Market Size n of E-Commerce Platform

From Figure 2, it can be seen that the potential market size of the e-commerce platform positively affects its profits, and the profits of the e-commerce platform under the three modes increase with the increase in n. With the expansion of potential market size, the profits of the e-commerce platform under the wholesale sales mode grow significantly. And when n is smaller, moderate, and larger, the most favorable sales mode for e-commerce platform are, in order, the hybrid sales mode, the agency sales mode, and the wholesale sales mode. Figure 3 shows that the profits of the offline retailer under the three sales modes decrease as n increases. The reason behind this result is that when n takes a larger value, the manufacturer may abandon the offline retail channel, and as a result, the profits of the offline retailer keep decreasing. This further confirms the conclusions related to Proposition 1 of this paper. As can be seen in Figure 4, the manufacturer's profits decrease first and then increase as n increases for all three modes. The increase in the manufacturer's profits under the agency sales mode is the largest when n is greater than a certain value. This is because when the commission is fixed, the manufacturer's sales volume significantly increases in the agency sales mode, leading to a substantial increase in profits.

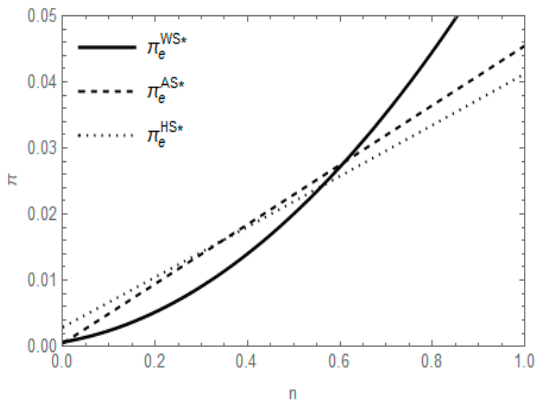


Figure 2. Impact of n on e-commerce platform's profits.

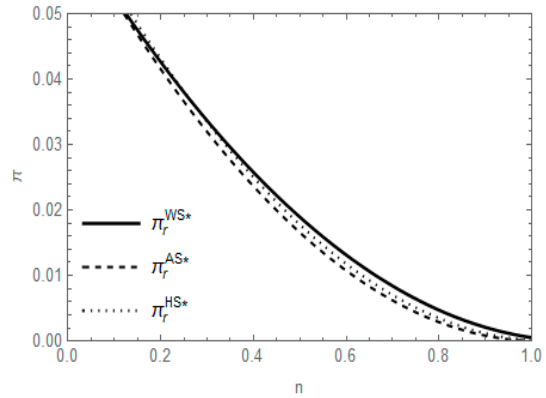


Figure 3. Impact of n on offline retailer's profits.

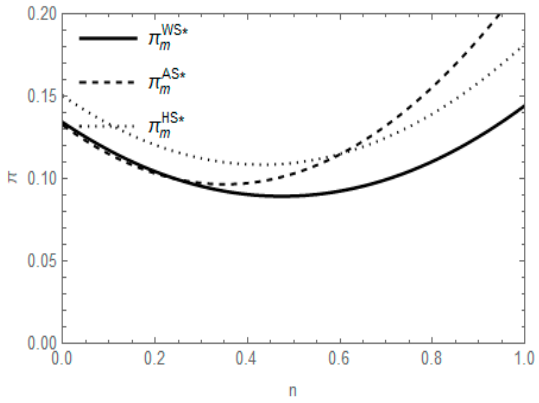


Figure 4. Impact of n on manufacturer's profits.

6.2. Impact of Consumer Sensitivity λ on CSR Input Level

As shown in Figures 5–7, the demand for the e-commerce platform increases with λ, and that of the offline retail channel decreases with λ, regardless of the mode. The reason is that the e-commerce platform is more willing to increase the CSR input level when consumers are strongly sensitive to it, and consumers are more likely to buy products from the e-commerce platform channel. It causes the demand for offline retail channel to become less and less, and the offline retailer is likely to be eliminated from the market. It can be seen that the e-commerce platform shall do well in market research to grasp consumers' sensitivity to CSR as well as the purchase desire of potential customers. Thus, it can adjust the level of CSR investment in a timely manner to ensure the realization of maximum economic benefits.

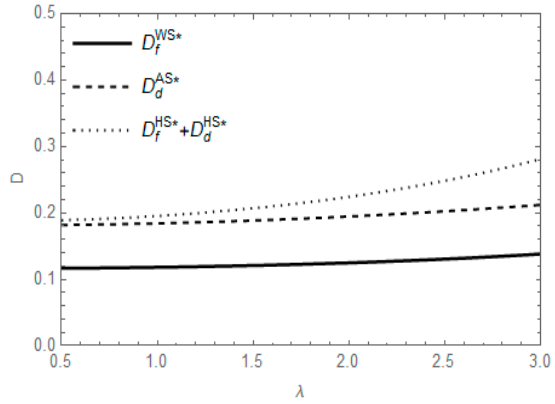


Figure 5. Impact of λ on e-commerce platform's demand.

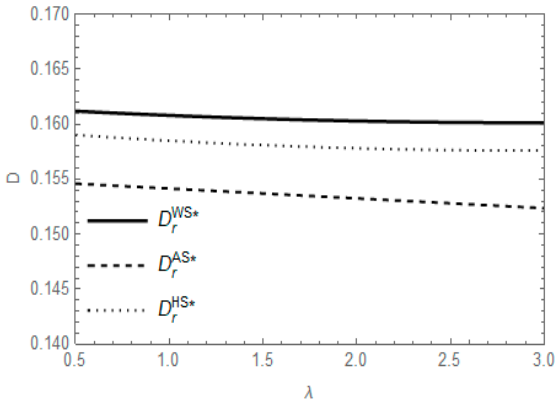


Figure 6. Impact of λ on offline retailer's demand.

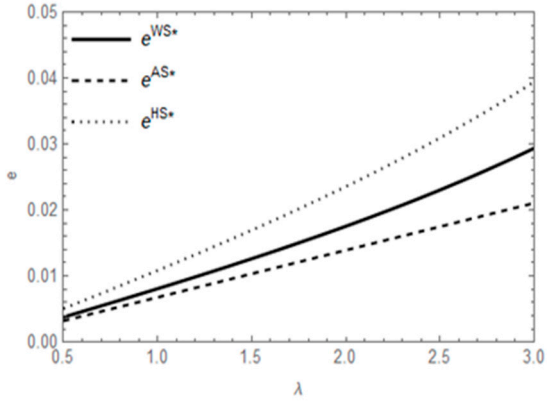


Figure 7. Impact of λ on CSR input level.

According to Figure 8, the profits of the e-commerce platform increase with the increase in λ, irrespective of the sales mode. The profits of the e-commerce platform under the hybrid sales mode grow most evidently as λ increases. Thus, the e-commerce platform will choose the hybrid sales mode when λ is larger. When λ is smaller, the e-commerce platform's profits are the largest under the agency sales mode, and it is the optimal sales mode for the e-commerce platform. Figure 9 shows that the profits of the offline retailer in all three modes keep decreasing along with the increase in λ. The reason for this is that when the e-commerce platform assumes CSR and consumers have sensitivity to the CSR input level, not only do the existing consumers shift from offline to online channels to purchase, but it also stimulates the purchase intention of the potential consumers. This further promotes the increase in sales in the online channel. By this time, it brings a huge challenge to the offline retailer so that the traditional marketing methods no longer have a competitive advantage. From Figure 10, it can be seen that the manufacturer's profits increase as λ increases. The manufacturer's profit growth under the hybrid sales mode becomes higher with larger λ. Consequently, the e-commerce platform and the manufacturer under the hybrid sales mode can simultaneously fulfill the optimal profits when consumers are deeply sensitive to the CSR input level. As a result, it is essential for win–win cooperation between the e-commerce platform and the manufacturer to consider λ when deciding on the sales mode.

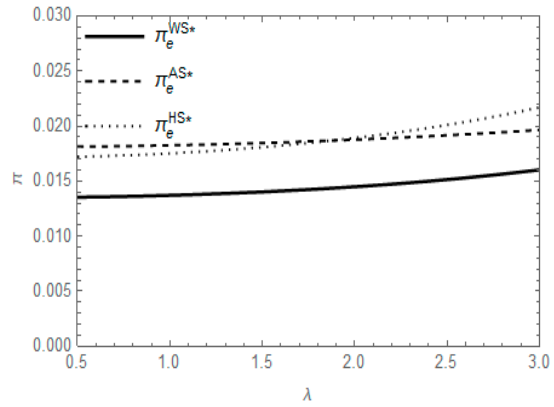


Figure 8. Impact of λ on e-commerce platform's profits.

6.3. Impact of CSR Input Cost Coefficient ε

As can be seen from Figures 11–13, the increase in ε has an unfavorable impact on the demand for its products, regardless of which mode is chosen by the e-commerce platform, while the demand in the offline retail channel increases with the increase in ε. The following reason drives this phenomenon. The e-commerce platform will consider

the cost pressure and cut down the investment in CSR input level when ε increases. In other words, the decrease in the testing level of product quality and consumer satisfaction leads to consumers being less willing to buy it from the e-commerce platform and more willing to select the offline retail channel. Also, the success rate of e-commerce platforms in developing potential customers is significantly lower. Hence, e-commerce platforms ought to focus on the efficiency of their CSR input level to prevent the cost coefficient of CSR input from being too high rather than reducing the CSR input level.

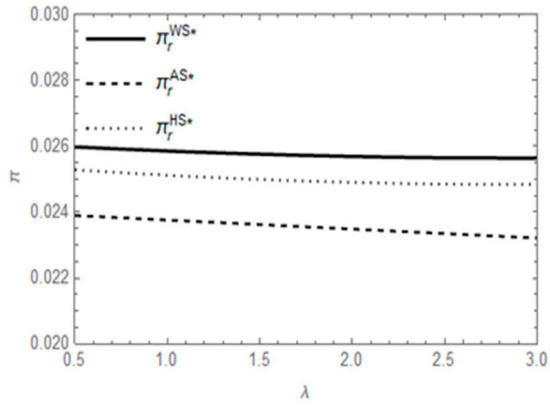


Figure 9. Impact of λ on offline retailer's profits.

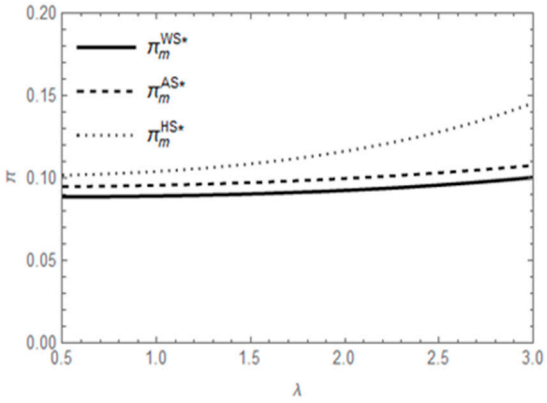


Figure 10. Impact of λ on manufacturer's profits.

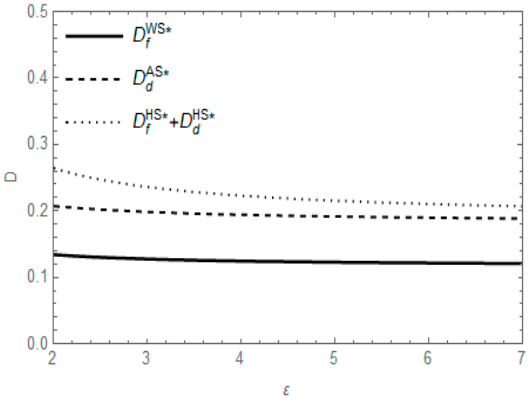


Figure 11. Impact of ε on e-commerce platform's demand.

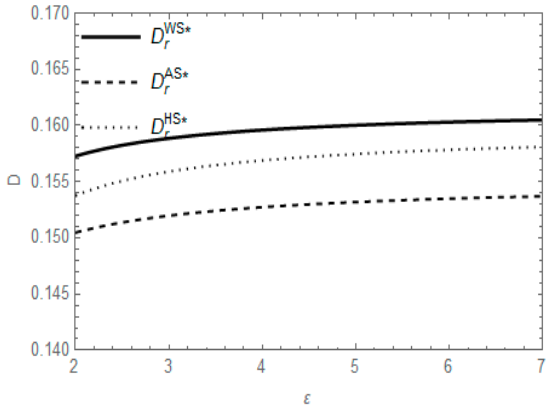


Figure 12. Impact of ε on offline retailer's demand.

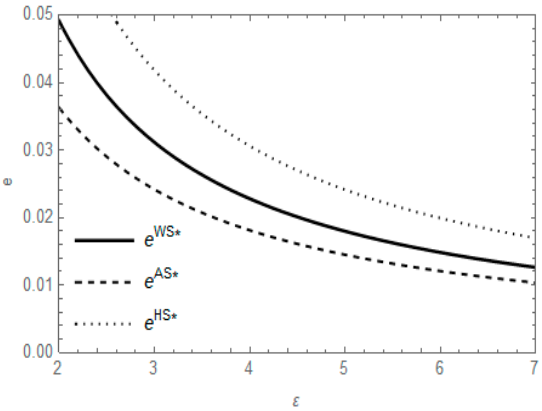


Figure 13. Impact of ε on CSR input level.

As can be seen from Figure 14, the profits of the e-commerce platform decrease with the increase in ε under either mode. The larger ε is, the higher the upfront sales cost. In order to make a profit, the e-commerce platform has to reduce the CSR input level. However, it will reduce the purchase desire of consumers who are sensitive to CSR input level. The potential customers will not consider the platform channel because of its diminished competitive advantage. Figure 15 shows that offline retailer's profits increase with the increase in ε in all three modes. This is due to the fact that the larger ε turns consumers to the offline retail channel to buy the products, and this results in higher demand and economic efficiency in the offline retail channel. Figure 16 shows that the profits of the manufacturer decrease with the increase in ε under the three modes, and the profits of the hybrid sales mode are still the largest. From the above, it can be seen that when the input cost of the e-commerce platform is high, it is not feasible to only reduce the cost of the expenditure. It undermines not only its own economic benefits but also the effectiveness of cooperation with the upstream manufacturer.

6.4. Optimal Sales Mode Selection of E-Commerce Platform

Figure 17a shows that regardless of how sensitive consumers are to CSR input level, when the potential market size of the e-commerce platform is smaller, hybrid sales mode is selected; when the potential market size of the e-commerce platform is larger, wholesale sales mode is selected. Only when consumers are less sensitive to CSR input level and the potential market size of the e-commerce platform is moderate does the e-commerce platform choose the agency sales mode. As shown in Figure 17b, regardless of the CSR input cost coefficient, when the potential market size of the e-commerce platform is smaller, the hybrid sales mode is selected; when the potential market size of the e-commerce platform is larger, the wholesale sales mode is selected. Only when the CSR input cost coefficient

is larger and the potential market size of the e-commerce platform is moderate does the e-commerce platform choose the agency sales mode. The details are shown in Table 2.

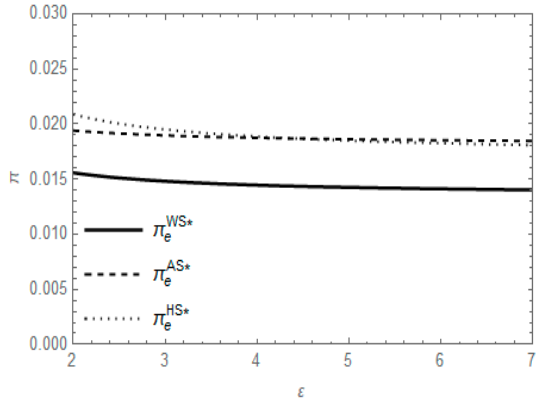


Figure 14. Impact of ε on e-commerce platform's profits.

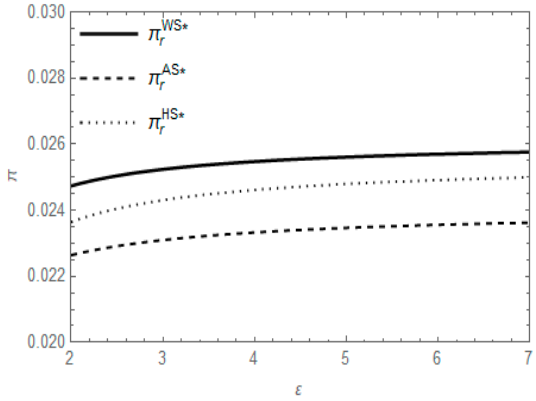


Figure 15. Impact of ε on offline retailer's profits.

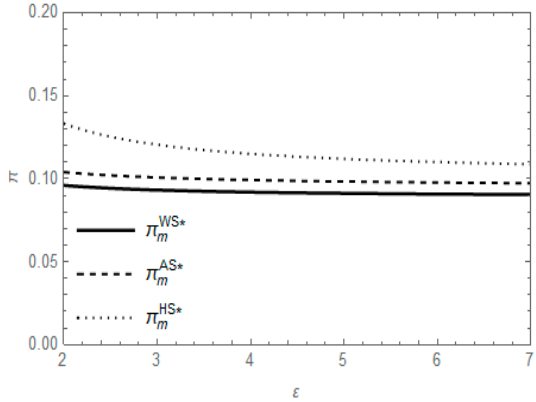
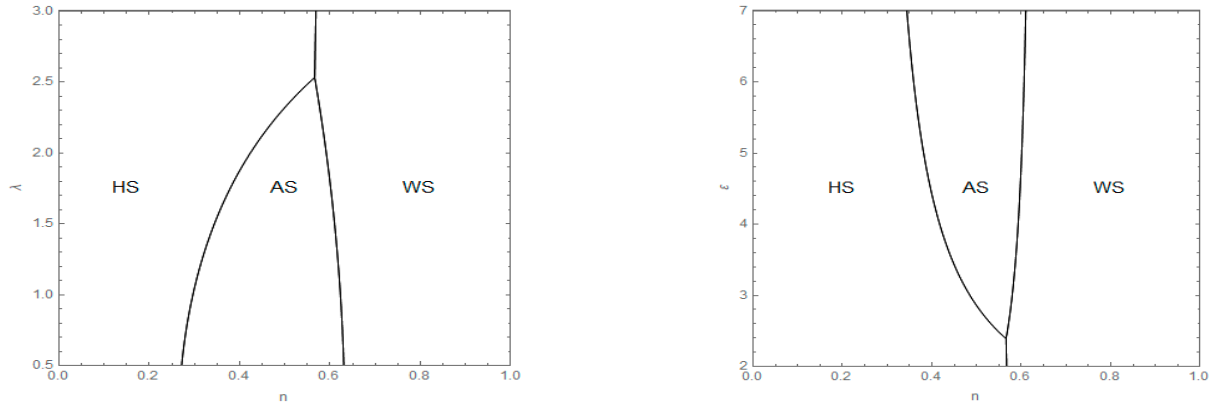


Figure 16. Impact of ε on manufacturer's profits.

Table 2. Selection of sales mode for e-commerce platform.

n	λ		ε	
	Smaller	**Larger**	**Smaller**	**Larger**
Smaller	HS	HS	HS	HS
Moderate	AS	—	—	AS
Larger	WS	WS	WS	WS



(**a**) Sales mode selection under the influence of n and λ (**b**) Sales mode selection under the influence of n and ε

Figure 17. Selection area of optimal sales mode for e-commerce platform.

7. Conclusions

This paper constructs a Stackelberg game model for wholesale sales, agency sales, and hybrid sales modes based on the assumption that the e-commerce platform undertakes CSR and analyzes the impact of the potential market size of the e-commerce platform, consumers' sensitivity to CSR input level, and CSR input cost coefficient on the selection of the optimal sales mode of the e-commerce platform and each supply chain member. The results show the following: (1) The selection of wholesale sales and hybrid sales modes is only related to the potential market size of the e-commerce platform. When the potential market size of the e-commerce platform is smaller, it will choose the hybrid sales mode; when the market size is more significant, it will choose the wholesale sales mode. When the potential market size of the e-commerce platform is moderate, consumers are less sensitive to CSR input level, or when the CSR input cost coefficient is larger, the e-commerce platform will choose the agency sales mode. (2) As the potential market size of the e-commerce platform increases, regardless of which mode the e-commerce platform opts for, its profits will increase. However, the profits of the offline retailer will decrease, and the profits of the manufacturer will decrease first and then increase. (3) As consumers' sensitivity to CSR input level increases, the profits of the e-commerce platform and the manufacturer increase, regardless of which mode the e-commerce platform opts for. However, the profits of the offline retailer decrease. In fact, the offline retailer may face the risk of being eliminated from the market. (4) As the CSR input cost coefficient increases, the profits of the e-commerce platform and manufacturer decrease, whichever mode the e-commerce platform opts for. Conversely, the profits of the offline retailer increase. Accordingly, the e-commerce platform shall seek to improve the efficiency of undertaking CSR. (5) The demand for e-commerce platform in all three sales modes increases as the potential market size of the e-commerce platform increases, the consumers' sensitivity to the CSR input level increases, or the CSR input cost coefficient decreases, and vice versa.

The following management recommendations can be made based on the above conclusions: (1) When the e-commerce platform undertakes CSR, the selection of the optimal sales mode should take into account the market share of its products and expand the market size by improving the core competitive level of CSR so that it can obtain optimal benefits. (2) When the e-commerce platform emphasizes consumer sensitivity to CSR input level, the higher consumer sensitivity to CSR input level prompts the e-commerce platform and the manufacturer to be able to achieve a win–win situation under the hybrid sales mode and can further undermine the competitiveness of offline retailers. Therefore, the e-commerce platform should fully perform market research, understand consumer sensitivity, develop potential consumers to control the CSR input level, and ultimately choose the appropriate sales mode. (3) When the e-commerce platform takes into account the CSR input cost coefficient, the increase in the CSR input cost coefficient will result in the loss of consumers

in either mode as well as hinder further market expansion. Even if the the platform is committed to CSR, it will not be able to achieve the maximum economic efficiency. Therefore, the e-commerce platform is required to improve technological means to reduce costs, thereby increasing the efficiency of undertaking CSR input and promoting the sustainable development of the platform.

This paper only studies the supply chain model of CSR undertaken by the e-commerce platform. Future research may consider the selection of sales mode in the scenario where both the e-commerce platform and the manufacturer undertake CSR at the same time and also consider the situation of uncertain demand.

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Appendix A

Table A1. $x_1 - x_{10}$ anaphoric meaning.

Parameter	Meaning	Parameter	Meaning
x_1	$-4+\theta^2$	x_6	$-2+\theta^2$
x_2	$\beta\theta-2\lambda$	x_7	$-1+\theta^2$
x_3	$-2+\theta$	x_8	$2\alpha-\theta$
x_4	$\beta-\lambda$	x_9	$-1+\theta+2\theta^2$
x_5	$-1+\theta$	x_{10}	$-1+n-T\theta$

Table A2. $X_1 - X_{20}$ anaphoric meaning.

Parameter	Meaning	Parameter	Meaning
X_1	$1+n^2(-3+\theta)x_5+\theta^2+2T\theta x_7$	X_{11}	$\alpha(8+\theta(-8+\theta(-7+\theta+\theta^2)))-T(-1+2\alpha){x_2}^2$
X_2	$T^2(2-3\theta^2+\theta^4)-2nx_5(x_5+Tx_3(1+\theta))$	X_{12}	$\varepsilon(32+\theta(-32-32\theta+5\theta^3+\theta^4))-(3+\theta){x_2}^2$
X_3	$\beta(1-n{x_7}^2+\theta(\theta+Tx_7))-2(n+\theta-n\theta+Tx_7)\lambda$	X_{13}	$-(1-2\theta)^2x_3(1+\theta)^2(2+\theta)$
X_4	$x_7-4\beta\theta\lambda+2\lambda^2$	X_{14}	$2\varepsilon{x_1}^2(-x_5+n(-1+2\theta))-x_2n\beta(2\alpha x_5+\theta^2)$
X_5	$4(-1+\alpha)\varepsilon x_3x_7(2+\theta)^2-(-1+2\alpha){x_2}^2$	X_{15}	$x_5+n+2n(-1+\alpha)\theta+\theta^2-n\theta^2$
X_6	$2\varepsilon x_3(2+\theta)^2(-2+3\theta)-(5+\theta){x_2}^2)$	X_{16}	$(1+\theta)(-8+\theta^2)(\beta x_5+2\theta\lambda)$
X_7	$2+2T\theta(1+\theta)+n(-2+\alpha\theta)$	X_{17}	$(1+\theta)(2\varepsilon(-1+2\theta){x_1}^2-x_2(\beta\theta(-9+\theta(2+\theta))+10\lambda-\theta(4+\theta)\lambda))$
X_8	$n\alpha\beta+\lambda-n\lambda+T(1+\theta)(4\beta-\theta\lambda)$	X_{18}	$-2(-1+\alpha)\varepsilon(-1+2\theta){x_1}^2+x_2(\beta\theta(1-3\alpha-\theta+2\alpha\theta)+(-2+4\alpha+3\theta-4\alpha\theta)\lambda)$
X_9	$-\varepsilon\theta^2-n^2\varepsilon{x_8}^2+2T\varepsilon\theta(1+\theta)(-8+\theta^2)$	X_{19}	$n\varepsilon x_8x_1+\varepsilon\theta{x_1}(1+T\theta(1+\theta))-T(1+\theta){x_2}^2$
X_{10}	$-2\varepsilon\theta x_8+2T\varepsilon(-16-\theta(1+2\theta)(-8+\theta^2)$	X_{20}	$-2\alpha\varepsilon(-1+2\theta){x_1}^2+\alpha\theta(\beta+2\beta\theta-4\lambda x_2-\theta x_2(\beta\theta-\lambda)$
X_{21}	$-\theta\lambda+T(1+\theta)(\beta\theta(-8+\theta(-1+3\theta))+(8+(2-5\theta)\theta)\lambda)$		

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