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Pricing Decision Models of the Dual Channel Supply Chain with Service Level and Return

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Abstract: The interests of upstream, midstream, downstream companies and consumers in the supply chain are jointly affected by service levels and returns. Improving service levels can increase market demand and improve market position, as well as reduce return rates. But the increase in service level will bring an increase in service cost. How to balance the service cost and return cost through pricing decision, so that the profit of supply chain members can be improved, is the problem studied in this paper. In this paper, we consider the effect of service level of network channel on consumers' return behavior in the context of manufacturer's dual-channel supply chain when dual channels provide services at the same time, and discuss the effect of service level and return rate on pricing decision of dual-channel supply chain. It was found that return behavior can stimulate manufacturers to improve service levels and increase overall supply chain profits. The higher the return rate in the network channel, the greater the benefits from improved service levels by the manufacturer and the less detrimental to retailers' returns. This study enriches the research on pricing decisions in dual-channel supply chains, increases the motivation of merchants to improve service levels, and has some guiding implications for supply chain members to develop price and service strategies.

Keywords: dual-channel supply chain; return; service level; price strategy

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1. Introduction

With the popularity of dual-channel supply chain model, companies are opening up online channels to expand their own market demand, while the phenomenon of returns also occurs. The main reason for unwarranted returns is that the goods purchased do not meet their actual needs. Since consumers can't have an intuitive understanding of the product when buying goods in the network channel, they can only judge by the description of the merchant and the evaluation, etc. After purchase, they find that the goods do not match their needs; leading to the return phenomenon is common. According to a survey by IHL Group, global retailers lose about 225.6 million pounds annually due to consumer returns [1]. Canadian retailers lose up to $10 billion annually due to consumer returns, with Wal-Mart alone incurring annual return costs of $6 billion [2]. Traditional channels can reduce returns by offering services such as trials and hiring salespeople to explain them, thereby reducing ex-ante uncertainty.

As consumer perceptions have changed, more and more consumers are paying more attention to the service experience when shopping. Customer service is often what sets a company, product or service apart in the minds of consumers, and it is what makes it successful or unsuccessful in the marketplace. Establishing a more customer-oriented approach in corporate logistics management means increasing demands on the level of service provided [3]. This service refers to all pre and after-sales services that add value to the customer's perception of the product; therefore, the difference in the level of service between online and offline channels affects the consumer's shopping choice.

The emergence of webcasting has brought a new model for the provision of services in online channels, where merchants show and explain goods to consumers by live-streaming with a series of promotions through major live video platforms. When consumers choose to purchase goods through online channels, they can also learn about other people's evaluation of the goods through the online evaluation system. These services of online channels also reduce the return rate of online channels to a certain extent. Improving the level of service can reduce the return rate to lower the return cost, but it will bring about an increase in service cost.

Given the strong relationship between returns and service, this paper considers consumer return behavior in supply chain pricing decisions, investigates optimal pricing decisions that consider both service level and return behavior in a manufacturer-led dual-channel supply chain, and explores how service level and return rate affect channel price, channel demand, and profit. The pricing decision to balance the cost of returns with the cost of service for the purpose of supply chain optimization has important research implications.

2. Literature Review

As the quality of life continues to improve, consumers' needs are also changing. While consumers are concerned about price, they are increasingly focused on the quality of service provided by the merchant and on their personal experience when shopping. Pi et al. [4] used game theory and a two-stage optimization approach to study the pricing and service strategies of retailers in a dual-channel supply chain system consisting of one manufacturer and two retailers and found that the interaction between retail prices and service strategies depends on the sensitivity to self-service, cross-service, and cross-price. Wang et al. [5] studied the pricing and service decisions of complementary products in a dual-channel supply chain consisting of two manufacturers and one retailer. He et al. [6] consider a two-channel supply chain consisting of a manufacturer and a retailer, with uniform or separate pricing by the manufacturer. The results found that the level of logistics was positively related to e-tailing prices and that the level of logistics services played a positive role in the manufacturer's national advertising expenditures. Guo et al. [7] analyzed the impact of pre-sales service and delivery time parameters on pricing and supply chain performance under centralized and decentralized decision making. The results showed that the sensitivity of pre-sales service level did not always positively affect retailers' profits when centralized decision making was in place in a two-channel structure, but it positively affected price, pre-sales service level, and retailers' demand. Xin et al. [8] proposed a two-level two-channel supply chain consisting of a manufacturer and a retailer, and a Stackelberg game was used to describe the optimal decisions of supply chain participants considering product pricing, CSR level and service level in the supply chain, and the results showed that service level has a significant effect on the pricing decisions of all participants in the supply chain. Pu et al. [9] studied the impact of consumer free-rider behavior on supply chain decisions by considering a situation where consumers in online channels can enjoy pre-sales services in offline channels for free and designed a service cost-sharing contract to improve supply chain performance. Zhang et al. [10] studied the impact of consumer free-rider behavior on supply chain decisions in a retailer-led supply chain, facing the invasion of the manufacturer's direct sales channel, the retailer can effectively resist the invasion of the direct sales channel by improving the service level of the traditional channel. Wu et al. [11] studied the pricing decisions and profits of a dual-channel reverse supply chain with a recycling center and a third-party recycler under centralized and decentralized decision-making, respectively, and showed that as the consumer's online channel preference increases, the profits of recycling centers and supply chain systems will increase, while the profits of third-party recyclers will decrease. Zhang et al. [12] used variational inequalities to develop an equilibrium model of a dual-channel supply chain network considering pricing and service decisions, and found that the introduction of online channels can bring more profits to the entire dual-channel supply chain network, and that manufacturers should provide reasonable profit allocation schemes

for retailers to get their participation in the supply chain network. Zhou et al. [13] studied the dual-channel pricing and service strategy issues in a dual-channel supply chain, in which the manufacturer's online channel provides free rides to retailers' pre-sales services by offering SCS contracts, and conclude that in both pricing schemes, SCS contracts can effectively incentivize retailers to improve their service levels when free rides are offered. Guo et al. [14] studied the supply chain under the sharing economy based on the social responsibility perspective of Xia et al. [15]. studied service level and distribution channel decisions in two competing service supply chains, focusing on how service competition affects channel structure. Guajardo et al. [16] studied the service level and distribution channel decisions in two competing service supply chains with significantly heterogeneous service preference for customer groups under after-sales service differentiation strategies.

When consumers buy goods through online channels, they cannot actually experience and try the goods, but can only perceive the goods through the merchant's descriptions, which can easily cause the actual condition of the purchased goods to be different from consumers' expectations, thus leading to return problems. The return problem has a huge impact on the operation and management of the supply chain. Ruiz-Torres et al. [17] proposed a model that combines sourcing and reverse logistics decisions by considering supplier capabilities and return incentives. Each source of returns is given an incentive that affects the number of possible returns per quality level. Wang et al. [18] investigated the impact of distribution distance and return service on the equilibrium decisions of supply chain members in a dual-channel supply chain and explored the impact of system parameters on supply chain members' decisions and profits. The results showed the existence of thresholds regarding the distribution distance and the allowable return period. Genc et al. [19] studied several consumer return behaviors for used products based on product prices and rebates within a closed-loop supply chain framework to find the optimal rebate mechanism. Javadi et al. [20] studied the optimal pricing decisions in a dual-channel supply chain considering flexible return policies and different government intervention policies, and made useful management recommendations for the government and the supply chain. Kumar et al. [21] analyzed the impact of omnichannel and e-tailing on total channel profit by developing an omnichannel analytical model with and without return policies. Giri et al. [22] studied a closed-loop supply chain with two dual channels and analyzed the pricing and return product collection decisions for the supply chain in five different scenarios, and the results showed that The retailer-led decentralized scenario yielded more profits than the other decentralized scenarios. Lin et al. [23] developed an analytical model based on consumer utility to study the optimal pricing decisions of retailers and the value of return shipping insurance. The study found that retailers who purchase return shipping insurance for consumers do not necessarily charge higher prices.

Some other scholars have studied from the perspective of return strategy, Batarfi et al. [24] studied retail channel strategy and dual channel strategy considering return policy and the results showed that the more generous the return policy is, the higher the demand, selling price and total profit, and the use of dual channel strategy is more beneficial to the supply chain. Chen [25] argued that service and pricing are effective ways for retailers to remain competitive in the market and that retailers should choose a full return strategy when the returned product can be utilized twice and can achieve Pareto improvement in profits. Assarzadegan et al. [26] found that a manufacturer's full refund strategy to one of the retailers for products with quality problems can incentivize retailers to implement a money-back guarantee policy, thus increasing the profit level of both the manufacturer and the retailer. Huang and Jin [27] compared the offline return strategy for online purchases in a monopoly environment and a competitive environment on the supply chain profit The results show that cross-channel returns in a monopolistic environment hurt retailers who refuse to provide cross-channel returns, and cross-channel returns in a competitive environment can enhance the revenue of each supply chain member. Li et al. [28] find that in a dual-channel supply chain where manufacturing is the dominant player, manufacturers can gain more revenue by adopting a return strategy with full refunds for both channels

when the return rate is low; when return rates are high, manufacturers can yield more revenue by prohibiting consumer returns. Taleizaden et al. [29] studied the money-back guarantee policy in a closed-loop supply chain and found that the policy not only increased manufacturer and retailer profits but also reduced retailer prices. Huang and Feng [30] studied the introduction of store brands in a secondary supply chain in the context of Giri et al. [31] study the pricing and product quality decision problem for a supply chain consisting of multiple manufacturers and the same retailer with competitive relationships, comparing the supply chain decision in the presence of 2 scenarios: full refund and no product return. Batarfi et al. [24] study the effect of different return policies (including full refund policy, partial refund policy, and no refund policy) on pricing and ordering decisions in a dual-channel supply chain and found that a lenient return policy leads to higher selling prices and supply chain profits.

In studies of dual-channel supply chains that consider service levels, the majority of cases are those in which the retailer provides services through traditional retail channels or in which the manufacturer pays an additional fee to the retailer for service cooperation, and fewer studies involve cases in which both traditional and online channels provide services independently. In the research on returns, mainly for the return strategy, which is mostly by the traditional single-channel supply chain and closed-loop supply chain as the research background, less in the context of dual-channel supply chain research. There are studies on the impact of consumers' return behavior on supply chain pricing decisions, most of which only consider the impact of retailers' service provision on return rates, and very little literature has examined the impact of consumers' return behavior on inter-channel pricing and service strategies when manufacturers provide services in online channels. In view of this, this paper explores how supply chain members can develop pricing strategies to coordinate service and return costs in order to maximize their profits based on the dual influence of service levels and return behavior when both online and traditional channels are considered to provide services.

With the development of dual-channel supply chains, the service and return situation of the online channel has received increasing attention. Based on this, this study considers the impact of the sales service and return rate of the network channel on the pricing decisions of supply chain participants when dual channels provide services at the same time. The situation considered in this study is closer to reality, which makes up for the deficiencies of existing studies, further enriches the research on pricing decisions in dual-channel supply chains, and provides decision support for supply chain participants to develop pricing strategies. It enhances the motivation of enterprises to improve their service level, improves consumers' shopping satisfaction, and provides a different management perspective for supply chain enterprise managers.

3. Problem Description and Model Assumptions

In this paper, assuming a dual-channel supply chain consisting of a single manufacturer and a single retailer, the impact of consumer return behavior and network channel service level on the pricing decisions of supply chain members is investigated by constructing a Stackelberg game model. To facilitate the study, only the return behavior due to ex-ante uncertainty is considered, and the return behavior due to product failure, damage, etc. is not considered. Referring to the study by Lu Meiyi et al. [32], when consumers choose the traditional channel, they will try the product and receive explanations from the salesperson before making a purchase decision, while when they choose the network channel, they cannot experience the service beforehand and the merchant's product description is somewhat misleading. Therefore, it is assumed that there is no return behavior in the traditional channel, and only the return of the network channel is considered. The manufacturer sells products to the retailer at wholesale price w, the retailer sells products to the consumer at price p_r and provides service at level s_r through the traditional retail channel, and the manufacturer sells goods to the consumer at price p_d and provides service at level s_m through the network channel. The return rate is μ when the network channel

does not provide the service, and becomes $\mu_m = (1 - s_m)\mu$ when the service is provided. The structure diagram of the manufacturer dual-channel supply chain with service and returns is shown in Figure 1.

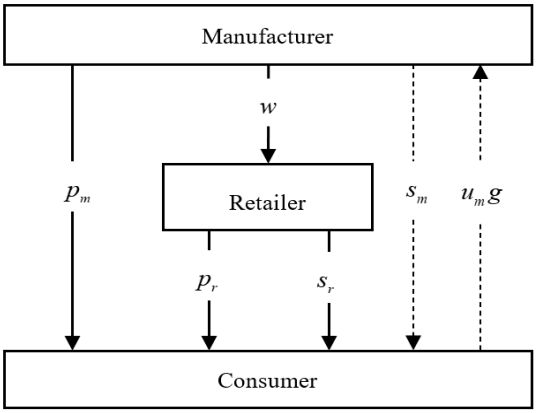

Figure 1. Manufacturer dual-channel supply chain with service and returns.

In order to facilitate the model calculation, the main parameters and explanatory notes of the model constructed in this paper are shown in Table 1.

Table 1. Description and interpretation of model symbols.

Symbols	Description and Explanation of Symbols	Symbols	Description and Explanation of Symbols
a	Initial market demand	ω	Cross-elasticity of demand for services coefficient
θ	Coefficient of consumer preference for traditional channels	k	Service Cost Factor
w	Manufacturer wholesale prices	c	Unit production cost of the product
p_r, p_d	Sales price of traditional channels and network channels	C_r, C_m	Service cost of traditional channel and network channel
s_r, s_m	Service level of traditional channels and network channels	μ	Return rate
b	Coefficient of elasticity of demand with respect to price	h	Coefficient of impact of return cost on demand
β	Coefficient of cross-elasticity of demand to price	D_r	Market demand for traditional channels
γ	Elasticity of demand for services coefficient	D_d	Market demand for network channels
g	Unit return cost	Π_r, Π_m, Π	Representing manufacturer's profit, retailer's profit and total supply chain profit, respectively

In Table 1, $b > \beta$, $\gamma > \varphi$, indicates that the price and service level of this channel have a greater degree of influence on the demand function.

In the manufacturing-based two-channel supply chain model, the demand function is not only influenced by price and service level, but also by the return cost, which is closely related to the service level. Therefore, the market demand functions for the two channels are as follows.

$$D_r = \theta a - p_r + \beta p_m + s_r - \varphi s_m + h(1 - s_m)\mu g \tag{1}$$

$$D_m = (1 - \theta)a - bp_m + \beta p_r + \gamma s_2 - \varphi s_1 - h(1 - s_m)\mu g \tag{2}$$

According to Yan et al. [33], a strictly concave function is used to represent the relationship between unit service cost and service level: $C_i = \frac{1}{2}k{s_i}^2$, $(i = r, m)$, at which point the overall profit function of the retailer, manufacturer, and supply chain is:

$$\Pi_r = (p_r - C_r - w)D_r \tag{3}$$

$$\Pi_m = (w - c)D_r + (p_m - C_m - c)D_m \tag{4}$$

$$\Pi = \Pi_r + \Pi_m = (p_r - C_r - c)D_r + (p_m - C_m - c)D_m \tag{5}$$

4. Model Building and Solving

In this section, we develop a Stackelberg game model in which the manufacturer and the retailer make their own decisions independently with the goal of maximizing their own profits in a manufacturer's dual-channel supply chain pricing decision that considers service levels and returns. At this point, the manufacturer is the leader and the retailer is the follower. The sequence of the game is: (1) first, the manufacturer decides the wholesale price and online direct sales price; (2) the retailer decides the retail price of the product in the offline channel according to the manufacturer's decision and the market demand. At this point, the retailer profit function is:

$$\Pi_r = (p_r - C_r - w)[\theta a - p_r + \beta p_m + s_r - \varphi s_m + h(1 - s_m)\mu g] \tag{6}$$

The approach to solving the model takes a reverse induction approach. The second-order partial derivative of the retailer's profit function Π_r with respect to the retail price p_r, $\frac{\partial^2 \Pi_r}{\partial {p_r}^2} = -2 < 0$, has an optimal solution such that $\frac{\partial \Pi_r}{\partial p_r} = 0$ and the retail price response function is obtained as:

$$p_r = \frac{\theta a + w + \beta p_m + s_r - \varphi s_m + h(1 - s_m)\mu g + C_r}{2b} \tag{7}$$

The second-order Hessian matrix of the manufacturer's profit function Π_m with respect to the wholesale price w and the network channel sales price p_m is: $H = \begin{bmatrix} \frac{\partial^2 \Pi_m}{\partial w^2} & \frac{\partial^2 \Pi_m}{\partial w \partial p_m} \\ \frac{\partial^2 \Pi_m}{\partial p_m \partial w} & \frac{\partial^2 \Pi_m}{\partial {p_m}^2} \end{bmatrix} = \begin{bmatrix} -1 & \beta \\ \beta & \beta^2 - 2 \end{bmatrix} = 2(1 - \beta^2)$. Since $H > 0$ and $\frac{\partial^2 \Pi_m}{\partial w^2} < 0$, the second order Hessian matrix is negative definite and Π_m is a strictly concave function with respect to w and p_m. Extreme values exist and the manufacturer's optimal network channel sales price and wholesale price are solved as:

$$\begin{cases} {p_m}^* = \frac{(\beta\theta - \theta + 1)a + (\beta - 1)h(1 - s_m)\mu g + \beta(s_r - \varphi s_m) + s_m - \varphi s_r}{2(1 - \beta^2)} + \frac{c + C_m}{2} \\ w^* = \frac{(\theta - \beta\theta + \beta)a + (1 - \beta)h(1 - s_m)\mu g + \beta(s_m - \varphi s_r) + s_r - \varphi s_m}{2(1 - \beta^2)} + \frac{c - C_r}{2} \end{cases} \tag{8}$$

Substituting Equation (8) into Equation (7) yields the retailer's optimal selling price as:

$${p_r}^* = \frac{2\beta a + (3 - 2\beta - \beta^2)\theta a + (3 - \beta^2)(s_r - \varphi s_m) + 2\beta(s_m - \varphi s_r) + (3 - 2\beta - \beta^2)h(1 - s_m)\mu g}{4(1 - \beta^2)} + \frac{\beta C_m + C_r + (1 + \beta)c}{4} \tag{9}$$

At this point, the retailer and manufacturer demand and the optimal profit for the retailer and the optimal profit for the manufacturer are:

$$\begin{cases} {D_r}^* = \frac{\theta a + s_r - \varphi s_m + h(1 - s_m)\mu g + \beta C_m - C_r - (1 - \beta)c}{4} \\ {D_m}^* = \frac{(1 - \theta a) - C_m - c + s_m - \varphi s_r}{2} + \frac{\beta\theta a + (\beta - 2)h(1 - s_m)\mu g + \beta(s_r - \varphi s_m) + \beta^2 C_m + \beta C_r + \beta(1 + \beta)c}{4} \\ {\Pi_r}^* = \frac{[\theta a + s_r - \varphi s_m + h(1 - s_m)\mu g + \beta C_m - C_r - (1 - \beta)c]^2}{16} \\ \qquad [\theta a + s_r - \varphi s_m + \beta C_m - C_r + (\beta - 1)c] * \begin{bmatrix} (\theta - \beta\theta + \beta)a + (1 - \beta)h(1 - s_m)\mu g \\ +\beta(s_m - \varphi s_r) + s_r - \varphi s_m - (1 - \beta^2)(c + C_r) \end{bmatrix} \\ \qquad + \begin{bmatrix} (\beta\theta - \theta + 1)a + (\beta - 1)h(1 - s_m)\mu g \\ +\beta(s_r - \varphi s_m) + s_m - \varphi s_r - (1 - \beta^2)(c + C_m) \end{bmatrix} * \begin{bmatrix} 2(1 - \theta)a + \beta\theta a + \beta(s_r - \varphi s_m) \\ +2(s_m - \varphi s_r) + (\beta^2 - 2)C_m + \beta C_r \\ +(\beta^2 + \beta + 2)c \end{bmatrix} \\ {\Pi_m}^* = \frac{}{8(1 - \beta^2)} \end{cases} \tag{10}$$

Theorem 1. *In a dual-channel supply chain considering service level and returns, the manufacturer's network channel sales price increases and the retailer's traditional channel sales price decreases as the network channel service level increases, and the wholesale price increases with the network channel service level when the return rate* $\mu < \frac{\beta-\varphi}{(1-\beta)hg}$ *and decreases with the network channel service level when the return rate* $\mu > \frac{\beta-\varphi}{(1-\beta)hg}$.

Proof. $\frac{\partial {p_m}^*}{\partial s_m} = \frac{h\mu g+\varphi}{2(1+\beta)} + \frac{ks_m}{2}$; $\frac{\partial {p_r}^*}{\partial s_m} = \frac{2\beta-\left(3-\beta^2\right)\varphi-\left(3-2\beta-\beta^2\right)h\mu g}{4(1-\beta^2)} + \frac{\beta ks_m}{4}$.

Since $0 < \beta < 1$, $\frac{\partial {p_m}^*}{\partial s_m} > 0$, $\frac{\partial {p_r}^*}{\partial s_r} < 0$; $\frac{\partial w^*}{\partial s_m} = \frac{\beta-\varphi-(1-\beta)h\mu g}{2(1-\beta^2)}$.

When $\frac{\partial w^*}{\partial s_m} < 0$, $\mu > \frac{\beta-\varphi}{(1-\beta)hg}$; when $\frac{\partial w^*}{\partial s_m} > 0$, $\mu < \frac{\beta-\varphi}{(1-\beta)hg}$. □

Theorem 1 illustrates that when manufacturers improve the service level of the network channel, the service cost of the network channel increases, and in order to ensure their own revenue maximization, they therefore increase the sales price of the network channel, the network channel to improve the service level will attract some of the consumers of the traditional channel, and retailers to maintain market share, reduce the sales price of the traditional channel to attract consumers. When the return rate is low, improving the service level has a greater impact on the demand of the network channel, when manufacturers focus on the network channel, the service cost brought by improving the service level is transferred to consumers and retailers by raising the price of the network channel and wholesale prices.

Theorem 2. *The manufacturer's optimal sales price for the network channel decreases as the return rate increases; the manufacturer's wholesale price, as well as the retailer's traditional channel sales price, increases as the return rate increases.*

Proof. $\frac{\partial {p_m}^*}{\partial \mu} = \frac{h(s_m-1)g}{2(1+\beta)}$; $\frac{\partial {p_r}^*}{\partial \mu} = \frac{(\beta+3)h(1-s_m)g}{2(1+\beta)}$; $\frac{\partial w^*}{\partial \mu} = \frac{h(1-s_m)g}{2(1+\beta)}$.

Since $0 < s_m < 1$, $\frac{\partial {p_m}^*}{\partial \mu} < 0$, $\frac{\partial {p_r}^*}{\partial \mu} > 0$, $\frac{\partial w^*}{\partial \mu} > 0$. □

Theorem 2 illustrates that as the return rate increases, the online channel sales volume decreases due to severe information asymmetry, and manufacturers take measures to reduce the online channel sales price in order to maintain the market share of the online channel and reduce the loss of consumers, while increasing the wholesale price to obtain greater wholesale profits from the traditional channel. The traditional channel reduces ex-ante uncertainty by providing on-site services. When the return rate increases, the advantage of ex-ante experience services of the traditional channel becomes apparent, and retailers take advantage of their own channels to increase traditional retail prices to expand their own revenue.

Theorem 3. *When the service level of network channel meets* $s_m < \frac{\varphi h\mu g}{\beta k}$, *the increase of service level of network channel leads to the decrease of demand of traditional channel, and when the service level meets* $s_m > \frac{\varphi h\mu g}{\beta k}$, *the increase of service level leads to the increase of demand of traditional channel. When the service level satisfies* $s_m < \frac{(2-\beta)h\mu g-\beta\varphi+2}{2k-\beta^2 k}$, *the demand of network channel increases with the increase of service level, and when the service level satisfies* $s_m > \frac{(2-\beta)h\mu g-\beta\varphi+2}{2k-\beta^2 k}$, *the demand of network channel decreases with the increase of service level. And with the increase of return rate, the degree of influence of service level on traditional channel demand gradually decreases and the degree of influence on network channel demand gradually increases.*

Proof. $\frac{\partial {D_r}^*}{\partial s_m} = \frac{\beta ks_m-\varphi-h\mu g}{4}$, $\frac{\partial {D_m}^*}{\partial s_m} = \frac{(2-\beta)h\mu g-\beta\varphi+\beta^2 ks_m-2ks_m+2}{4}$.

Let $\frac{\partial {D_r}^*}{\partial s_m} = 0$ and find $s_m = \frac{\varphi h\mu g}{\beta k}$. So when $s_m < \frac{\varphi h\mu g}{\beta k}$, $\frac{\partial {D_r}^*}{\partial s_m} < 0$; when $s_m > \frac{\varphi h\mu g}{\beta k}$, $\frac{\partial {D_r}^*}{\partial s_m} > 0$.

Let $\frac{\partial D_m{}^*}{\partial s_m} = 0$ and find $s_m = \frac{(2-\beta)h\mu g-\beta\varphi+2}{2k-\beta^2 k}$. So when $s_m < \frac{(2-\beta)h\mu g-\beta\varphi+2}{2k-\beta^2 k}$, $\frac{\partial D_m{}^*}{\partial s_m} > 0$; when $s_m > \frac{(2-\beta)h\mu g-\beta\varphi+2}{2k-\beta^2 k}$, $\frac{\partial D_m{}^*}{\partial s_m} < 0$.

Let $\frac{\partial D_r{}^*}{\partial s_m} = \mathrm{b}_1$, $\frac{\partial b_1{}^*}{\partial \mu} = \frac{-hg}{4} < 0$, let $\frac{\partial D_m{}^*}{\partial s_m} = b_2$, $\frac{\partial b_2{}^*}{\partial \mu} = \frac{(2-\beta)hg}{4} > 0$. □

Theorem 3 illustrates that improving service level increases the demand of online channel, but service has spillover effect, too high service level leads to high service cost, which makes online channel lose the advantage of price and some consumers shift to traditional channel. On the other hand, as the return rate increases, the more significant the effect of manufacturers to improve the service level of the network channel on reducing the return rate, at this time, the impact of improving the service level on the demand of the network channel increases, while the degree of impact on the demand of the traditional channel decreases.

5. Numerical Simulation and Result Analysis

Under the consideration of service level and return behavior, we verify the correctness and validity of the above conclusions through numerical simulation, and visualize the impact of service level s_m return rate of the network channel on the optimal pricing decision, product demand and supply chain profit of the dual-channel supply chain members.

5.1. Impact of Service Level and Return Rate on Price

This section discusses the impact of network channel service levels and return rates on pricing decisions in a dual-channel supply chain, using Matlab for simulation studies. Referring to the related studies [32,34], the parameters were assigned as $a = 1000$, $\beta = 0.3$, $\varphi = 0.6$, $\theta = 0.6$, $k = 1.5$, $c = 5$, $g = 2$, $s_r = 0.4$, $h = 0.5$, network channel service level s_m varies in the range (0,1), and return rate μ varies in the range (0,1). Figures 2–4 represent the effects of network channel service level s_m and return rate μ on network channel sales price p_m, traditional channel sales price p_r, and wholesale price w, respectively.

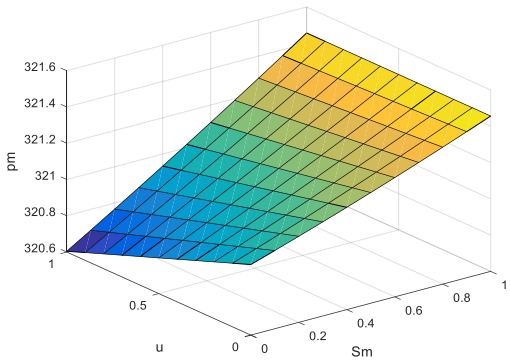

Figure 2. Effect of s_m and μ on p_m.

As can be seen in Figure 2, the selling price of the online channel increases with the increase in service level and decreases with the increase in return rate. This is because manufacturers increase their service level, which leads to an increase in service cost, and in order to keep their own revenue from decreasing, they transfer the increased service cost to consumers by increasing the sales price. And as the return rate increases, consumers' experience of shopping through online channels decreases, thus some consumers shift to traditional channels that can have prior experience services, and manufacturers take measures to reduce the sales price in order to reduce the loss of consumers and reduce profit loss.

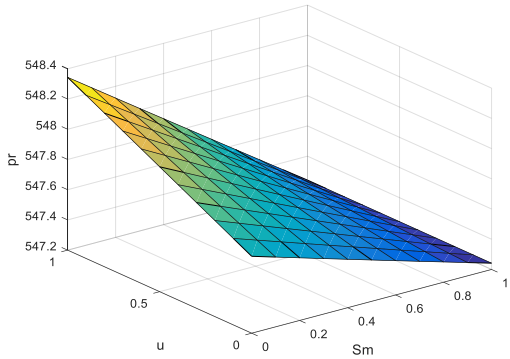

Figure 3. Effect of s_m and μ on p_r.

From Figure 3, it can be seen that the retail price of traditional channels decreases with the increase of service level and increases with the increase of return rate. When the service level of the network channel increases, some consumers move from the traditional channel to the network channel, and retailers choose to reduce the retail price to attract consumers in order to maintain market share and reduce their own profit loss. And as the return rate increases, consumers are more inclined to choose traditional channels because they can provide ex-ante experience services, and at this time, retailers can use their own channel advantages to increase the retail price and thus gain more revenue.

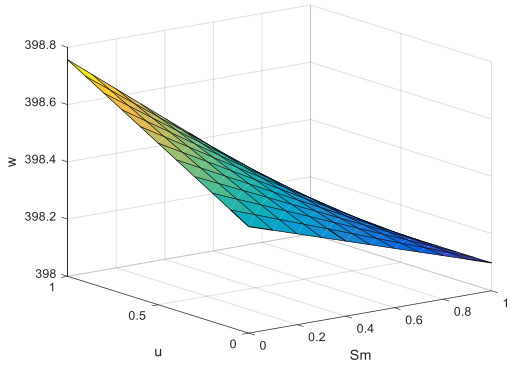

Figure 4. Effect of s_m and μ on w.

As can be seen from Figure 4, when the return rate is low, the manufacturer's wholesale price decreases with the increase in service level, and as the return rate increases, the wholesale price begins to increase with the increase in service level. The increase in return behavior causes consumers to become less sticky to the network channel and begin to move to the traditional channel. Since the traditional channel takes a product + service model that can be experienced in person, with the channel advantage, retail raises the sales price of the traditional channel, thus expanding its own profit, and the manufacturer, as the dominant supply chain player, also raises the wholesale price to make up for the network by increasing the profit of the wholesale channel The loss of profit of the channel.

5.2. Impact of Service Level and Return Rate on Demand and Profitability

This section discusses the combined effects of network channel service levels and return rates on the demand and profitability of products in a manufacturer's dual-channel supply chain and uses Matlab for simulation analysis. First, the parameters are set as follows: $a = 1000$, $\beta = 0.3$, $\varphi = 0.6$, $\theta = 0.6$, $k = 1.5$, $c = 5$, $g = 2$, $s_r = 0.4$, $h = 0.5$, network channel service level $s_m \in (0, 1)$, and return rate $\mu \in (0, 1)$, respectively.

Figures 5 and 6 show the impact of service level s_m and return rate μ on product demand in the traditional channel and online channel, respectively. Figures 7 and 8 show the impact of network channel service level s_m and return rate μ on the profit of traditional channel and network channel, respectively.

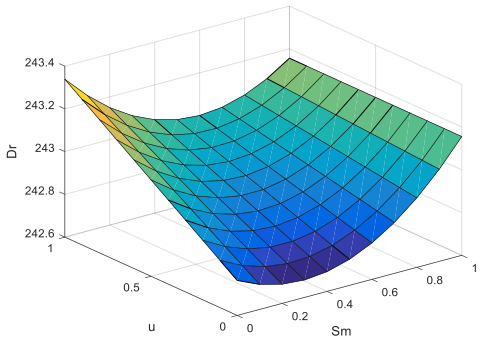

Figure 5. Effect of s_m and μ on D_r.

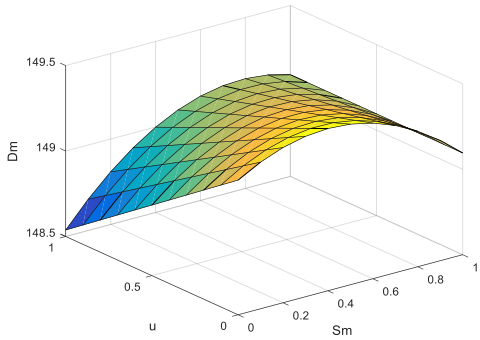

Figure 6. Effect of s_m and μ on D_m.

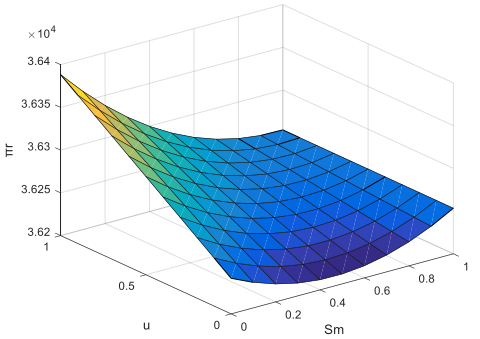

Figure 7. Effect of s_m and μ on π_r.

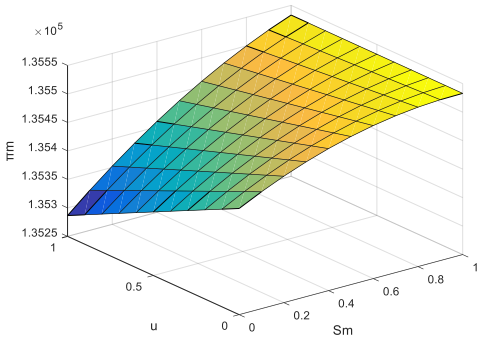

Figure 8. Effect of s_m and μ on π_m.

From Figure 5, it can be seen that in the manufacturer-led dual-channel supply chain, when the service level of the network channel satisfies the constraint $0 < s_m \leq \frac{\varphi h \mu g}{\beta k}$, the demand of the traditional channel gradually decreases, and when this critical value is exceeded, the demand of the traditional channel gradually increases. With the increase of

return rate, the degree of influence of service level on the demand of traditional channel gradually decreases. When the service level of the network channel is increased within the appropriate range, some consumers will shift from the traditional channel to the network channel, but when the service level is too high, the demand of the network channel will decrease and the demand of the traditional channel will increase due to the influence of service spillover. With the increase of the return rate of the network channel, it will cause the rejection of the consumers to the network channel, and the impact of improving the service level on the demand of the traditional channel will be less and less.

As can be seen from Figure 6, when the network channel service level satisfies the constraint $0 < s_m \leq \frac{(2-\beta)h\mu g-\beta\varphi+2}{2k-\beta^2 k}$, the network channel demand gradually increases, and after exceeding this threshold, the demand decreases as the service level continues to increase. An increase in the return rate enhances the impact of service level on the demand of the network channel. Therefore, when the return rate is high, manufacturers should strive to improve the service level of the network channel so that they can gain more revenue, but at the same time, they should also pay attention to the spillover of the service, and the excessive pursuit of service level improvement will be counterproductive.

As can be seen from Figure 7, retailer profit decreases and then increases as the level of service in the network channel increases, and gradually increases as the return rate increases. From Figure 8, it can be seen that with the improvement of the service level of the network channel, the manufacturer's profit increases and then decreases slightly with the increase of the return rate. With the improvement of service level, the improvement of service experience is more obvious, the network channel still has a certain price advantage, consumers move from traditional channels to network channels, the demand of network channels increases and the demand of traditional channels decreases; the manufacturer's profit increases and the retailer's profit decreases.

The return behavior of the network channel has a negative impact on the manufacturer's revenue, but it can stimulate the manufacturer to improve the service level of the network channel, which has a favorable impact on the retailer's revenue. The combined effect is favorable to the overall supply chain revenue. Although the emergence of return behavior can promote the manufacturer to improve the service level of the network channel, it should be noted that the service level should not be too high, too high service level will have a negative impact on the manufacturer as well as the supply chain as a whole.

6. Conclusions

The existence of return behavior can reduce the efficiency of the supply chain, and how to effectively deal with returns is a concern for supply chain members. This paper investigates the impact of the service level and return behavior of the network channel on pricing decisions in a manufacturer-led dual-channel supply chain, when both the network channel and the traditional channel provide services. The following conclusions are obtained.

(1) Manufacturers improve the service level of the network channel can reduce the return rate to a certain extent and attract some traditional channel consumers, thus enhancing the demand of the network channel and improving the profit level of this channel, but as the service level increases, the high service cost is transferred to consumers, the original low-price advantage of the network channel gradually disappears, and some consumers shift to the traditional channel, which is more convenient to purchase. Therefore, manufacturers should consider the impact of service level and return rate on demand and profit when developing network channel services, and improve the service level within a reasonable range.

(2) With the increase in consumer return behavior, manufacturers improve the level of service on their own channels to increase the impact of traditional channels to reduce the impact. The return behavior of the network channel can stimulate manufacturers to improve service levels, and at the same time, due to the smaller loss of profit to retailers, can improve the overall supply chain revenue. The higher the return rate is,

the greater the gain for manufacturers to improve their service level to enhance their own profits. As traditional channels generally provide ex-ante experience services, the excessive return rate of the network channel for will lead consumers to choose traditional channels, the return rate has a positive impact on retailers' profit, when the manufacturer improves the service level of the network channel, it will retain some consumers, thus the network channel service level has a reverse impact on retailers' profit, when the return rate is too high, as the manufacturer improves the service provider level on the return behavior When the return rate is too high, consumers will still tend to choose the traditional channel because of the limited improvement of the manufacturer to improve the service provider level on the return behavior, so the higher the return rate the smaller the reverse effect.

The research in this paper addresses a dual-channel supply chain with a single manufacturer and retailer, but the market is mostly a competitive environment, and future research will be conducted in the following aspects in combination with a more complex situation: manufacturers produce multiple products, there is substitutability between products, and there are multiple competing manufacturers and retailers. In this case, how service levels and return behavior affect pricing decisions.

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References

1. Ketzenberg, M.E.; Abbey, J.D.; Heim, G.R.; Kumar, S. Assessing Customer Return Behaviors through Data Analytics. *J. Oper. Manag.* **2020**, *66*, 622–645. [CrossRef]
2. Biederman, D. Many Happy Returns. *J. Commer.* **2005**, *5*, 1–3.
3. Kadłubek, M.; Thalassinos, E.; Domagała, J.; Grabowska, S.; Saniuk, S. Intelligent Transportation System Applications and Logistics Resources for Logistics Customer Service in Road Freight Transport Enterprises. *Energies* **2022**, *15*, 4668. [CrossRef]
4. Pi, Z. Service and Pricing Strategies with Competition and Cooperation in a Dual-Channel Supply Chain with Demand Disruption. *Ind. Eng.* **2019**, *138*, 106130. [CrossRef]
5. Wang, L.; Song, H.; Wang, Y. Pricing and Service Decisions of Complementary Products in a Dual-Channel Supply Chain. *Comput. Ind. Eng.* **2017**, *105*, 223–233. [CrossRef]
6. He, L.; Liao, X.; Zhang, Z.G.; Haug, P. Analysis of Online Dual-Channel Supply Chain Based on Service Level of Logistics and National Advertising. *Qual. Technol. Quant. Manag.* **2016**, *13*, 473–490. [CrossRef]
7. Guo, J.; Cao, B.; Xie, W.; Zhong, Y.; Zhou, Y.-W. Impacts of Pre-Sales Service and Delivery Lead Time on Dual-Channel Supply T Chain Design. *Ind. Eng.* **2020**, *147*, 106579. [CrossRef]
8. Baogui, X.; Le, Z.; Lei, X. Pricing Decision of a Dual-Channel Supply Chain with Different Payment, Corporate Social Responsibility and Service Level. *RAIRO-Oper. Res.* **2022**, *56*, 49–75.
9. Pu, X.; Gong, L.; Han, X. Consumer Free Riding: Coordinating Sales Effort in a Dual-Channel Supply Chain. *Electron. Commer. Res. Appl.* **2017**, *22*, 1–12. [CrossRef]
10. Zhang, S.; Zhang, J.; Zhu, G. Retail Service Investing: An Anti-Encroachment Strategy in a Retailer-Led Supply Chain. *Omega* **2019**, *84*, 212–231. [CrossRef]

11. Wu, D.; Chen, J.; Li, P.; Zhang, R. Contract Coordination of Dual Channel Reverse Supply Chain Considering Service Level. *J. Clean. Prod.* **2020**, *260*, 121071. [CrossRef]
12. Zhang, G.; Dai, G.; Sun, H.; Zhang, G.; Yang, Z. Equilibrium in Supply Chain Network with Competition and Service Level between Channels Considering Consumers' Channel Preferences. *J. Retail. Consum. Serv.* **2020**, *57*, 102199. [CrossRef]
13. Zhou, Y.-W.; Guo, J.; Zhou, W. Pricing/Service Strategies for a Dual-Channel Supply Chain with Free Riding and Service-Cost Sharing. *Int. J. Prod. Econ.* **2018**, *196*, 198–210. [CrossRef]
14. Guo, J.; Guo, Y. Optimal Coordination and Service Level of the Supply Chain in the Sharing Economy: The Perspective of Social Responsibility. *Complex Intell. Syst.* **2021**, 1–17. [CrossRef]
15. Xia, Y.; Xiao, T.; Zhang, G.P. Service Investment and Channel Structure Decisions in Competing Supply Chains. *Serv. Sci.* **2019**, *11*, 57–74. [CrossRef]
16. Guajardo, J.A.; Cohen, M.A. Service Differentiation and Operating Segments: A Framework and an Application to After-Sales Services. *Manuf. Serv. Oper. Manag.* **2018**, *20*, 440–454. [CrossRef]
17. Ruiz-Torres, A.J. Joint Determination of Supplier Capacity and Returner Incentives in a Closed-Loop Supply Chain. *J. Clean. Prod.* **2019**, *215*, 1351–1361. [CrossRef]
18. Wang, Q.; Wu, J.; Zhao, N. Optimal Operational Policies of a Dual-Channel Supply Chain Considering Return Service. *Math. Comput. Simul.* **2022**, *199*, 414–437. [CrossRef]
19. Genc, T.S. Optimal Return and Rebate Mechanism in a Closed-Loop Supply Chain Game. *Eur. J. Oper. Res.* **2018**, *269*, 661–681. [CrossRef]
20. Dan, B.; Xu, G.; Liu, C. Pricing Policies in a Dual-Channel Supply Chain with Retail Services. *Int. J. Prod. Econ.* **2012**, *139*, 312–320. [CrossRef]
21. Jena, S.K.; Meena, P. Shopping in the Omnichannel Supply Chain under Price Competition and Product Return. *J. Retail. Consum. Serv.* **2022**, *65*, 102848. [CrossRef]
22. Giri, B.C.; Chakraborty, A.; Maiti, T. Pricing and Return Product Collection Decisions in a Closed-Loop Supply Chain with Dual-Channel in Both Forward and Reverse Logistics. *J. Manuf. Syst.* **2017**, *42*, 104–123. [CrossRef]
23. Lin, J.; Choi, T.-M.; Kuo, Y.-H. Will Providing Return-Freight-Insurances Do More Good than Harm to Dual-Channel e-Commerce Retailers? *Eur. J. Oper. Res.* **2022**, S0377221722007500. [CrossRef]
24. Batarfi, R.; Jaber, M.Y.; Aljazzar, S.M. A Profit Maximization for a Reverse Logistics Dual-Channel Supply Chain with a Return Policy. *Comput. Ind. Eng.* **2017**, *106*, 58–82. [CrossRef]
25. Chen, B.; Chen, J. Compete in Price or Service?—A Study of Personalized Pricing and Money Back Guarantees. *J. Retail.* **2017**, *93*, 154–171. [CrossRef]
26. Assarzadegan, P.; Rasti-Barzoki, M. A Game Theoretic Approach for Pricing under a Return Policy and a Money Back Guarantee in a Closed Loop Supply Chain. *Int. J. Prod. Econ.* **2020**, *222*, 107486. [CrossRef]
27. Huang, M.; Jin, D. Impact of Buy-Online-and-Return-in-Store Service on Omnichannel Retailing: A Supply Chain Competitive Perspective. *Electron. Commer. Res. Appl.* **2020**, *41*, 100977. [CrossRef]
28. Li, G.; Li, L.; Sethi, S.P.; Guan, X. Return Strategy and Pricing in a Dual-Channel Supply Chain. *Int. J. Prod. Econ.* **2019**, *215*, 153–164. [CrossRef]
29. Taleizadeh, A.A.; Alizadeh-Basban, N.; Niaki, S.T.A. A Closed-Loop Supply Chain Considering Carbon Reduction, Quality Improvement Effort, and Return Policy under Two Remanufacturing Scenarios. *J. Clean. Prod.* **2019**, *232*, 1230–1250. [CrossRef]
30. Huang, Z.; Feng, T. Money-Back Guarantee and Pricing Decision with Retailer's Store Brand. *J. Retail. Consum. Serv.* **2020**, *52*, 101897. [CrossRef]
31. Giri, B.C.; Roy, B.; Maiti, T. Multi-Manufacturer Pricing and Quality Management Strategies in the Presence of Brand Differentiation and Return Policy. *Comput. Ind. Eng.* **2017**, *105*, 146–157. [CrossRef]
32. Mei-Li, L.U.; Zuo-Liang, Y.E.; Wang, F. Online Retail Prices and Service Level Decision with Considering Return. *Syst. Eng.* **2017**.
33. Yan, R.; Pei, Z. Information Asymmetry, Pricing Strategy and Firm's Performance in the Retailer- Multi-Channel Manufacturer Supply Chain. *J. Bus. Res.* **2011**, *64*, 377–384. [CrossRef]
34. Mentzer, J.T.; Flint, D.J.; Hult, G.T.M. Logistics Service Quality as a Segment-Customized Process. *J. Mark.* **2001**, *65*, 82–104. [CrossRef]