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Pricing and Service Decisions of Products in a Dual-Channel Supply Chain Introducing Ship-to-Store

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Abstract: This study investigates the optimal pricing and service decisions when implementing ship-to-store (STS) in a dual-channel supply chain comprising one BM store and one manufacturer. Homogeneous products within the market are categorized into mainstream and niche products. The effects of consumer service sensitivity, channel preference, and degree of personalization on optimal decisions and profitability are analyzed, followed by numerical simulation and analysis. It is found that (1) the supply chain should charge high prices for mainstream products and low prices for niche products to maximize profits. (2) Implementing STS is conducive to expanding niche products in the market when facing highly service-sensitive consumer groups. (3) Based on highly service-sensitive consumer segments, supply chains are more profitable implementing STS strategies in a centralized decision-making model than in a traditional dual-channel one; however, under decentralized decision-making, it is only profitable to implement an STS strategy if consumers have a low level of personalization and have a particularly pronounced preference for online direct marketing channels.

Keywords: Dual-channel, Ship-to-store, Pricing and service decisions, Niche product.

1. Introduction

As of the first half of 2023, the size of China's Internet users totaled 1.079 billion, and the size of online shopping users accounted for 82.0% of the overall Internet users (1). The development and popularity of the Internet have changed consumer preferences and shopping habits, and retailers and manufacturers have begun to collaborate on various omnichannel strategies to provide consumers with a seamless shopping experience in response to the new retail environment. Bell (2) concluded the current Omnichannel retail comprises four distinct approaches to customer engagement and fulfilment: traditional retail stores; online sales plus physical showrooms where customers can engage with products; online sales with in-store pickup; and pure-play e-commerce, in which both fulfilment and engagement occur online. BOPS (Buy Online and Pick-up in Store) and STS(Ship-to-Store) are the leading representatives of online sales with in-store pickup.

In the fast fashion industry, many companies have adopted an omnichannel strategy. For example, companies such as Uniqlo, HLA, and PEACEBIRD have adopted the BOPS strategy, while companies such as Zara and H&M have opted for the STS strategy. Although the BOPS strategy is more widely used, it has some limitations. The BOPS channel utilizes the BM store's inventory to fulfill the order task, which means that the BM store must maintain high inventory levels to satisfy consumer demand. However, high inventory levels not only increase inventory costs but also tend to cause inventory backlog problems (3). At this point, introducing STS may become an effective way to solve the drawbacks of BOPS. From an inventory perspective, the BOPS channel uses the inventory of the BM store to complete orders, while the STS channel uses distribution centers to complete order tasks. For the BM store, implementing STS can not only effectively link inventory pressure but also reduce the 'last mile' cost from the BM store to the consumer (4).

In addition, retailers should consider market segmentation when adopting omnichannel strategies. Products in the market can be divided into niche and mainstream products through market segmentation. Mainstream products refer to a few items that dominate the majority of market share, while products with more variety but more minor market shares are classified as niche products (5). For example, in the fast fashion industry, some homogeneous products will attract most consumers due to color, size, or style, while the remaining products are only accepted by a smaller consumer group. However, in recent years, with the advancement of information technology and the evolution of consumer demand, the market share of niche products has been gradually increasing. Therefore, retailers and manufacturers must pay sufficient attention to niche products when transitioning to an omnichannel strategy to ensure appropriate channel allocation.

2. Related Literature

This paper's research focuses primarily on two key areas. First, it delves into the impact of implementing STS on profits and product demand. Second, it explores the varying product types across different channels within the context of STS.

Firstly, when deciding whether or not to introduce an STS strategy, retailers must first consider whether the implementation of the strategy will result in higher or maintained normal profit levels. To address this issue, Gallino et al. (6) analyzed data from a large U.S. housewares retailer that introduced STS, which allows customers to ship products to their local store free of charge when they are unavailable at their local store. There was no evidence that STS significantly impacted the retailer's sales after the implementation of STS, but found that STS significantly increased the retailer's sales dispersion. Expressly, sales of best-selling products before the implementation of the strategy declined, while products that had been selling at lower levels increased. And then Akturk et al. (7) conducted an empirical study on a jewelry retailer, which showed that implementing the STS increased sales in

BM stores, but online sales decreased. By analyzing the transaction data in detail, Akturk et al. found that after the implementation of STS, some online consumers shifted to offline purchases, especially when purchasing high-value products. In contrast, the consumers who shopped through the STS channel were mainly focused on low-value products. Regarding theoretical research, most scholars explore the impact of implementing STS from the inventory perspective. For example, Yang and Zhang (8) found that retailers with fast response times tend to reduce the inventory of BM stores if they adopt STS. Wang et al. studied retailers who implement both STS and SFS strategies through the Newsvendor Model, and they similarly support the idea that STS reduces the inventory of BM stores, and after further research, they found that, for the retailers with multiple BM stores, BM stores in different geographic locations should implement different omnichannel strategies. Specifically, BM stores in busy areas should implement STS, whereas BM stores in peri-urban areas are more suitable for SFS, which can minimize inventory costs. In addition, Yang et al. (10) likewise considered the case of mixing STS with other omnichannel strategies, mainly BOPS-STS and BOSS-BOPS-STS hybrid strategies. By comparing with BOPS, it was found that both hybrid strategies can expand the market for time-sensitive or experiential products.

Secondly, some scholars have studied the types of products in each channel under STS. Gallino et al. proved through empirical studies that the implementation of STS is favorable to the market expansion of niche products. Akturk et al. pointed out that the STS channel is dominated by the consumer groups that buy low-value products. Then, Ertekin, N. et al. (11) proved from both theoretical models and empirical studies that the type of online-exclusive (i.e., products available only online) and hybrid (i.e., products available both online and offline) affects the effectiveness of the implementation of STS. The study's results suggest that to improve the effectiveness of STS, omnichannel retailers should use products with high versatility, low price, and sufficient in-store supply as online-exclusive products and products with uniqueness, high price, and limited in-store supply as hybrid products.

Literature on STS mainly focuses on inventory research, and many scholars have proved through empirical research or theoretical models that the implementation of STS can effectively reduce the inventory pressure of BM stores. Some scholars have also considered the issue of product types in each channel under the implementation of STS. However, the current research on omnichannel mainly focuses on BOPS, and not many studies have been conducted on STS, while the studies considering product types under STS are even scarcer. This paper combines the long-tail phenomenon in the market, divides homogeneous products into mainstream and niche products, and proposes that niche products be sold in online channels while mainstream products are sold in both online and offline channels. This is because Brynjolfsson et al. (12) demonstrated that online channels face significant competition from BM stores when selling mainstream products but are virtually unaffected when selling niche products. The problem addressed in this paper is whether a dual-channel supply chain composed of manufacturers and retailers operating within the specified market environment should adopt STS under traditional dual-channel, and the optimal decisions and implications of implementing STS.

3. Problem Description

This paper considers a two-tier supply chain composed of a BM store and a manufacturer, where the BM store is responsible for offline channel demand, and the manufacturer handles online channel demand. The online channel accounts for θ of the total market demand, while the offline market accounts for $(1-\theta)$ of total demand. Additionally, we consider a market with total demand a, where two homogeneous products exist: Product 1 and Product 2. Product 1 is a niche product aimed at satisfying consumers' personalized needs, while Product 2 is mainstream. Since demand for Product 1 is lower, to avoid inventory backlog for the BM store, we assume that Product 1 is not available for sale through the BM store. The channels of sales for Product 1 can be divided into two cases depending on whether the supply chain adopts STS. In the first case, when the supply chain does not implement STS, Product 1 is sold exclusively through the online direct sales channel. In the second case, after the supply chain adopts STS, Product 1 is available through online direct sales and STS channels. For Product 2, regardless of whether the supply chain adopts STS, its sales channels include both online and offline direct sales channels. Both Product 1 and Product 2 can be sold through the online direct sales channel. Assume that Product 1 occupies θ_1 of the online direct sales channel demand, where a larger θ_1 indicates a higher degree of consumer personalization. Correspondingly, the proportion of demand for Product 2 in the online direct sales channel is $(1-\theta_1)$. After the supply chain implements STS, consumers can purchase Product 1 through the "buy online, pick up in-store" option. Whether consumers choose to purchase Product 1 through the STS channel depends on the channel preference of consumers. Suppose the proportion of online market demand prefers the online direct sales channel is λ, then the proportion of consumers who prefer to purchase Product 1 through the STS channel is $(1-\lambda)$.

Based on practical considerations and research feasibility, the assumptions in this paper are as follows:

1) Assumed that a uniform pricing strategy is applied to both Product 1 and Product 2 across online and offline channels.

2) Assumed that the level of service provided by the physical retailer is l, and the associated service cost is $c(l)=\frac{l^2}{2}$.

3) Assumed that Product 1 and Product 2 are homogeneous products, with a uniform manufacturing cost of $c_1=c_2=0$.

4) Assumed that $\beta_1>\beta_2, \beta_{21}>\beta_{12}, \min\{\beta_1,\beta_2\}>\max\{\beta_{12},\beta_{21}\}$.

5) Assumed no stockouts or returns in online or offline channels.

6) Assumed that each consumer purchases only one unit of the product.

The demand under the traditional dual-channel and the STS model, based on different strategies implemented by supply chain members, can be described as follows:

(1) Traditional Dual-Channel Model

In the traditional dual-channel model, Product 1 is sold exclusively through the online direct sales channel, while Product 2 is available online and offline direct sales channels. Depending on the product and the consumer's shopping

channel, consumer demand in the traditional dual-channel model can be categorized into the following three types:

Demand for Product 1 through the online direct sales channel is given by:

$$D_{1o}^{B} = \theta\theta_1 a - \beta_1 p_1 + \beta_{21} p_2$$

Where:

p_1 is the price of Product 1

p_2 is the price of Product 2

β_1 is the sensitivity of Product 1's price on its demand

β_{21} is the cross-price elasticity, reflecting the impact of Product 2's price on the demand for Product 1.

Demand for Product 2 through the online direct sales channel is given by:

$$D_{2o}^{B} = \theta(1-\theta_1)a - \beta_2 p_2 + \beta_{12} p_1$$

Where:

β_2 is the sensitivity of Product 2's price on its demand

β_{12} is the impact of Product 1's price on Product 2's demand.

Demand for Product 2 through the offline direct sales channel is given by:

$$D_{2s}^{B} = (1-\theta)a - \beta_2 p_2 + \beta_{12} p_1 + ml$$

Where:

m is the consumer sensitivity to the level of service l provided by the BM store.

(2) STS

After implementing STS, Product 1 is available sold through both the online direct sales channel and the STS channel, while Product 2 continues to be sold through the online direct sales channel and the offline direct sales channel. Based on different products and shopping channels, consumer demand under STS can be categorized as follows:

Demand for Product 1 through the online direct sales channel is given by:

$$D_{1o}^{T} = \theta\lambda\theta_1 a - \beta_1 p_1 + \beta_{21} p_2$$

Demand for Product 1 through the STS channel is given by:

$$D_{1t}^{T} = \theta(1-\lambda)a - \beta_1 p_1 + \beta_{21} p_2 + ml$$

Demand for Product 2 through the online direct sales channel is given by:

$$D_{2o}^{T} = \theta\lambda(1-\theta_1)a - \beta_2 p_2 + \beta_{12} p_1$$

Demand for Product 2 through the offline direct sales channel is given by:

$$D_{2o}^{T} = \theta\lambda(1-\theta_1)a - \beta_2 p_2 + \beta_{12} p_1$$

In the optimal value of the solution, $*$ in the superscript represents the optimal value; c, d in the subscript represents the centralized and decentralized decision-making modes, respectively. π, π_1, π_2 represent supply chain system profit, manufacturer profit, and retailer profit, respectively.

4. Modeling Framework

4.1. Centralized Decision-making Model

When the supply chain adopts a centralized decision-making model, The leader in the supply chain makes decisions on the price of products and level of service based on profit maximization in the supply chain system. In this paper, the retailer is the decision maker in the supply chain system and is responsible for setting the price of Product 1, the price of Product 2, and the level of service in the retailer. To examine the impact of STS on product pricing, the level of service, and overall profitability in a centralized supply chain, this paper develops a decision-making framework incorporating both traditional dual-channel and STS strategies.

4.1.1. Traditional Dual Channel Strategy

When the supply chain adopts the traditional dual-channel strategy, the sales channels of Product 2 include the online direct sales channel and the offline direct sales channel, whereas Product 1 can only be sold in the online direct sales channel. The supply chain system profit function π_c^B consists of the sales profit of Product 1 and Product 2 and the service cost of the retailer, which can be expressed as:

$$\pi_c^B = p_{c1}^B D_{1o}^B + p_{c2}^B (D_{2o}^B + D_{2s}^B) - c(l_c^B) \quad (1)$$

When the supply chain system adopts the traditional dual-channel strategy under the centralized decision-making mode, the Hessian matrix of the supply chain system's profit function $\pi_c^B(p_{c1}^B, p_{c2}^B, l_c^B)$ is negative definite under the condition of $8\beta_1\beta_2 - (\beta_{21} + 2\beta_{12})^2 - 2m^2\beta_1 > 0$, i.e., π_c^B is a joint concave function concerning, and there exists p_{c1}^{B*}, p_{c2}^{B*}, l_c^{B*} so that the profit function π_c^B reaches the maximum value.

4.1.2. STS

When the supply chain introduces the STS strategy on top of the traditional dual-channel model, Product 1 can be sold through the online direct and STS channels. However, for every unit of Product 1 sold in the STS channel, the manufacturer has to bear t transportation costs. The supply chain system profit π_c^T consists of the sales profit of Product 1 and Product 2, the transportation cost of the STS channel, and the service cost of the retailer, which can be expressed as follows:

$$\pi_c^T = p_{c1}^T D_{1o}^T + (p_{c1}^T - t) D_{1t}^T + p_{c2}^T (D_{2o}^T + D_{2s}^T) - c(l_c^T) \quad (2)$$

When the supply chain system adopts the traditional dual-channel strategy under the centralized decision-making mode, the Hessian matrix of the supply chain system profit function $\pi_c^T(p_{c1}^T, p_{c2}^T, l_c^T)$ is negative definite under the condition of $4\beta_1\beta_2 - (\beta_{21} + \beta_1 + \beta_2 + \beta_{12})m^2 - \beta_{21}^2 - 2\beta_{12}\beta_{21} - \beta_{12}^2 > 0$, i.e., $\pi_c^T(p_{c1}^T, p_{c2}^T, l_c^T)$ is a joint concave function about $p_{c1}^T, p_{c2}^T, l_c^T$, and there exists price p_{c1}^{T*}, p_{c2}^{T*}, and l_c^{T*} so that the supply chain profit π_c^T function reaches the maximum value.

4.2. Decentralized Decision-making Model

When the supply chain system implements a decentralized decision-making model, the manufacturer and the retailer make decisions based on the principle of maximizing their respective profits, where the manufacturer is responsible for setting the price of Product 1, and the retailer is responsible for setting the price of Product 2 and the level of service in the BM store. In this paper, the retailer is the leader and the manufacturer is the follower. The order of the game between

the manufacturer and the retailer is as follows: firstly, the retailer sets the price of Product 2 and the level of service in the BM store, and then the manufacturer sets the price of Product 1. This is because BM stores are directly facing the final consumers and can obtain real-time consumer preferences and market feedback, which enables retailers to quickly make pricing and service strategies that better meet the market and consumer needs, which also satisfies the concept of consumer-centered marketing.

In this paper, we adopt the backward induction method to solve the optimal price of Product 1, the optimal price of Product 2 and the optimal level of service under the decentralized decision-making model. The specific solution steps are as follows: firstly, we use the manufacturer's profit function to obtain the optimal price of Product 1 response function $p_1(p_2,l)$ concerning p_2 and l, then we bring $p_1(p_2,l)$ into the retailer's profit function to obtain the optimal price of Product 2 p_{d2}^* and the optimal level of service l_d^*, and finally, we bring p_{d2}^* and l_d^* into $p_1(p_2,l)$ to obtain the optimal price of Product 1.

4.2.1. Traditional Dual Channel Strategy

When the supply chain system adopts the traditional dual-channel strategy under the decentralized decision-making model, the manufacturer's profit includes the profit from selling Product 1 and Product 2 in the online direct channel and the profit from distributing Product 2 to the retailer, while the retailer's profit includes the profit from selling Product 2 in the offline direct channel, the wholesale cost of Product 2, and the cost of the paid services. Then, the manufacturer's profit function is:

$$\pi_{d1}^B = p_{d1}^B D_{1o}^B + p_{d2}^B D_{2o}^B + wD_{2s}^B \tag{3}$$

The retailer's profit function is:

$$\pi_{d2}^B = (p_{d2}^B - w)D_{2s}^B - c(l_d^B) \tag{4}$$

When the supply chain system adopts the traditional dual-channel strategy under the decentralized decision-making model, the manufacturer's profit function π_{d1}^B is a concave function concerning the price of Product 1 p_{d1}^B, i.e., there exists an optimal price of Product 1 p_{d1}^{B*} that maximizes the manufacturer's profit function. While the retailer profit function π_{d2}^B satisfies the condition of $2\beta_1\beta_2 - \beta_{12}^2 - \beta_{12}\beta_{21} - m^2\beta_1 > 0$, the Hessian matrix of the retailer profit function π_{d2}^B concerning p_{d2}^B, l_d^B is negative definite, i.e., π_{d2}^B is a joint concave function concerning p_{d2}^B, l_d^B, and there exists p_{d2}^{B*} and l_d^{B*} to maximize the retailer profit function π_{d2}^B.

4.2.2. STS model

When the supply chain system adopts the STS strategy under the decentralized decision-making model, Product 1 can be sold through the online direct sales channel and the STS channel, in which the profit from the sales in the STS channel is credited to the manufacturer, but at the same time, the manufacturer has to bear the cost of products transportation generated by the STS channel. Then, the manufacturer's profit function is:

$$\pi_{d1}^T = p_{d1}^T D_{1o}^T + (p_{d1}^T - t)D_{1t}^T + p_{d1}^T D_{2o}^T + wD_{2s}^T \tag{5}$$

The retailer's profit function is:

$$\pi_{d2}^T = (p_{d2}^T - w)D_{2s}^T - c(l_d^T) \tag{6}$$

When the supply chain system adopts the STS strategy under the decentralized decision-making mode, the manufacturer's profit function π_{d1}^T is a concave function concerning the price of Product 1 p_{d1}^T, i.e., there exists an optimal price of Product 1 p_{d1}^{T*} to maximize the manufacturer's profit function. The retailer profit function π_{d2}^T under the condition of satisfying, the Hessian matrix of the retailer profit function π_{d2}^T for p_{d2}^T, l_d^T is negative definite, i.e., π_{d2}^T is a joint concave function concerning p_{d2}^T, l_d^T, and there exists an optimal price of Product 2 p_{d2}^{T*} and an optimal level of service l_d^{T*} that maximizes the retailer profit function.

5. Sensitivity Analysis

5.1. Consumer Service Sensitivity

There exist $\frac{\partial p_{c1}^{B*}}{\partial m} > 0, \frac{\partial p_{c2}^{B*}}{\partial m} > 0, \frac{\partial l_c^{B*}}{\partial m} > 0, \frac{\partial \pi_c^B}{\partial m} > 0;$

And there exist $\frac{\partial p_{d1}^{B*}}{\partial m} > 0, \frac{\partial p_{d2}^{B*}}{\partial m} > 0, \frac{\partial l_d^{B*}}{\partial m} > 0,$ if $a > \frac{w(2\beta_1\beta_2 - 2\beta_{12}^2 - \beta_{12}\beta_{21})}{\beta_{12}\theta\theta_1 - 2\theta\beta_1 + 2\beta_1}$.

Proposition 1 According to Proposition 1, it can be concluded that when a supply chain implements a traditional dual-channel strategy, whether the decision is centralized or decentralized, the consumer service-sensitivity coefficients positively affect the price of products, the level of service, and the profitability of the supply chain system under certain conditions.

As consumers become more sensitive to the service, they are willing to pay extra for the high quality of service provided by the BM store. As a result, higher profits can be achieved by raising product prices. To attract and retain these highly service-sensitive consumers, retailers will invest more costs to improve the level of service in their stores. This includes investments in training service personnel, renovating stores, and updating hardware facilities. By improving the level of services, retailers are not only able to attract and secure such consumers, but also maximize profits by charging them higher prices. When consumers' service sensitivity reaches a certain level, i.e., $\max\{\beta_{12},\beta_{12}\} < m < \min\{\beta_1,\beta_2\}$, the main factors influencing the purchasing decision of consumers who come to a BM store to buy Product 2 are, in descending order, Product 2 price, the BM store the level of service, and the price of Product 1. For highly service-sensitive consumers, a situation may arise where consumers choose to buy Product 2 in a BM store even though the price of Product 1 is lower than the price of Product 2 because they are willing to pay a higher price for the service within the retailer. The retailer, in turn, will take the opportunity to charge a higher price for Product 2 to make more profit. This explains the phenomenon that in fast fashion, where highly service-sensitive consumers are predominant, products in BM stores are generally sold at slightly higher prices than their online counterparts. However, the high price of Product 2 may put it at a disadvantage in the competition in the online market, which dominates it. Therefore, the overall market demand for

Product 2 is likely to be lower.

5.2. Sensitivity Analysis of Consumer Channel Preferences

There exist $\frac{\partial l_c^{T*}}{\partial \lambda} > 0, \frac{\partial p_{d1}^{T*}}{\partial \lambda} < 0, \frac{\partial p_{d2}^{T*}}{\partial \lambda} < 0, \frac{\partial l_d^{T*}}{\partial \lambda} < 0,$

And there exist $\frac{\partial p_{c1}^{T*}}{\partial \lambda} < 0, \frac{\partial p_{c2}^{T*}}{\partial \lambda} > 0.$ if $m^2 < 2\beta_2 - \beta_{12} - \beta_{21},$

Proposition 2: The above equation shows that after the supply chain adopts the STS strategy, in the centralized decision-making mode, when certain conditions are met, the price of Product 1 is negatively related to the consumer's preference for the online direct marketing channel, and the price of Product 2, as well as the level of service, are positively related to the consumer's preference for the online direct marketing channel. However, in the decentralized decision-making model, the price of Product 1, the price of Product 2, and the level of service are negatively related to consumer preference for online direct marketing channels.

After the implementation of the STS strategy, all other things being equal, the degree of consumer online direct sales channel preference increases, which means that the demand for the online direct sales channel in the market rises; in contrast, the demand for the STS channel decreases accordingly. Since Product 1 accounts for a relatively small share of the online direct sales channel and the STS channel only offers Product 1, the overall demand for Product 1 will show a downward trend as consumer preference for the online direct sales channel strengthens, while the overall demand for Product 2 will show an upward trend.

In the centralized decision-making model, the goal is to maximize the profit of the supply chain system. The demand for Product 1 is more sensitive to price, so it can maximize profit by lowering the price to attract more consumers. Consumers are willing to pay a higher price to enjoy in-store services when they buy Product 2 from a BM store, so Product 2 can realize profit growth by increasing the price.

In the decentralized decision-making model, a decrease in demand in the STS channel represents a decrease in foot traffic at the retailer, and the retailer will correspondingly reduce the level of in-store service based on maximizing its profits. However, the reduction in the level of services may result in the loss of the highly service-sensitive segment of the retailer's Product 2 purchases, and the retailer may choose to reduce the selling price of Product 2 to regain this segment of consumers. As a follower in the market, the manufacturer may adopt a price reduction strategy to increase the competitiveness of Product 1 to maintain its market share after the retailer has decided to reduce the price of Product 1.

5.3. Sensitivity Analysis of the Personalization of Consumer

There exist $\frac{\partial l_c^{T*}}{\partial \theta_1} < 0, \frac{\partial p_{d1}^{B*}}{\partial \theta_1} > 0, \frac{\partial p_{d2}^{B*}}{\partial \theta_1} > 0, \frac{\partial l_d^{B*}}{\partial \theta_1} > 0, \frac{\partial p_{d1}^{T*}}{\partial \theta_1} > 0, \frac{\partial p_{d2}^{T*}}{\partial \theta_1} > 0, \frac{\partial l_d^{T*}}{\partial \theta_1} > 0$;

There exist $\frac{\partial p_{c1}^{B*}}{\partial \theta_1} > 0, \frac{\partial p_{c1}^{T*}}{\partial \theta_1} > 0, \frac{\partial p_{c2}^{T*}}{\partial \theta_1} < 0$, if $m^2 < 2\beta_2 - \beta_{12} - \beta_{21}$

There exist $\frac{\partial p_{c2}^{B*}}{\partial \theta_1} < 0, \frac{\partial l_c^{B*}}{\partial \theta_1} < 0$, if $\beta_1 > \beta_{12} + \frac{\beta_{21}}{2}$.

Proposition 3: Under the centralized decision-making model, when certain conditions are met, the optimal price of Product 1 is positively related to the degree of consumer personalization, and the price of Product 2 and the level of service is negatively related to the degree of consumer personalization. In the decentralized decision-making mode, the optimal price of products and the level of service always increase with consumer personalization. In addition, all other things being equal, an increase in the degree of consumer personalization leads to a rise in the demand for Product 1 and a decrease in the demand for Product 2 in the market.

In the centralized decision-making model, under the premise of no other changes in conditions and considering only the impact of price and the level of service on market demand, a supply chain that raises the price of Product 1, lowers the price of Product 2, and simultaneously reduces the level of service will result in a decrease in demand for Product 1, while the change in demand for Product 2 is uncertain. When the increase in demand for product 2 caused by a fall in the price of product 2 and a rise in the price of product 1 is greater than the decrease in demand caused by a fall in the level of service, the demand for product two is in an upward spiral, and conversely in a downward spiral. If the market is in a state of falling demand for Product 1 and rising demand for Product 2, it may be because the profit per unit of Product 1 is lower than the profit per unit of Product 2. In a traditional dual-channel strategy, this may be due to the price of Product 1 being lower than the price of Product 2, whereas in an STS strategy, this may be due to the transportation costs in the STS channel or the lower price of Product 1. In addition, the lower profit of Product 1 compared to Product 2 can be explained by the change in the level of service, where, all other things being equal and the degree of consumer personalization increasing, there is more demand for Product 1 and less demand for Product 2 in the market, which can lead to a downward trend in the profit of the supply chain system. To maintain the original profit level, the supply chain may lower the level of service appropriately to reduce the service cost.

In the decentralized decision-making model, when the increase in the price of Product 2 can compensate for the loss of profit caused by the decrease in sales volume and the increase in the level of service, the retailer will increase the price of Product 2 to obtain higher profit and take measures to improve the level of service to attract and retain the group of high service-sensitive consumers. After the retailer raises the price of Product 2, the competition between Product 2 and Product 1 in the online channel demand is at a disadvantage, leading to an increase in the market share of Product 1. However, this change is detrimental to the manufacturer when the profit per unit of Product 1 is lower than that of Product 2. To cope with the unfavorable situation brought about by the increase in the share of Product 1, the manufacturer may raise the price of Product 1 by a significant amount and at a rate higher than the rate of the price increase of Product 2, which on the one hand serves to raise the profit per unit of Product 1, and on the other hand, suppresses the growth of the demand for Product 1.

6. Numerical Simulation and Analysis

In this section, we further analyze consumer channel preference, service sensitivity and personalization through

numerical examples and study the trends of optimal price, optimal level of service, market demand, and supply chain profit in the traditional dual-channel strategy and the STS strategy under the implementation of different decision-making modes in the supply chain system. According to the range of values of model variables, it is assumed that the base parameters are: $a=100, \theta=0.7,$ $\beta_1=3, \beta_2=2, \beta_{12}=0.7, \beta_{21}=1, w=5, t=1$.

6.1. Sensitivity Analysis of Consumer Services

$\theta_1=0.7, \lambda=0.3$, The range of m is $(0,1.21)$, and the trends of optimal price, the level of service, market demand, and profit of the supply chain system are shown in Figure 1.

Figure 1 illustrates the impact of consumer service sensitivity coefficients on prices of products, the level of services, market demand, and supply chain system profits, which is consistent with the conclusions in Proposition 1. In addition, the following conclusions can be drawn from Figure 1:

(1) For the demand of Product 1, the supply chain's adoption of STS favors Product 1 market expansion, partly due to the opening of STS channels and partly due to the low price and high level of service of Product 1 under the implementation of STS. However, for the demand of Product 2, the supply chain's adoption of the STS strategy is beneficial to market growth under centralized decision-making. However, it is detrimental to market growth under decentralized decision-making. The main reason is that compared with the decentralized model, the level of service and the price of Product 1 increase faster under the centralized decision-making, which brings about a higher demand rise than the demand fall caused by the price increase of Product 2, so the demand for Product 2 rises. In contrast, the opposite is valid under decentralized decision-making, which ultimately leads to a decline in the demand for Product 2.

(2) Whether it is a traditional dual-channel or STS strategy, the profit under the centralized decision-making mode is always higher than the decentralized decision-making mode. When implementing traditional dual-channel, compared with decentralized decision-making, centralized decision-making does not have an advantage in market demand, but gains high profits by high prices. When implementing STS, when facing low service-sensitive groups, the price of products under centralized decision-making is lower than in decentralized decision-making, the market advantage is not obvious, and the level of service is very high. The above reasons lead to no obvious gap between the profits under the two decision-making models. When facing highly service-sensitive groups, the price of the centralized decision is reversed. The market advantage is fully utilized, and the overall profit is higher than the decentralized decision.

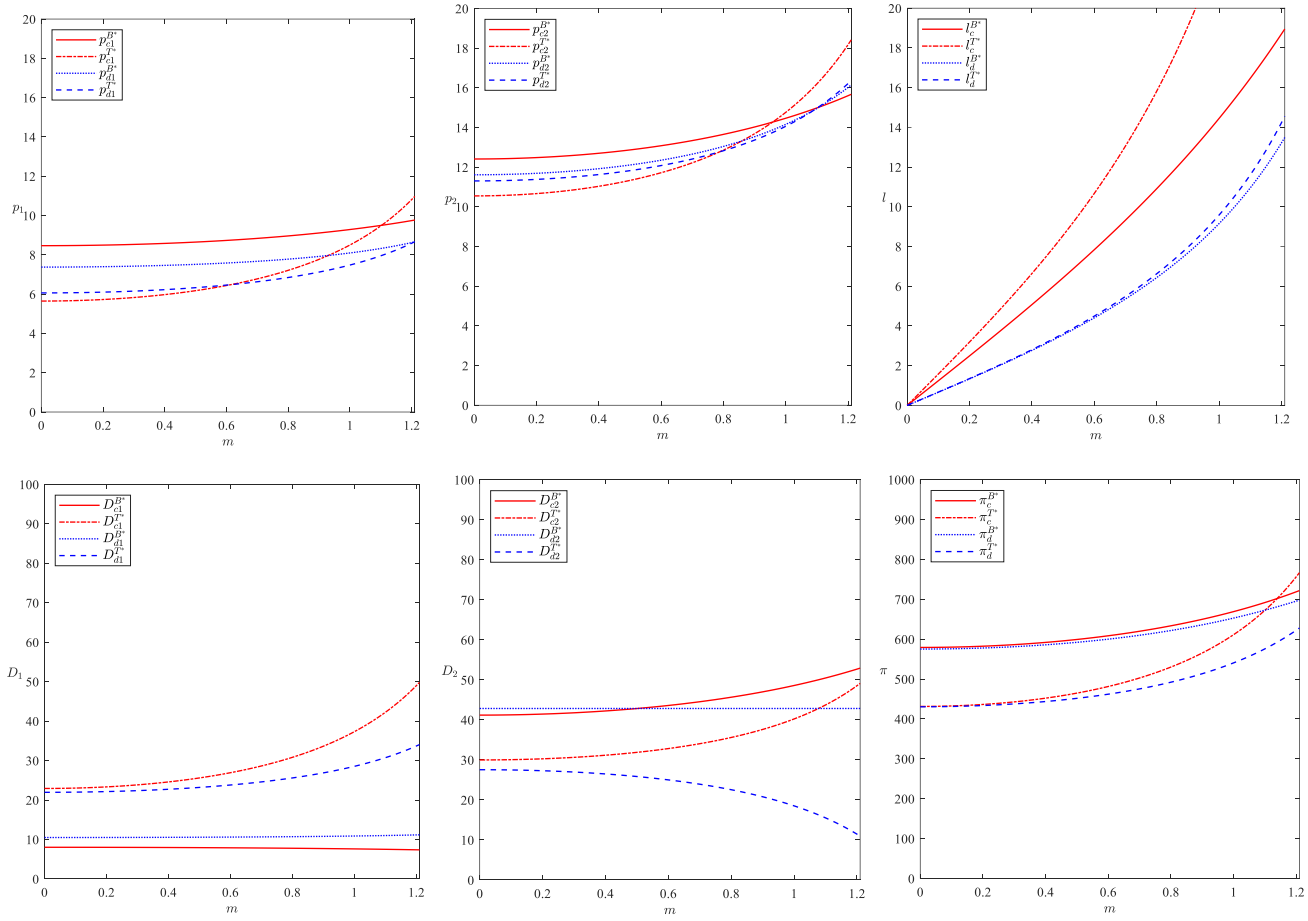

Figure 1. Variation of Optimal Decisions, Demand, and Profit with m

6.2. Consumer Online Direct Marketing Channel Preference Analysis

In the apparel industry, especially in the apparel sector, consumers are very sensitive to the level of service in BM stores. This is because consumers need to use hand touch, close observation, service staff's introduction and feedback, and try to decide whether they want to buy the products when they buy apparel products in BM stores. Therefore, in the analysis of consumer online direct marketing channel preference and the degree of consumer personalization are both based on highly service-sensitive consumers. Let the

value of $m=1.2, \theta_1=0.7,$ and the range of λ is $(0.66,1)$. The trends of optimal price, the level of service, market demand, and profit of the supply chain system are shown in Figure 2:

From Figure 2, the changes in the price of products and the level of service after the implementation of the STS strategy are consistent with the conclusions in Proposition 2, and the following conclusions are drawn:

(1) Under the implementation of STS, the demand for Product 1 in the centralized decision-making model is significantly higher than in the decentralized decision-making model. This is mainly because the demand for Product 1 depends primarily on the price of the products, the price of substitutes, the level of service, etc. According to Figure 2, The price difference between centralized and decentralized decision-making models is not apparent. Still, the gap between the level of service is vast, which is an essential factor that separates the centralized and decentralized decision-making models of Product 1 demand.

(2) After the implementation of STS, the supply chain system becomes more profitable as consumer preference for online direct marketing channels increases. In the centralized decision-making mode, the implementation of STS is significantly better than the traditional dual-channel strategy. In the decentralized decision-making mode, when consumer preference for online direct marketing channels is very high, implementing STS can also enable the supply chain to obtain higher profits.

The supply chain system profit rises as consumers' preference for online direct selling channels increases. On the one hand, this is because the demand for STS decreases due to the increase in consumers' preference for online direct selling channels, the transportation cost decreases, and the profit rises. On the other hand, with the increase in consumer preference for online direct marketing channels, the price and demand for Product 2 increased, and even though the price and demand for Product 1 is decreasing, and the profit generated by Product 2 exceeds the sum of the reduced profit of Product 1 and the cost of service, so the profit of the supply chain system is on an upward trend. Under centralized decision-making, the implementation of STS, the price of products and the overall market demand is higher, especially for Product 1, whose market demand is significantly higher than the traditional dual-channel strategy. Similarly, the market demand for Product 1 after the implementation of STS in a decentralized decision-making mode is also higher than the traditional dual-channel strategy. Therefore, compared with the traditional dual-channel strategy, although the price of products under the STS strategy is lower, it is better in that it can fully utilize the market, and the STS strategy under the centralized decision-making mode is the optimal choice for the supply chain when the degree of consumers' preference for direct marketing channels is very high.

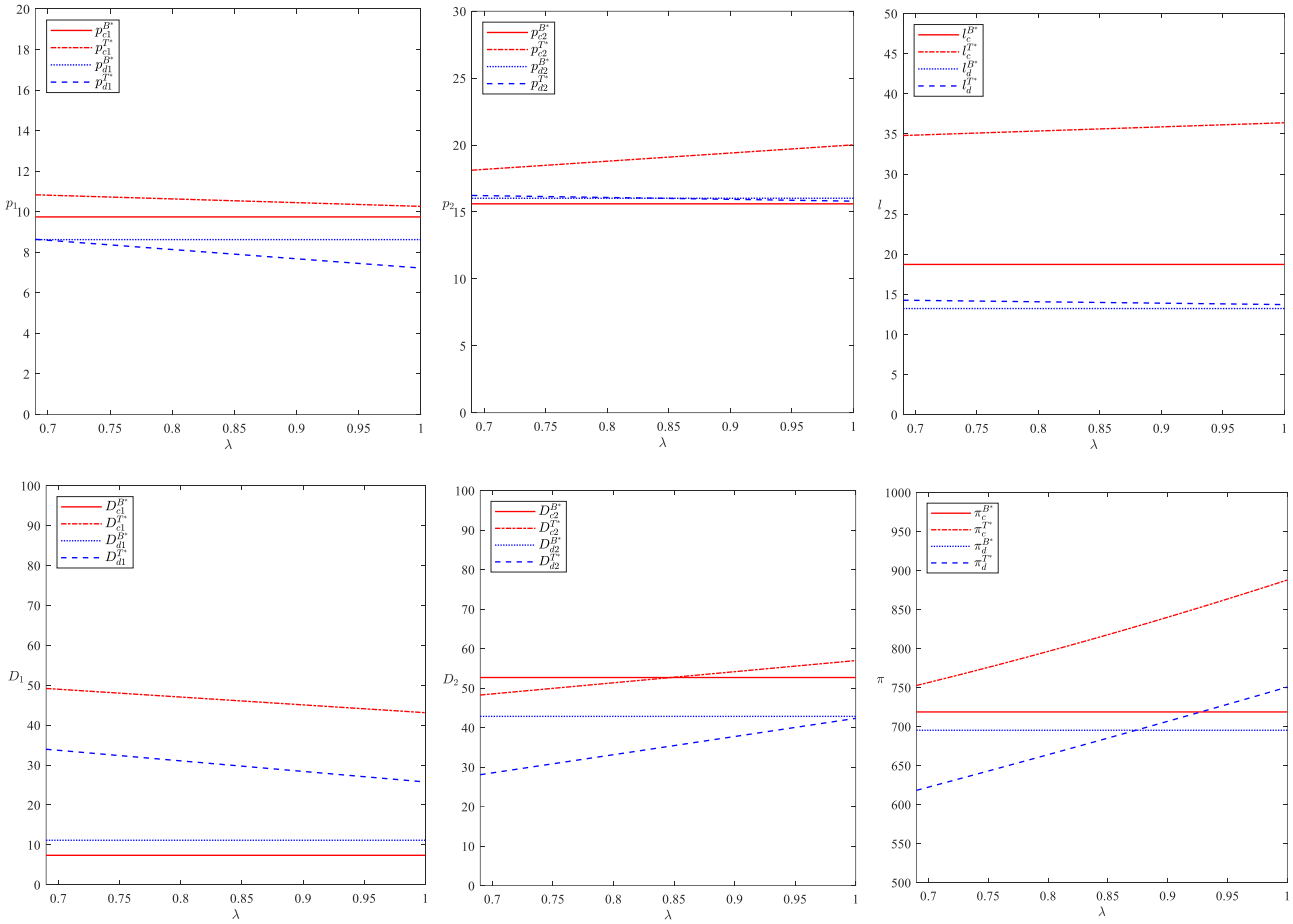

Figure 2. Variation of Optimal Decisions, Demand and Profit with λ

6.3. Analysis of the Personalization of Consumer

The value of $m=1.2, \lambda=0.3,$ the range of θ_1 is $(0.29, 0.45)$, the trends of optimal price, the level of service, market demand, and profit of the supply chain system are shown in Figure 3:

Figure 3 shows that with the growth of consumer personalized demand, the profit of the supply chain system

shows a decreasing trend, but the implementation of the STS strategy in the supply chain under the centralized decision-making model can effectively improve profit.

This is because, under centralized decision-making, consumer personalization increases, Product 1 prices rise, the price of Product 2 and the level of services fall, which is consistent with the conclusions of Proposition 3, and Product 1 prices are always lower than Product 2 prices, which Validates the findings in Proposition 3. Generally, the rise in price leads to a fall in demand; however, the rise in the price of Product 1 and the fall in the price of Product 2 ultimately lead to a rise in demand for Product 1 and a fall in demand for Product 2, on the one hand, because of the growth of consumers' personalization demand. On the other hand, the price of the products and the level of service are also important factors. Product 1 and Product 2 are homogeneous products; the higher the price, the higher the unit profit, so Product 1 unit profit is lower than Product 2 profit; combined with the demand for products in the market at this time, the overall profit of the supply chain shows a downward trend. Compared with the traditional dual-channel strategy, the demand for Product 1 is higher under the STS strategy, while the demand for Product 2 is lower. Although the demand for products in the market under the STS strategy is in an unfavorable situation, the market is fully utilized, and the price of the products is at a higher level compared with the traditional dual-channel strategy, so the STS strategy is preferred to the traditional dual-channel strategy under the centralized decision-making model.

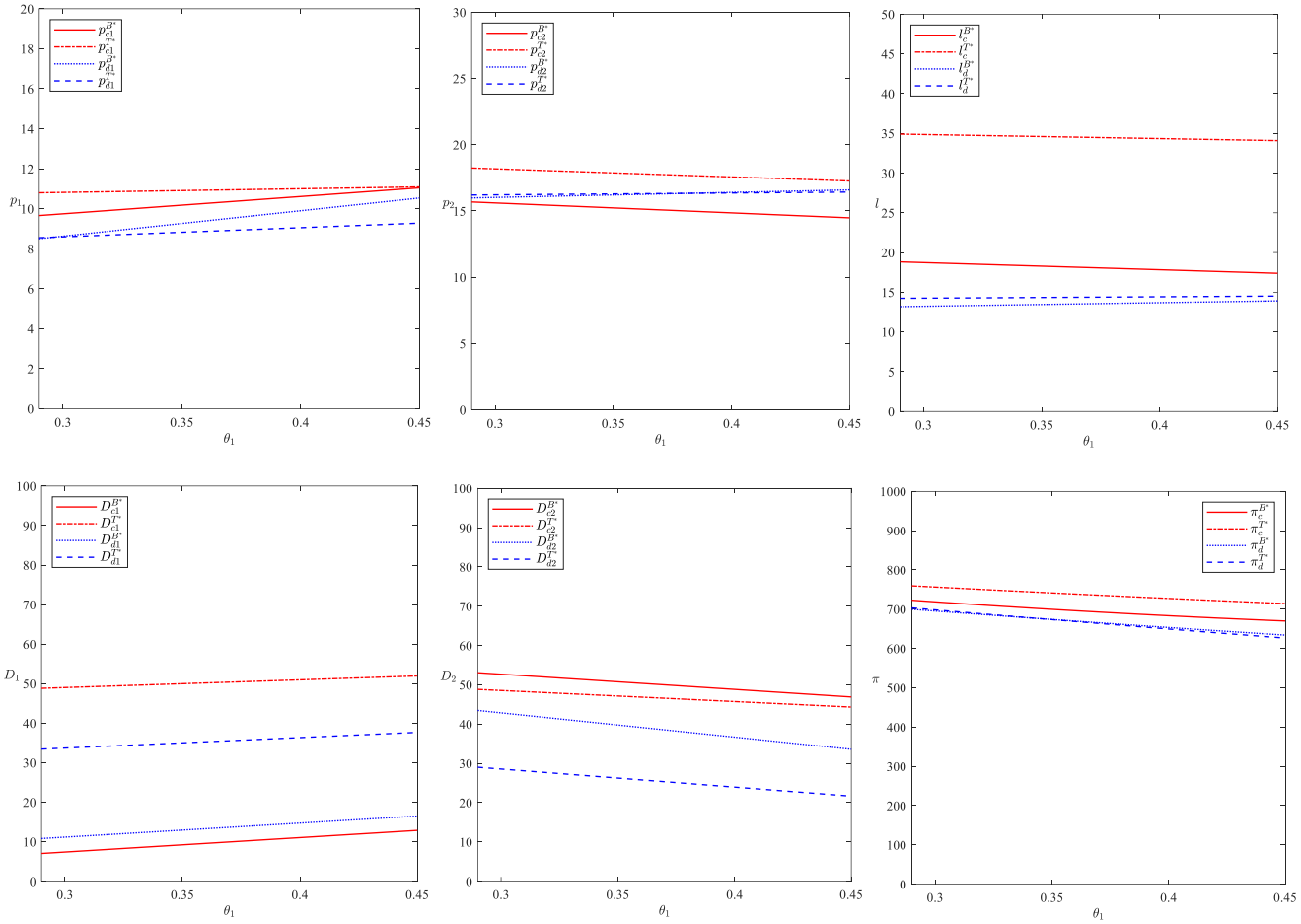

Figure 3. Variation of Optimal Decisions, Demand and Profit with θ_1

7. Conclusion

In this paper, based on a secondary supply chain consisting of manufacturers and retailers, two homogeneous products within the market are considered: mainstream and niche products. It also establishes decision-making models under centralized and decentralized decision-making models for traditional dual-channel and STS strategies, respectively, and solves the optimal price and level of service decisions using the Stackelberg model. The effects of consumers' service sensitivity, channel preference, and degree of personalization on the optimal decision and profit are analyzed. The results of the study show that:

(1) Given the consumer personalization and channel preference coefficients, supply chains will use different channel strategies when facing service-sensitive consumer groups to different degrees. When facing low service sensitivity groups, whether the decision is centralized or decentralized, implementing STS is not a good choice when oriented to maximum profit. When the coefficient of consumer service sensitivity is higher than the coefficient of substitutes' price influence, the supply chain chooses the STS strategy as the optimal strategy under the centralized decision-making model. In the decentralized decision-making model, although the growth of profit is faster under the STS strategy, it is still lower than that of the traditional dual-channel. If the supply chain aims to maximize profit, the traditional dual-channel strategy should be implemented, and if it is for the purpose of expanding the market of niche products, the implementation of the STS strategy can get obvious results.

(2) In a market with mostly online demand, the supply

chain should maximize profits by charging high prices for mainstream products that occupy a large share of the online market to achieve profit growth and low prices for niche products to increase sales. When facing a highly service-sensitive consumer group, after implementing the STS strategy, retailers need to improve their level of services accordingly.

Based on high service-sensitive consumer groups, when consumer personalization is certain and consumer online direct sales channel preference grows, the market share of higher-margin classic products grows, effectively increasing supply chain system profits. In the centralized decision-making model, the implementation of STS is significantly better than the traditional dual-channel strategy. In the decentralized decision-making model, the implementation of the STS strategy is profitable only when consumer preference for online direct marketing channels is particularly pronounced.

Also, based on a highly service-sensitive consumer base, when consumers prefer the online direct channel, the growth in consumer personalized demand expands the market demand for niche products with lower unit margins, which hurts supply chain system profits. In the centralized decision-making model, the supply chain can consider the STS strategy, which effectively improves the supply chain system profit compared to the traditional dual channel. However, the growth of personalized demand still reduces profits. In the decentralized decision-making model, the supply chain can implement STS to significantly increase the market share of niche products, although it cannot effectively increase profits.

(3) When dealing with highly service-sensitive consumer groups, the implementation of STS strategies under both centralized and decentralized decision-making facilitates the expansion of niche products in the market, mainly due to the STS channels for niche products. For the supply chain, if the goal is not to maximize profits, but to promote niche products in the market, for example, seasonal apparel products that can only be accepted by a small number of groups in the market because of factors such as color, style, or size, the supply chain needs to expand the market share of the niche product at the end of the quarter to avoid the problem of inventory buildup, then the supply chain can consider the implementation of the STS strategy and make corresponding changes to the price and the level of service of products. At this point, the supply chain can consider implementing the STS strategy and make corresponding changes to product prices and the level of services, e.g., improve the level of services within the retailer, and the prices of niche products should be lower than those of mainstream products. Although the implementation of STS in both centralized and decentralized decision-making modes of the supply chain is beneficial to the market expansion of niche products, the expansion effect is more obvious under centralized decision-making.

This paper focuses on the implementation conditions of STS, but there are some limitations. First of all, consumers in the shopping process will appear in the phenomenon of return, especially in the apparel industry, which is the return of the most brutal hit. The return of the problem into account is the future focus of the research direction. Secondly, the service effect and the level of service in this paper show a linear relationship; however, in real life, too high service may make consumers have an aversion, so reconsidering the relationship between the service effect and the level of service is also one of the future research directions.

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