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Pricing and Return Strategy Selection of Online Retailers Considering Consumer Purchasing Behavior

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Abstract: This article mainly considers the coexistence of physical sales channels and online sales channels. Online retailers with online sales channels consider whether to provide return policies and whether to provide consumers with return insurance. The research established four return strategy models that: do not provide returns; provide returns but do not provide return insurance; provide return insurance, but the cost is borne by online retailers; and provide return insurance, but the cost is borne by consumers. The authors then studied the online retailers' optimal return and shipping insurance selection strategies. The results show that when the proportion of residual return value after the value reduction of unit returned products was large, online retailers set higher sales prices and provided return policies, while offline retailers needed to reduce sales prices in order to attract more consumers. When the consumer unit product return compensation was relatively large, online retailers chose to provide consumers with free return insurance; otherwise, it was more beneficial for online retailers not to provide return insurance. Further research found that although the cost of online retailers increased when freight insurance was taken, it could better attract consumers, which was more beneficial to online retailers.

Keywords: online retailer; consumer purchase behavior; return strategy; return insurance

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1. Introduction

The rapid development of the Internet has changed the traditional sales model based on physical retailing, and online shopping has become the norm. According to The National Bureau of Statistics of China, online retail sales in China reached CNY 13.1 trillion in 2021 and accounted for 24.5% of total retail sales of consumer goods [1]. However, compared to brick-and-mortar retailing, e-tailing has information-asymmetries problems owing to spatial distance, lack of "touch and experience," and a "Money-Back Guarantee (MBG)" consumer protection clause, resulting in a higher volume of returns. MBGs are popular because consumers can return unsatisfactory products and receive a full refund [2,3]. For instance, Taobao.com and JD.com e-merchants have adopted a "seven-day no questions asked" full refund return strategy. Securities Daily reported that during the most famous shopping festival in China, "Double 11" in 2021, the return rate of Taobao.com exceeded 20%, that of JD.com was approximately 10%, and that of e-commerce live streaming reached 60% [4]. Such lenient return terms have led to a shift away from quality-only returns, prompting online retailers to wonder whether they should offer returns on all products. Currently, online retailers only offer conditional returns on products such as skincare and fresh produce, which means that unless the product is defective, the online retailer usually requires the consumer to cover the cost of the return. Therefore, the main reason for online returns is the failure to meet consumer expectations rather than product defects, and the resulting return reverse logistics costs (return shipping) have become a significant barrier for consumers when purchasing online [5]. Thus, online retailers must consider return strategies carefully.

Return shipping insurance ("Return Insurance") was introduced in response to the cost of returning goods. Huatai Insurance Group first offered return insurance to consumers and merchants on Taobao.com in 2010 [6]. Then, in 2013, PICC and China Life launched similar return insurance on B2C platforms such as JD.com and Dangdang [7]. One of the issues is whether the online retailer or the consumer should purchase the return insurance, which is a contentious point. Suppose that online retailers provide return insurance. This can increase consumers' willingness to purchase the product, while the low return cost caused by the return insurance compensation may lead to more returns [8,9] and thus increase the return cost for the retailers. As a result, online retailers offer return insurance purchased by consumers, which may prompt consumers to choose products more carefully and provide a return guarantee for returns that are not due to quality. However, this may also dissuade some consumers. Especially when competing with offline retailers, this may prompt online retailers to make return insurance decisions by weighing return costs more thoroughly against consumer demand.

In a competitive scenario with offline retailers, the ability of return insurance to improve the profitability of online retailers and increase consumers' willingness to pay has become the focus of current researchers. Moreover, adopting pricing decisions and return strategies is also vital for online retailers. This paper examines online retailers' pricing decisions, return strategy choices, and return insurance strategies. Specifically, it considers the following questions:

1. When should an online retailer choose to offer a return service, and what return strategy can increase the online retailer's market share?
2. Should online retailers provide free return insurance to consumers? If not, should consumers purchase their return insurance?
3. How do consumer returns and the cost of return insurance affect the performance of online retailers?

In order to solve these questions, this research constructed a game model of duopoly channel competition between an offline retailer and an online retailer. We explored the pricing and return decisions under the competition of different retail channels through a comparative analysis of online and offline sales channels. Furthermore, we studied the choice and impact of multiple return strategies based on a dual-channel perspective to provide a decision basis for manufacturers' channel development. In addition, from the standpoint of online retailers, we also compared four return strategies: not providing a return channel, providing a return channel but not providing return insurance, providing return insurance but at the cost of the online retailer, and providing return insurance but at the cost of the consumer. The aim was to provide a reference for online retailers to develop optimal pricing and return strategies. The study made a vital contribution to the existing literature. First, the author identified the pricing strategies by analyzing the competition between online and offline retailers. Second, the author provided the conditions for the online retailer's return policy. Finally, the author provided online retailers with a decision basis for pricing and return insurance in the presence of consumer unit product return compensation.

The paper is structured as follows: (Section 1) Introduction and presentation of the topic. (Section 2) Literature Review, including the definitions of main terms and related literature about (Section 2.1) Return Motivation and Return Policies and (Section 2.2) Return Insurance. (Section 3) Problem Description and Assumptions, concluding the description of the conceptual research model and hypotheses. (Section 4) Model Construction and Analysis, investigating the optimal pricing decisions under four scenarios: *NN*, *MN*, *MR*, and *MC* strategy. (Section 5) Strategy Selection, which compared the online retailer's optimal return and shipping insurance selection strategies. (Section 6) Numerical Analysis, reflecting the effect of the residual value ratio of returned products on pricing, demand, and profitability. (Section 7) Conclusions. All proofs are included in the Appendix A.

2. Literature Review

This study was closely relevant to two main streams of literature: (1) return motivation and return policies and (2) return insurance.

2.1. Return Motivation and Return Policies

Consumer returns are a common phenomenon in the retail industry. The main reason for returning products online is the virtuality of the online shopping environment [10,11], where consumers are uncertain about the price, demand, and quality of the product [12–14]. However, a loose return policy can reduce consumers' risk perception and stimulate a purchase's emotional response, thereby increasing consumers' willingness to buy and, ultimately, their willingness to pay [15–19]. For example, Griffs et al. [16] used empirical methods to verify that customer returns could significantly improve repeat purchase behavior.

With limited information available to consumers in online consumption, the decision made by consumers under high uncertainty improves the return rate of online sales [20]. How to help retailers prevent (or reduce) such return risks has become an issue of concern [21]. In terms of the application of a return fee, Hess et al. [22] believed that the practice of charging a return fee can effectively control the return rate; Shulman et al. [23] believed that the return rate could be reduced to some extent by setting the corresponding return cost and return period; further, Akcay et al. [2] reduced the return rate by controlling the selling price while considering the use of a return fee. Additionally, some studies start from the aspect of improving the disclosure of online product information. For example, considering the way to help customers better see the details of products through technology investment [24], using the offline store assistance [25,26], or arranging a physical exhibition hall for the online sales of products [27,28] to control the return rate of online sales. In addition, Lee [29] and Walsh et al. [30] believe that improving the supporting services of online sales, improving the quality of online sales, and constantly enhancing the reputation of online sales stores can greatly reduce the return rate.

Some studies have focused on the impact of the return policy on operations strategies. Xia et al. [26] demonstrated that product returns and retailer-assisted investment strongly impacted a manufacturer's decision on whether to increase online channels. Cai et al. [31] found that the choice of refund policy had a decisive impact on the competitiveness of new-entrant retailers. Batarfi et al. [32] and Guo et al. [33] found that the sales price of products in physical and online channels was only related to whether they provided MBG services in that channel and had nothing to do with whether another channel provided MBGs. Letizia et al. [34] investigated the impact of product returns on the multichannel sales strategies of manufacturers. Zhang et al. [35] found that a buyback policy helped the manufacturer obtain returns-rate information for free when the salvage value was the same for the manufacturer and the retailer. Ertekin and Agrawal [36] assessed the impact of a return period policy change on a multichannel retailer's performance.

Some studies have focused on the problem of return policy choice. Davis et al. [37] developed a model to determine the conditions under which MBGs are most effective in improving profits and social welfare. Guo [38] and Chen and Grewal [39] studied the effect of duopoly competition on retailers' return strategy choices. McWilliams [40] explored the problem of return strategy selection of competitive retailers in a competitive environment between high-quality and low-quality retailers. Nasiry and Popescu [41] studied how sellers choose an appropriate presale strategy based on consumer regret behavior and analyzed the defect-free return strategy in the case of limited capacity. Chen and Chen [42] analyzed two retailers' personalized pricing strategies and return policies with different customer satisfaction rates through a duopoly model. Li and Liu [43] investigated both return policies and found that a manufacturer's return policy could induce the retailer to adopt a return policy. Mondal and Giri [44] investigated two types of return policies in a green e-commerce supply chain: refund and replacement policies. Wang and He [45] established a dual-channel supply chain composed of one manufacturer and one retailer under mass customization and examined the manufacturer's channel strategy and return policy decisions.

The above research discussed the main reasons for returning products, the impact of the return policy on operations strategies, and the problem of return policy choice. However, researchers have not yet considered the impact of return insurance. Therefore, this research compared four types of returns: no return channel; a return channel but no return insurance; return insurance, but the cost is borne by the online retailer; and return insurance, but the cost is borne by the consumer. The strategies can provide a reference for online retailers.

2.2. Return Insurance

Some scholars have paid attention to the research on return insurance, but most of them have focused on traditional offline insurance, such as the early research of [46,47] and the recent research by Geng et al. [48]. Geng et al. [48] considered internet return insurance to deal with return risks and implemented a generous and economically viable return policy for online products. Marotta et al. [49] summarized the basic understanding of Internet insurance, discussed the uniqueness of return insurance, and analyzed the market reaction to Internet insurance through various empirical methods. Lin [50] showed that whether return insurance benefits retailers depended on the unit premium and return shipping costs.

Some studies have focused on the impact of return insurance on operations strategies. Chen et al. [51] proved that offering a return insurance strategy did not necessarily expand demand, and e-sellers with different qualities would increase selling prices when offering return insurance. Lin et al. [52] uncovered that a retailer who purchased RFI for consumers did not necessarily charge a higher price. A few scholars have focused on the question of when to introduce return insurance. Fan and Chen [53] studied the question of when e-tailers should offer free return insurance. Ren et al. [54] showed that when the net salvage value of the product is greater than or equal to zero, the online retailer should provide a refund guarantee return policy. Chen et al. [55] investigated an e-seller's strategy of offering return-freight insurance in the reselling and agency selling formats and proved that offering return-freight insurance may narrow the consumer market. Yang and Ji [56] assessed the impact of cross-selling on managing consumer returns under these three innovative mechanisms in omnichannel operations, that is, buy online and return to the store, return insurance, and a virtual try-on experience.

3. Problem Description and Assumptions

3.1. Problem Description

The paper considered a selling system comprising an offline retailer (represented by subscript "r"), an online retailer (represented by subscript "e"), and customers. In this system, there are two types of retailers from a duopoly competition, where the ordering cost per unit of product is c, and the same products are sold to consumers at prices p_r and p_e because of the different operation modes and costs. It is common for online and offline retailers to adopt different pricing strategies [57]. Zhang et al. [58] and Zhang et al. [59] provided a competitive model between the retailers. The paper assumed that the offline retailer and the online retailer are located at the two ends of the Hotelling line segment (i.e., 0 and 1) and that consumers are uniformly distributed on the line segment, with their locations denoted by $x \in [0,1]$. x is the transportation distance for the consumer to purchase from the offline retailer, and $(1-x)$ is the transportation distance for the consumer to purchase from the online retailer. The online retailer transportation distance is the invisible distance which includes searching for products on the website and the time spent on transportation.

As consumers cannot experience the products while shopping online, the author assumed that when a product does not match a consumer's expectations, the consumer returns the product to the online retailer and receives a full refund. The online retailer can make secondary sales of those products with a discount price. Because those products have been used or damaged during the return process, for each product returned, this research assumed that the impairment value proportion is $(1-k)$ and that the secondary sales price of each returned product is kp_e. The paper also assumed that the residual value of the retailers' unsold surplus product at the end of the selling season is 0.

In practice, if the product itself does not have defects, consumers generally need to pay the return-freight fee (s) when returning [11]. To improve the customers' experience and the adverse effect of reducing the return-freight fee, the online retailer could choose to spend t to afford the return insurance for customers. In addition, if the online retailer does not provide this, customers can purchase the insurance themselves. Regardless of who pays the return insurance, customers can obtain the return-freight compensation $r(r \leq s)$ when they return the product. The online retailer decides whether to provide the return strategy and whether to pay for the return-freight fee. Customers determine whether they buy this product and whether they pay for the return insurance. Based on this, the paper focused on following these four scenarios:

1. Scenario *NN*, where article 25 of the Consumer Protection Law stipulates the types of goods that cannot be returned or exchanged without reason for 7 days. In this scenario, the online retailer can refuse the return application if the customers are unsatisfied with the goods received;
2. Scenario *MN*, where the online retailer provides the return strategy, that is, allows customers to return the goods with which they are unsatisfied, whatever the product and without reason, for 7 days. In this scenario, the online retailer offers a return policy, but the consumer must bear the shipping costs if customers need to return the product;
3. Scenario *MR*, where the online retailer offers a return policy and provides free return insurance to consumers. In this scenario, the online retailer offers free return insurance to consumers, alleviating a certain degree of uncertainty about the consumer's purchase, which may encourage the consumer to purchase;
4. Scenario *MC*, where the online retailer offers a return policy but does not provide free return insurance to consumers. In this scenario, the consumer purchases return insurance, which significantly reduces the return shipping costs faced by the consumer when they return an unsatisfactory good.

3.2. Benchmark

The following assumptions were made here to analyze the subsequent studies in this section.

Assumption 1. *Whether customers buy the product depends on their purchase intention and utility. To illustrate the demand rate of the products purchased by consumers, the paper assumes that the potential market demand is 1 [54].*

Assumption 2. *Customers only buy products from the online retailer or offline retailer, and they do not buy multiple goods.*

Assumption 3. *When customers choose the online retailer, they cannot experience products, and the goods they receive may not match prior expectations. The paper assumes that the probability of the products matching the consumers' expectation is $\theta(0 < \theta < 1)$ [60,61]. When customers purchase from the offline retailer, this can reduce their uncertainty about the experience. Usually, the probability of consumers' expectation match is low. To highlight the differences, this research assumes that when consumers choose the offline retailer, $\theta = 1$.*

Assumption 4. *The paper assumes that consumers are completely rational people, they do not keep useless products, and there is no speculation about getting a return. If the online retailer provides return services, then when the goods do not match the customers' experience, they return the product to the online retailer and obtain a full refund [53,54].*

Assumption 5. *While differences in order quantities between online and offline retailers may affect ordering costs, to highlight the impact of the different effects of online and offline return insurance, the paper assumes that the ordering costs (c) of retailers are the same.*

The symbols of the relevant parameters involved in this paper are shown in Table 1.

Table 1. Symbol definition.

Symbol	Definition
v	Product valuation for consumers matched to products purchased by consumers at online retailers
p_r	Offline retailer sales price
p_e	Online retailer sales price
θ	Matching rate of online purchase products and consumer needs
s	The cost of returning a consumer unit of a product
r	Consumer unit product return compensation ($r \leq s$)
t	The cost of purchasing return insurance for unit products ($t \leq r$)
k	Percentage of residual value after impairment of the importance of returned products per unit
c	Unit product ordering cost
h	Consumer travel cost per unit distance
x	The transportation distance
U_r, U_e	Net utility of products purchased by consumers at offline retailers and online retailers
D_r, D_e	The demand for offline retailers and online retailers
π_r, π_e	Profits of offline retailers and online retailers

4. Model Construction and Analysis

4.1. NN Strategy

At this time, if the consumer is satisfied with the product purchased online, that is, it meets the consumer's expectations, they obtain utility $(v - p_e)$. However, if the customer is not satisfied with the product, they obtain utility $(0 - p_e)$. The preference cost of a consumer in position x to purchase products from online retailers is $h(1 - x)$. Therefore, in case NN, the utility of a consumer to purchase products from online retailers is

$$U_e^{NN} = \theta(v - p_e) + (1 - \theta)(0 - p_e) - (1 - x)h \tag{1}$$

In addition, a consumer can purchase products from offline retailers, and the preference cost of a consumer in position x to purchase products from offline retailers is hx. Therefore, the utility of a consumer to purchase products from offline retailers is

$$U_r^{NN} = v - p_r - hx \tag{2}$$

By comparing the consumer's utility U_e^{NN} and U_r^{NN}, the demand of online retailers and offline D_e^{NN} retailers can be obtained, which are D_e^{NN} and D_r^{NN}, respectively, as shown in Lemma 1.

Lemma 1. $D_r^{NN} = \frac{h+p_e-p_r+v(1-\theta)}{2h}$; $D_e^{NN} = \frac{h-p_e+p_r-v(1-\theta)}{2h}$.

By comparing the consumer's utility U_e^{NN} and U_r^{NN}, and the market demands D_r^{NN} and D_e^{NN}, the paper can obtain the profit functions of offline retailers and online retailers as follows:

$$\pi_r^{NN} = (p_r - c)D_r^{NN} \tag{3}$$

$$\pi_e^{NN} = (p_e - c)D_e^{NN} \tag{4}$$

The optimal sales price can be calculated by combining the profit functions of offline retailers and online retailers. As online retailers and offline retailers are in perfect competition, it is assumed that they both decide the sales price (p_e and p_r) at the same time. The result is shown in Proposition 1.

Proposition 1. $p_r^{NN} = c + h + \frac{(1-\theta)v}{3}$, $p_e^{NN} = c + h - \frac{(1-\theta)v}{3}$; $D_r^{NN} = \frac{3h+v(1-\theta)}{6h}$, $D_e^{NN} = \frac{3h-(1-\theta)v}{6h}$; $\pi_r^{NN} = \frac{(3h+v(1-\theta))^2}{18h}$, $\pi_e^{NN} = \frac{(3h-v(1-\theta))^2}{18h}$.

Proposition 1 gives the optimal selling price, demand function, and profit of offline retailers and online retailers under the *NN* strategy. Next, the paper analyzes the influence of parameters θ and h on the optimal sales price, demand function, and optimal profit of offline retailers and online retailers.

Corollary 1.

(1) $\frac{\partial p_r^{NN}}{\partial \theta} < 0$, $\frac{\partial p_e^{NN}}{\partial \theta} > 0$; $\frac{\partial D_r^{NN}}{\partial \theta} < 0$, $\frac{\partial D_e^{NN}}{\partial \theta} > 0$;

(2) $\frac{\partial \pi_r^{NN}}{\partial \theta} < 0$; *when* $0 < \theta < \frac{v-3h}{v}$, $\frac{\partial \pi_e^{NN}}{\partial \theta} < 0$; *when* $\max\{0, \frac{v-3h}{v}\} < \theta < 1$, $\frac{\partial \pi_e^{NN}}{\partial \theta} > 0$;

(3) $\frac{\partial p_r^{NN}}{\partial h} > 0$, $\frac{\partial p_e^{NN}}{\partial h} > 0$, $\frac{\partial D_r^{NN}}{\partial h} < 0$, $\frac{\partial D_e^{NN}}{\partial h} > 0$;

(4) *when* $0 < h < \frac{v}{3}(1-\theta)$, $\frac{\partial \pi_r^{NN}}{\partial h} < 0$, $\frac{\partial \pi_e^{NN}}{\partial h} < 0$; *when* $\frac{v}{3}(1-\theta) < h$, $\frac{\partial \pi_r^{NN}}{\partial h} > 0$, $\frac{\partial \pi_e^{NN}}{\partial h} > 0$.

Corollary 1 shows that under the *NN* strategy, the greater the probability that the consumers purchase products online to match their expectation, the lower the risk of the consumers' online purchase, which causes customers' online purchase intention to increase. At this time, the increase in D_e^{NN} makes online retailers set higher sales prices, while D_r^{NN} decreases, and they should reduce sales prices to attract consumers to buy from offline retailers. Finally, as the matching rate increases, the profit of offline retailers gradually decreases. π_e^{NN} is related to the matching rate. When the matching rate is low, the U_e^{NN} is small and h is higher, so the consumer tends to choose offline retailers rather than online retailers. When the matching rate between online purchase products and consumer expectation is greater, the consumer's value of products is greater and the h is smaller, so more consumers choose to buy products from online retailers. When h is relatively small, consumers can choose to buy products from online retailers or offline retailers at the same time. Therefore, the two parties adopt the strategy of reducing the selling price to compete for the market, which reduces profits. However, the higher h is, the higher cost of purchasing products is from offline retailers. More consumers choose to purchase products from online retailers, so online retailers may set higher sales prices, and offline retailers correspondingly increase their sales prices. π_e^{NN} increases with the increase in h under the combined effect of increased sales price and demand.

4.2. MN Strategy

At this time, if the consumer is satisfied with the products, the consumer can obtain utility $v - p_e$. On the contrary, if the consumers are not satisfied with the products, the utility is $0 - s$, where s is the return freight cost of the consumer. Therefore, in the case of MN, the utility of a consumer to buy products from online and offline retailers is

$$U_e^{MN} = \theta(v - p_e) + (1-\theta)(0-s) - h(1-x) \tag{5}$$

$$U_r^{MN} = v - p_r - hx \tag{6}$$

Lemma 2. $D_r^{MN} = \frac{h-p_r+\theta p_e+s(1-\theta)+v(1-\theta)}{2h}$; $D_e^{MN} = \frac{h+p_r-\theta p_e-s(1-\theta)-v(1-\theta)}{2h}$.

Thus, the profit functions of offline retailers and online retailers are

$$\pi_r^{MN} = (p_r - c)D_r^{MN} \tag{7}$$

$$\pi_e^{MN} = (\theta p_e - c + (1-\theta)kp_e)D_e^{MN} \tag{8}$$

By comparing the U_e^{MN} and U_r^{MN}, and D_r^{MN} and D_e^{MN}, the paper can obtain Proposition 2 by combining the profit functions of offline retailers and online retailers.

Proposition 2. $p_r^{MN} = \frac{c(2k(1-\theta)+3\theta)}{3k(1-\theta)+3\theta} + \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{3k(1-\theta)+3\theta}$, $p_e^{MN} = \frac{c(k(1-\theta)+3\theta)}{3\theta(k(1-\theta)+\theta)} + \frac{(3h-(1-\theta)(s+v))}{3\theta}$; $D_r^{MN} = \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{6h(k(1-\theta)+\theta)} \frac{ck(1-\theta)}{6h(k(1-\theta)+\theta)}$,

$D_e^{MN} = \frac{ck(1-\theta)}{6h(k(1-\theta)+\theta)} + \frac{3h-(1-\theta)(s+v)}{6h}$; $\pi_r^{MN} = \frac{((k(1-\theta)+\theta)(3h+(1-\theta)(s+v))-ck(1-\theta))^2}{18h(k(1-\theta)+\theta)^2}$, $\pi_e^{MN} = \frac{ck(1-\theta)+(k(1-\theta)+\theta)(3h-(1-\theta)(s+v))}{3\theta}$.

Proposition 2 gives the optimal selling price, demand function, and profit of offline retailers and online retailers under the *MN* strategy. Next, the paper analyzes the effects of parameters θ and h on the optimal sales price, demand function, and optimal profit of offline retailers and online retailers.

Corollary 2.

(1) *When* $0 < s < \frac{ck}{(k(1-\theta)+\theta)^2} - v$, $\frac{\partial p_r^{MN}}{\partial \theta} > 0$; *when* $s > \max\{0, \frac{ck}{(k(1-\theta)+\theta)^2} - v\}$, $\frac{\partial p_r^{MN}}{\partial \theta} < 0$; *When* $0 < s < \frac{k^2c+c\theta(1-k)((3-k)\theta+2k)}{(k(1-\theta)+\theta)^2} + 3h - v$, $\frac{\partial p_e^{MN}}{\partial \theta} < 0$; *when* $s > \max\{0, \frac{k^2c+c\theta(1-k)((3-k)\theta+2k)}{(k(1-\theta)+\theta)^2} + 3h - v\}$, $\frac{\partial p_e^{MN}}{\partial \theta} > 0$.

(2) *When* $0 < s < \frac{ck}{(k(1-\theta)+\theta)^2} - v$, $\frac{\partial D_r^{MN}}{\partial \theta} > 0$, $\frac{\partial D_e^{MN}}{\partial \theta} < 0$; *when* $s > \max\{0, \frac{ck}{(k(1-\theta)+\theta)^2} - v\}$, $\frac{\partial D_r^{MN}}{\partial \theta} < 0$, $\frac{\partial D_e^{MN}}{\partial \theta} > 0$.

(3) *When* $\frac{(k(1-\theta)+\theta)^2 v}{k} < c \leq \frac{(k(1-\theta)+o)(3h+v(1-\theta))}{k(1-\theta)}$ *and* $0 < s < \frac{ck}{(k(1-\theta)+\theta)^2} - v$ *or* $c > \frac{(k(1-\theta)+o)(3h+v(1-\theta))}{k(1-\theta)}$ *and* $\frac{ck}{(k(1-\theta)+\theta)^2} - \frac{3h+v(1-\theta)}{1-\theta} < s < \frac{ck}{(k(1-\theta)+\theta)^2} - v$, $\frac{\partial \pi_r^{MN}}{\partial \theta} > 0$; *otherwise*, $\frac{\partial \pi_r^{MN}}{\partial \theta} < 0$.

(4) *When* $0 < s < \frac{(c+3h)k}{k(1-\theta^2)+\theta^2} - v$, $\frac{\partial \pi_e^{MN}}{\partial \theta} < 0$; *when* $s > \max\{0, \frac{(c+3h)k}{k(1-\theta^2)+\theta^2} - v\}$, $\frac{\partial \pi_e^{MN}}{\partial \theta} > 0$.

(5) $\frac{\partial p_r^{MN}}{\partial h} > 0$; $\frac{\partial p_e^{MN}}{\partial h} > 0$.

(6) *When* $0 < s < \frac{ck}{k(1-\theta)+\theta} - v$, $\frac{\partial D_r^{MN}}{\partial h} > 0$, $\frac{\partial D_e^{MN}}{\partial h} < 0$; *when* $s > \max\{0, \frac{ck}{k(1-\theta)+\theta} - v\}$, $\frac{\partial D_r^{MN}}{\partial h} < 0$, $\frac{\partial D_e^{MN}}{\partial h} > 0$.

(7) *When* $0 < h < \max\{\frac{(s+v)(1-\theta)}{3} - \frac{ck(1-\theta)}{3(k(1-\theta)+\theta)}, \frac{ck(1-\theta)}{3(k(1-\theta)+\theta)} - \frac{(s+v)(1-\theta)}{3}\}$, $\frac{\partial \pi_r^{MN}}{\partial h} < 0$; *when* $h > \max\{\frac{(s+v)(1-\theta)}{3} - \frac{ck(1-\theta)}{3(k(1-\theta)+\theta)}, \frac{ck(1-\theta)}{3(k(1-\theta)+\theta)} - \frac{(s+v)(1-\theta)}{3}\}$, $\frac{\partial \pi_r^{MN}}{\partial h} > 0$; $\frac{\partial \pi_e^{MN}}{\partial h} > 0$.

Corollary 2 shows that under the *MN* strategy, p_r^{MN} and p_e^{MN} is related to s. If c is small, the online retailers choose to reduce p_e^{MN}, as the demand probability increases in order to attract consumers to buy products. However, as the matching rate between offline products and consumer demand increases, D_r^{MN} naturally declines, so π_e^{MN} declines. When c is large, with the increase in matching rate, online retailers set higher sales prices. This is because when s is large, if the demand probability of consumers to purchase products is still large, online retailers naturally choose to increase the price of products. As the matching rate between online products and consumer demand increases, the demand for online products increases, so π_e^{MN} rises accordingly. In addition, π_r^{MN} is also related to the ordering cost per unit product. When unit ordering cost is greater than a certain value and s is less than a certain value, the profit of offline retailers increases with the matching rate. In the opposite scenario, it continues to decrease. In addition, with the increase in consumers' unit travel cost, p_r^{MN} and p_e^{MN} increases, but D_r^{MN} decreases while D_e^{MN} increases. This is because the increase in h leads the consumer to buy products online. Therefore, even if p_e^{MN} increases, the sales quantity still increases.

Corollary 3.

(1) $\frac{\partial p_r^{MN}}{\partial k} < 0$, $\frac{\partial p_e^{MN}}{\partial k} < 0$; $\frac{\partial D_r^{MN}}{\partial k} < 0$, $\frac{\partial D_e^{MN}}{\partial k} > 0$.

(2) *When* $0 < s < \frac{ck}{k(1-\theta)+\theta} - \frac{(1-\theta)v+3h}{1-\theta}$, $\frac{\partial \pi_r^{MN}}{\partial k} > 0$; *when* $s > \max\{0, \frac{ck}{k(1-\theta)+\theta} - \frac{(1-\theta)v+3h}{1-\theta}\}$, $\frac{\partial \pi_r^{MN}}{\partial k} < 0$.

(3) *When* $0 < s < \frac{c+3h}{1-\theta} - v$, $\frac{\partial \pi_e^{MN}}{\partial k} > 0$; *when* $s > \max\{0, \frac{c+3h}{1-\theta} - v\}$, $\frac{\partial \pi_e^{MN}}{\partial k} < 0$.

Corollary 3 shows that under the *MN* strategy, the greater the proportion of the surplus saleable value of product returns, the lower the impact of the consumers' return behavior on retailers' secondary sales. For example, the value of products that are easy to deteriorate or have a shorter shelf life is greatly discounted after a return. Usually, online and offline retailers can only reduce their selling prices to deal with them. Because online retailers provide a return strategy, as the surplus saleable value increases, the consumers often choose to buy online rather than offline. The profit of retailers is related to the unit return cost. If s is small, retailers choose to reduce the product price with the increase in the surplus saleable value to attract consumers to buy products. At this time, the increase in sales volume is greater than the decrease in product price, and the profit of online retailers continues to rise. On the contrary, when the s is large, offline retailers set a lower sales price with the increase in the surplus saleable value. At this time, with the continuous expansion of the online retail market, π_r^{MN} continues to decline.

4.3. MR Strategy

Under the *MR* strategy, online retailers buy return insurance for consumers and pay the cost of purchasing return insurance for unit products t. In case of a return, the online retailer refunds the product to the consumer (p_e), and the insurance company reimburses the consumer for the return freight, which is called return freight compensation (r). If the consumer is satisfied with the product, they can derive utility ($v - p_e$). On the contrary, if they are not satisfied, then the product is returned, so they can derive utility ($r - s$). Therefore, in the case of MR, the utility function of consumers buying products from online retailers is

$$U_e^{MR} = \theta(v - p_e) + (1-\theta)(r - s) - h(1-x) \tag{9}$$

In addition, consumers can buy products from offline retailers. The travel cost of consumers in location x to buy products from offline retailers is hx. Therefore, the utility of consumers buying products from offline retailers is

$$U_r^{MR} = v - p_r - hx \tag{10}$$

According to Equations (9) and (10), the demand of offline and online retailers is calculated to obtain Lemma 3.

Lemma 3. $D_r^{MR} = \frac{h-p_r+\theta p_e+(s+v-r)(1-\theta)}{2h}$, $D_e^{MR} = \frac{h+p_r-\theta p_e-(s+v-r)(1-\theta)}{2h}$.

By comparing consumers' utility of purchasing products from offline and online retailers, this research can obtain the demand of offline and online retailers. Thus, the profit functions of offline and online retailers are

$$\pi_r^{MR} = (p_r - c)D_r^{MR} \tag{11}$$

$$\pi_e^{MR} = (\theta p_e - (c+t) + (1-\theta)kp_e)D_e^{MR} \tag{12}$$

The following Proposition 3 can be obtained by combining the profit functions of offline and online retailers.

Proposition 3. $p_r^{MR} = \frac{2c+3h+(s+v-r)(1-\theta)}{3} + \frac{\theta(c+t)}{3(k(1-\theta)+\theta)}$, $p_e^{MR} = \frac{c+3h-(s+v-r)(1-\theta)}{3\theta} + \frac{2\theta(c+t)}{3\theta(k(1-\theta)+\theta)}$; $D_r^{MR} = \frac{\theta(c+t)}{6h(k(1-\theta)+\theta)} + \frac{(s+v-r)(1-\theta)+3h-c}{6h}$, $D_e^{MR} = \frac{3h-(s+v-r)(1-\theta)+c}{6h} -$

$\frac{\theta(c+t)}{6h(k(1-\theta)+\theta)}$; $\pi_r^{MR} = \frac{(\theta(c+t)+(k(1-\theta)+\theta)(3h-c+(s+v-r)(1-\theta)))^2}{18h(k(1-\theta)+\theta)^2}$, $\pi_e^{MR} = \frac{(\theta(c+t)+(k(1-\theta)+\theta)((s+v-r)(1-\theta)-3h-c))^2}{18h(k(1-\theta)+\theta)\theta}$.

Proposition 3 gives the optimal selling price, demand function, and optimal profit of offline and online retailers under strategy *MR*. In the following, the parameters θ and h as well as their impact on the optimal selling price, demand function, and optimal profit of offline and online retailers are analyzed.

Corollary 4.

(1) *When* $0 < s < \frac{k(c+t)}{(k(1-\theta)+\theta)^2} + (r-v)$, $\frac{\partial p_r^{MR}}{\partial\theta} > 0$; *when* $s > \max\{0, \frac{k(c+t)}{(k(1-\theta)+\theta)^2} + (r-v)\}$, $\frac{\partial p_r^{MR}}{\partial\theta} < 0$.

(2) *When* $0 < s < \min\{\frac{\theta(1-k)(2ck(1-\theta)+c(1+k)\theta+2\theta(c+t))+ck^2}{(k(1-\theta)+\theta)^2} + 3h + r - v, \infty\}^+$, $\frac{\partial p_e^{MR}}{\partial\theta} < 0$; *when* $s > \max\{0, \frac{\theta(1-k)(2ck(1-\theta)+c(1+k)\theta+2\theta(c+t))+ck^2}{(k(1-\theta)+\theta)^2} + 3h + r - v\}$, $\frac{\partial p_e^{MR}}{\partial\theta} > 0$.

(3) *When* $0 < s < \frac{k(c+t)}{(k(1-\theta)+\theta)^2} + (r-v)$, $\frac{\partial D_e^{MR}}{\partial\theta} > 0$, $\frac{\partial D_r^{MR}}{\partial\theta} < 0$; *when* $s > \max\{0, \frac{k(c+t)}{(k(1-\theta)+\theta)^2} + (r-v)\}$, $\frac{\partial D_e^{MR}}{\partial\theta} < 0$, $\frac{\partial D_r^{MR}}{\partial\theta} > 0$.

(4) $\frac{\partial \pi_r^{MR}}{\partial\theta} < 0$; $\frac{\partial \pi_e^{MR}}{\partial\theta} > 0$.

(5) $\frac{\partial p_r^{MR}}{\partial h} > 0$; $\frac{\partial p_e^{MR}}{\partial h} > 0$;

(6) *When* $0 < s < \frac{ck(1-\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + r - v$, $\frac{\partial D_r^{MR}}{\partial h} > 0$, $\frac{\partial D_e^{MR}}{\partial h} < 0$; *when* $s > \max\{0, \frac{ck(1-\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + r - v\}$, $\frac{\partial D_r^{MR}}{\partial h} < 0$, $\frac{\partial D_e^{MR}}{\partial h_r} > 0$.

(7) *When* $\frac{\theta(c+t)}{(k(1-\theta)+\theta)(1-\theta)} - \frac{c+3h-(1-\theta)v}{1-\theta} < r \le \frac{\theta(c+t)}{(k(1-\theta)+\theta)(1-\theta)} - \frac{c-3h-(1-\theta)v}{1-\theta}$ *and* $0 < s < \frac{ck(1-\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + \frac{3h+(1-\theta)(r-v)}{1-\theta}$ *or* $r > \frac{\theta(c+t)}{(k(1-\theta)+\theta)(1-\theta)} - \frac{c-3h-(1-\theta)v}{1-\theta}$ *and* $\frac{ck(1-\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(1-\theta)(r-v)-3h}{1-\theta} < s < \frac{ck(1-\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(1-\theta)(r-v)+3h}{1-\theta}$, $\frac{\partial \pi_r^{MR}}{\partial h} > 0$, $\frac{\partial \pi_e^{MR}}{\partial h} > 0$; *otherwise* $\frac{\partial \pi_r^{MR}}{\partial h} < 0$, $\frac{\partial \pi_e^{MR}}{\partial h} < 0$.

Corollary 4 shows that the optimal selling price, demand, and profit under the *MR* strategy depends on the probability that consumers match demand for products purchased online θ and the travel cost per unit distance of consumers h. In particular, when the unit product return cost of consumers s is high, with the increase in θ, the online retailers whose cost increases owing to the shipping insurance choose to raise the selling price ${p_e}^{MR}$ of products, and the online demand ${D_e}^{MR}$ decreases accordingly. Meanwhile, offline retailers choose to reduce product prices ${p_r}^{MR}$ to ensure the demand of offline retailers ${D_r}^{MR}$ in order to attract consumers who are sensitive to price increases. When s is low, with the increase in θ, the online retailers should set a lower ${p_e}^{MR}$, and the ${D_e}^{MR}$ increases. Meanwhile, the offline retailers also increase ${p_r}^{MR}$ in order to ensure the realization of profits. Corollary 4 also shows that as h rises, the selling prices of both online and offline retailers should be set higher. In this situation, when s is low, ${D_r}^{MR}$ increases with the rise of the consumers' unit distance travel cost h, while ${D_e}^{MR}$ decreases with the rise of h. When s is high, ${D_r}^{MR}$ decreases with the rise of h, while ${D_e}^{MR}$ increases with the rise of h. In addition, when the consumer unit product return compensation r is within the range stipulated in the above formula, and the s is small or the r is high and s is within the range limited in the formula, with the increase in h, both online and offline profits increase as h increases. Conversely, in other cases, both online and offline profits decrease as h increases.

In the following, the parameters and their impact on the optimal selling price, demand function, and optimal profit of offline and online retailers are analyzed.

Corollary 5.

(1) $\frac{\partial p_r^{MR}}{\partial t} > 0$, $\frac{\partial p_r^{MR}}{\partial r} < 0$; $\frac{\partial p_e^{MR}}{\partial t} > 0$, $\frac{\partial p_e^{MR}}{\partial r} > 0$;

(2) $\frac{\partial D_r^{MR}}{\partial t} > 0$, $\frac{\partial D_r^{MR}}{\partial r} < 0$; $\frac{\partial D_e^{MR}}{\partial t} < 0$, $\frac{\partial D_e^{MR}}{\partial r} > 0$.

(3) *When* $0 < s < \frac{ck(1-\theta)-3h(k(1-\theta)+\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + r - v$, $\frac{\partial \pi_r^{MR}}{\partial t} < 0$, $\frac{\partial \pi_r^{MR}}{\partial r} > 0$; *when* $s > \max\{0, \frac{ck(1-\theta)-3h(k(1-\theta)+\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + r - v\}$, $\frac{\partial \pi_r^{MR}}{\partial t} > 0$, $\frac{\partial \pi_r^{MR}}{\partial r} < 0$.

(4) *When* $0 < s < \frac{ck(1-\theta)-3h(k(1-\theta)+\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(r-v)(1-\theta)+6h}{1-\theta}$, $\frac{\partial \pi_e^{MR}}{\partial t} < 0$, $\frac{\partial \pi_e^{MR}}{\partial r} > 0$; *when* $s > \max\{0, \frac{ck(1-\theta)-3h(k(1-\theta)+\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(r-v)(1-\theta)+6h}{1-\theta}\}$, $\frac{\partial \pi_e^{MR}}{\partial t} > 0$, $\frac{\partial \pi_e^{MR}}{\partial r} > 0$.

Corollary 5 shows that the higher the cost of purchasing return insurance for unit products t under *MR* strategies, the higher the cost of online retailers. Therefore, the online retailers increase the p_e^{MR}, and D_e^{MR} decreases. Meanwhile, more consumers buy products from offline retailers, and the offline retailers improve p_r^{MR}. The impact of t on profit depends on s. When s is high, the profit of online and offline retailers increases with t. On the contrary, when s is low, the profit of online and offline retailers decreases as t increases. Corollary 5 also shows that the higher the r, the lower the extra cost of return, which leads to the stronger willingness of consumers to buy products online and increase D_e^{MR}. However, as t increases the cost of online retailers, the online retailers increase p_e^{MR}, and the simultaneous increase in demand and price increases the profits of online retailers. From the perspective of offline retailers, the increase in r makes online sales more attractive, and offline retailers adopt the strategy of cutting prices owing to the decline in demand. In addition, the impact of r on the profits of offline retailers also depends on s; that is, when s is high, the profits of offline retailers decrease with the increase in r. When s is low, and the profits of offline retailers increase with r. This is because when s is low, because the compensation amount r is less than the return freight s, consumers are less sensitive to the return freight, and consumers who prefer offline experience choose to buy offline, so the increase in consumer return compensation per unit product improves the profits of offline retailers.

Corollary 6.

(1) $\frac{\partial p_r^{MR}}{\partial k} > 0$, $\frac{\partial p_e^{MR}}{\partial k} < 0$.

(2) $\frac{\partial D_r^{MR}}{\partial k} < 0$, $\frac{\partial D_e^{MR}}{\partial k} > 0$.

(3) *When* $0 < s < \frac{ck(1-\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(r-v)(1-\theta)-3h}{1-\theta}$, $\frac{\partial \pi_r^{MR}}{\partial k} > 0$; *when* $s > \max\{0, \frac{ck(1-\theta)-\theta t}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(r-v)(1-\theta)-3h}{1-\theta}\}$, $\frac{\partial \pi_r^{MR}}{\partial k} < 0$.

Under the *MR* strategy, a higher proportion of available value is returned per unit of product, increasing sales opportunities for online retailers. Thus, as the unit to return products increases, the proportion of remaining available value decreases, and more consumers are attracted to buying products online. Thus, offline demand decreases, and offline retailers raise the p_r^{MR} because offline consumers are not sensitive to prices or are unfamiliar with online products. When the return cost is high, the increase in the proportion of the residual saleable value of a unit product return makes online retailers willing to spend more in return-insurance costs to attract more consumers to buy products online. As D_e^{MR} increases and D_r^{MR} decreases, the profits of offline retailers also decrease.

4.4. *MC* Strategy

In the *MC* strategy, the consumer needs to purchase return insurance and gain utility $(v - p_e - t)$ if the consumer is satisfied with the product purchased; conversely, if the consumer is not satisfied and needs to return the product, utility $(r - s - t)$ is gained.

Therefore, in the MC strategy, the consumer's utility for purchasing a product from an online retailer is

$$U_e^{MC} = \theta(v - p_e - t) + (1-\theta)(r - s - t) - h(1-x) \tag{13}$$

In addition, consumers can also purchase products from offline retailers, and when a consumer in position x purchases a product from offline retailers, the cost of travel is hx; therefore, the utility of a consumer purchasing a product from an offline retailer is

$$U_r^{MC} = v - p_r - hx \tag{14}$$

According to Equations (13) and (14), we calculate the demand of offline retailers and online retailers to obtain Lemma 4.

Lemma 4. $D_r^{MC} = \frac{h-p_r+\theta p_e+(s+v-r)(1-\theta)+t}{2h}$, $D_e^{MC} = \frac{h+p_r-\theta p_e-(s+v-r)(1-\theta)-t}{2h}$.

By comparing the consumers' utility of purchasing products from offline retailers and online retailers, the paper can derive the demand of offline retailers and online retailers, which yields the profit functions of offline retailers and online retailers, respectively:

$$\pi_r^{MR} = (p_r - c)D_r^{MC} \tag{15}$$

$$\pi_e^{MC} = (\theta p_e - c + (1-\theta)kp_e)D_e^{MC} \tag{16}$$

By combining the offline retailer and online retailer profit functions (15) and (16), the paper can derive Proposition 4.

Proposition 4. $p_r^{MC} = \frac{(c+t)\theta+kt(1-\theta)}{3(k(1-\theta)+\theta)} + \frac{(s+v-r)(1-\theta)+3h+2c}{3}$, $p_e^{MC} = \frac{2c}{3(k(1-\theta)+\theta)} + \frac{c-t+3h-(s+v-r)(1-\theta)}{3\theta}$; $D_r^{MC} = \frac{(s+v-r)(1-\theta)+3h}{6h} + \frac{k(1-\theta)(t-c)+t\theta}{6h(k(1-\theta)+\theta)}$, $D_e^{MC} = \frac{3h-(s+v-r)(1-\theta)}{6h} - \frac{k(1-\theta)(t-c)+t\theta}{6h(k(1-\theta)+\theta)}$; $\pi_r^{MC} = \frac{((k(1-\theta)+\theta)(3h+(s+v-r)(1-\theta)+t)-ck(1-\theta))^2}{18h(k(1-\theta)+\theta)^2}$, $\pi_e^{MC} = \frac{((k(1-\theta)+\theta)((s+v-r)(1-\theta)+t-3h)-ck(1-\theta))^2}{18h(k(1-\theta)+\theta)\theta}$.

Proposition 4 shows the optimal price, demand, and profit for the offline retailer and the online retailer in the MC strategy. Below, the paper analyzes the effect of parameters θ and h on the optimal price, demand, and profit for offline and online retailers.

Corollary 7.

(1) *When* $0 < s < \frac{ck}{(k(1-\theta)+\theta)^2} + r - v$, $\frac{\partial p_r^{MC}}{\partial\theta} > 0$, $\frac{\partial D_r^{MC}}{\partial\theta} > 0$, $\frac{\partial D_e^{MC}}{\partial\theta} < 0$; *when* $s > \max\{0, \frac{ck}{(k(1-\theta)+\theta)^2} + r - v\}$, $\frac{\partial p_r^{MC}}{\partial\theta} < 0$, $\frac{\partial D_r^{MC}}{\partial\theta} < 0$, $\frac{\partial D_e^{MC}}{\partial\theta} > 0$.

(2) *When* $0 < s < \frac{ck^2+c\theta(1-k)((3-k)\theta+2k)}{(k(1-\theta)+\theta)^2} + 3h + r - t - v$, $\frac{\partial p_e^{MC}}{\partial\theta} < 0$; *when* $s > \max\{0, \frac{ck^2+c\theta(1-k)((3-k)\theta+2k)}{(k(1-\theta)+\theta)^2} + 3h + r - t - v\}$, $\frac{\partial p_e^{MC}}{\partial\theta} > 0$.

(3) *When* $0 < s < \frac{ck(1-\theta)-ot}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(1-\theta)(r-v)-3h}{1-\theta}$, $\frac{\partial\pi_r^{MC}}{\partial\theta} > 0$; *when* $s > \max\{0, \frac{ck(1-\theta)-ot}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(1-\theta)(r-v)-3h}{1-\theta}\}$, $\frac{\partial\pi_r^{MC}}{\partial\theta} < 0$.

(4) *When* $0 < s < \frac{ck(1-\theta)-ot}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(1-\theta)(r-v)+3h}{1-\theta}$, $\frac{\partial\pi_e^{MC}}{\partial\theta} > 0$; *when* $s > \max\{0, \frac{ck(1-\theta)-ot}{(k(1-\theta)+\theta)(1-\theta)} + \frac{(1-\theta)(r-v)+3h}{1-\theta}\}$, $\frac{\partial\pi_e^{MC}}{\partial\theta} < 0$.

(5) $\frac{\partial p_r^{MC}}{\partial h} > 0$; $\frac{\partial p_e^{MC}}{\partial h} > 0$;

(6) *When* $0 < s < \frac{ck}{k(1-\theta)+\theta} + \frac{(1-\theta)(r-v)-t}{1-\theta}$, $\frac{\partial D_r^{MC}}{\partial h} > 0$, $\frac{\partial D_e^{MC}}{\partial h} < 0$; *when* $s > \max\{0, \frac{ck}{k(1-\theta)+\theta} + \frac{(1-\theta)(r-v)-t}{1-\theta}\}$, $\frac{\partial D_r^{MC}}{\partial h} < 0$, $\frac{\partial D_e^{MC}}{\partial h} > 0$.

(7) When $\frac{v(1-\theta)+t-3h}{1-\theta} - \frac{ck}{k(1-\theta)+\theta} < r \leq \frac{v(1-\theta)+t+3h}{1-\theta} - \frac{ck}{k(1-\theta)+\theta}$ and $0 < s < \frac{ck}{k(1-\theta)+\theta} + \frac{3h-t}{1-\theta} + r - v$ or $r > \frac{v(1-\theta)+t+3h}{1-\theta} - \frac{ck}{k(1-\theta)+\theta}$ and $\frac{ck}{k(1-\theta)+\theta} - \frac{3h+t}{1-\theta} + r - v < s < \frac{ck}{k(1-\theta)+\theta} + \frac{3h-t}{1-\theta} + r - v$, $\frac{\partial \pi_r^{MC}}{\partial h} > 0$, $\frac{\partial \pi_e^{MC}}{\partial h} > 0$; otherwise, $\frac{\partial \pi_r^{MC}}{\partial h} < 0$, $\frac{\partial \pi_e^{MC}}{\partial h} < 0$.

Corollary 7 suggests that under the *MC* strategy, the higher the return shipping cost, the higher the probability of consumers to purchase products matching online, and the stronger the consumers' willingness to purchase products from online retailers, which increases D_e^{MC} and decreases D_r^{MC}. On this basis, online retailers choose to increase p_e^{MC} to gain more profit, and offline retailers lower p_r^{MC} to attract more consumers to purchase offline. The effect of h on the sales price, demand, and profit of online and offline retailers also relies on consumer travel cost per unit distance and return compensation per unit product; the findings are similar to the MR strategy and are not repeated here.

Corollary 8.

(1) $\frac{\partial p_r^{MC}}{\partial t} > 0$, $\frac{\partial p_r^{MC}}{\partial r} < 0$; $\frac{\partial p_e^{MC}}{\partial t} < 0$, $\frac{\partial p_e^{MC}}{\partial r} > 0$.

(2) $\frac{\partial D_r^{MC}}{\partial t} > 0$, $\frac{\partial D_r^{MC}}{\partial r} < 0$; $\frac{\partial D_e^{MC}}{\partial t} < 0$, $\frac{\partial D_e^{MC}}{\partial r} > 0$.

(3) When $0 < s < \frac{ck}{k(1-\theta)+\theta} + \frac{(r-v)(1-\theta)-t-3h}{1-\theta}$, $\frac{\partial \pi_r^{MC}}{\partial t} < 0$, $\frac{\partial \pi_r^{MC}}{\partial r} > 0$; when $s > \max\{0, \frac{ck}{k(1-\theta)+\theta} + \frac{(r-v)(1-\theta)-t-3h}{1-\theta}\}$, $\frac{\partial \pi_r^{MC}}{\partial t} > 0$, $\frac{\partial \pi_r^{MC}}{\partial r} < 0$.

(4) When $0 < s < \frac{ck}{k(1-\theta)+\theta} + \frac{(r-v)(1-\theta)-t+3h}{1-\theta}$, $\frac{\partial \pi_e^{MC}}{\partial t} < 0$, $\frac{\partial \pi_e^{MC}}{\partial r} > 0$; when $s > \max\{0, \frac{ck}{k(1-\theta)+\theta} + \frac{(r-v)(1-\theta)-t+3h}{1-\theta}\}$, $\frac{\partial \pi_e^{MC}}{\partial t} > 0$, $\frac{\partial \pi_e^{MC}}{\partial r} < 0$.

Corollary 8 indicates that under the *MC* strategy, the higher the t, the more consumers are inclined to purchase products from offline channels, and D_r^{MC} also increases. Therefore, offline retailers choose a higher p_r^{MC}. Consumers' willingness to purchase offline forces online retailers to slow the decline in online demand by lowering sales price. The increase in r reduces the risk of consumers purchasing products from online retailers, and more consumers purchase products from online retailers, which induces D_e^{MC} to increase, so online retailers raise the selling price. In addition, as D_r^{MC} continues to decrease with the increase in r, offline retailers choose lower sales prices to attract more consumers to purchase products offline. Corollary 8 also shows that the impact of the t and r on the profits of both online and offline retailers depends on the return freight cost s. When s is high, the profits of both online and offline retailers increase with the increase in t and decrease with the increase in r.

Corollary 9.

(1) $\frac{\partial p_r^{MC}}{\partial k} < 0$, $\frac{\partial p_e^{MC}}{\partial k} < 0$.

(2) $\frac{\partial D_r^{MC}}{\partial k} < 0$, $\frac{\partial D_e^{MC}}{\partial k} > 0$.

(3) When $0 < s < \frac{ck}{k(1-\theta)+\theta} - \frac{3h+t}{1-\theta} + r - v$, $\frac{\partial \pi_r^{MC}}{\partial k} > 0$; when $s > \max\{0, \frac{ck}{k(1-\theta)+\theta} - \frac{3h+t}{1-\theta} + r - v\}$, $\frac{\partial \pi_r^{MC}}{\partial k} < 0$.

Under the *MC* strategy, the higher the proportion of the residual saleable value of unit product return k is, the greater the possibility for online retailers to resell. Therefore, the online sales price decreases with the increase in k. In this way, more consumers are attracted to purchase products online, which leads D_e^{MC} to increase, so D_r^{MC} decreases, leaving offline retailers reduce the sales price of offline products in order to ensure the offline demand. When the return cost s is high, consumers need to pay more costs and turn to offline purchases. The profits of offline retailers increase with the increase in the k. On the contrary, when s is low, there is a decrease in consumers' return cost, an increase in their willingness to consume online, an increase in their online demand, and a decrease in their offline demand. The profits of offline retailers decrease with the increase in k.

5. Strategy Selection

5.1. Return Strategy Selection

This section examines the selling prices, market shares, and profitability of online retailers under the *NN* and *MN* strategies and reveals managerial insights to investigate whether they ought to provide a return strategy.

Proposition 5.

(1) *When* $0 < s < \frac{ck}{k(1-\theta)+\theta}$*, the paper has* $p_r^{MN} < p_r^{NN}$, $D_r^{MN} < D_r^{NN}$, $D_e^{MN} > D_e^{NN}$*; When* $s > \frac{ck}{k(1-\theta)+\theta}$*, the paper has* $p_r^{MN} > p_r^{NN}$, $D_r^{MN} > D_r^{NN}$, $D_e^{MN} < D_e^{NN}$.

(2) *When* $0 < s < \frac{c(k+3\theta(1-k))}{k(1-\theta)+\theta} + 3h - (1-\theta)v$, $p_e^{MN} > p_e^{NN}$*; when* $s > \max\{0, \frac{c(k+3\theta(1-k))}{k(1-\theta)+\theta} + 3h - (1-\theta)v\}$, $p_e^{MN} < p_e^{NN}$.

(3) *When* $0 < s < \max\{0, \frac{ck}{k(1-\theta)+\theta} - \frac{6h+2v(1-\theta)}{1-\theta}\}$ *or* $s > \frac{ck}{k(1-\theta)+\theta}$*, the paper has* $\pi_r^{MN} > \pi_r^{NN}$*; when* $\max\{0, \frac{ck}{k(1-\theta)+\theta} - \frac{6h+2v(1-\theta)}{1-\theta}\} < s < \frac{ck}{k(1-\theta)+\theta}$, $\pi_r^{MN} < \pi_r^{NN}$.

(4) *When* $0 < s < \frac{3h-2(1-\theta)v+2c}{2(1-\theta)} - \frac{(1-\theta)\theta v^2 - 9h^2k - 6hv\theta}{6h(k(1-\theta)+\theta)} - \frac{c\theta}{(k(1-\theta)+\theta)(1-\theta)}$, $\pi_e^{MN} > \pi_e^{NN}$*; when* $s > \max\{0, \frac{3h-2(1-\theta)v+2c}{2(1-\theta)} - \frac{(1-\theta)\theta v^2 - 9h^2k - 6hv\theta}{6h(k(1-\theta)+\theta)} - \frac{c\theta}{(k(1-\theta)+\theta)(1-\theta)}\}$, $\pi_e^{MN} < \pi_e^{NN}$.

Three implications can be drawn from Proposition 5: First, the offline retailer should set a higher p_r^{NN} when s is relatively low and $D_r^{MN} < D_r^{NN}$, while D_e^{NN} is the opposite. The offline retailer should set a lower p_r^{NN} but only if s is sufficiently high. The demand for the online channel is higher under the *NN* strategy. Second, based on the extent of s, online retailers should set different p_e^{NN} and p_e^{MN}. The number of s is a third factor that affects the online retailer's strategy. When s is low, online sellers in particular should provide consumers with return strategies.

5.2. Return Insurance Strategy Selection

The selling prices, market shares, and profit margin of online retailers under the *MN*, *MR*, and *MC* strategies are now compared and analyzed with a view to providing further managerial implications on the issues of whether online retailers offer free return insurance, whether online retailers buy return insurance, or whether online retailers make the decision to purchase return insurance.

Proposition 6.

(1) $p_e^{MR} > p_e^{MN}$*; when* $0 < r < \frac{\theta t}{(k(1-\theta)+\theta)(1-\theta)}$, $p_r^{MR} > p_r^{MN}$, $D_r^{MR} > D_r^{MN}$, $D_e^{MR} < D_e^{MN}$*; when* $r > \frac{\theta t}{(k(1-\theta)+\theta)(1-\theta)}$, $p_r^{MR} < p_r^{MN}$, $D_r^{MR} < D_r^{MN}$, $D_e^{MR} > D_e^{MN}$.

(2) *When* $0 < c < \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{k(1-\theta)}$ *or* $c > \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{k(1-\theta)}$ *and* $t > \frac{2}{\theta}(ck(1-\theta) - (k(1-\theta)+\theta)(3h+(1-\theta)(s+v)))$*, if* $0 < r < \frac{\theta t}{(k(1-\theta)+\theta)(1-\theta)}$ *or* $r > \frac{ot-2ck(1-\theta)}{(k(1-\theta)+\theta)(1-\theta)} + \frac{6h+2(s+v)(1-\theta)}{1-\theta}$, $\pi_r^{MR} > \pi_r^{MN}$*; and if,* $\frac{\theta t}{(k(1-\theta)+\theta)(1-\theta)} < r < \frac{ot-2ck(1-\theta)}{(k(1-\theta)+\theta)(1-\theta)} + \frac{6h+2(s+v)(1-\theta)}{1-\theta}$*, the paper has* $\pi_r^{MR} < \pi_r^{MN}$.

When $c > \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{k(1-\theta)}$ *and* $0 < t < \frac{2}{\theta}(ck(1-\theta) - (k(1-\theta)+\theta)(3h+(1-\theta)(s+v)))$*, if* $0 < r < \frac{\theta t}{(k(1-\theta)+\theta)(1-\theta)}$, $\pi_r^{MR} < \pi_r^{MN}$*; and if* $r > \frac{\theta t}{(k(1-\theta)+\theta)(1-\theta)}$, $\pi_r^{MR} > \pi_r^{MN}$.

(3) *When* $0 < h < \overline{h}_{R-N}$, $\pi_e^{MR} > \pi_e^{MN}$*; when* $h > \overline{h}_{R-N}$, $\pi_e^{MR} < \pi_e^{MN}$*, where* $\overline{h}_{R-N}$ *is the solution to the equation*

$$\frac{1}{18\theta}\left(\begin{array}{l} ((s-r)(k(1-\theta)+\theta)(1-\theta)+\theta t+(1-\theta)(k+(1-k)\theta)v-(c+3h)k(1-\theta)-3h\theta)^2 \\ /(hk+h(1-k)\theta)+6(k(1-\theta)+\theta)((1-\theta)(s+v)-3h)-6ck(1-\theta) \end{array}\right)=0.$$

It is evident from Proposition 6 that p_e is continuously greater under the *MR* strategy than under the *MN* strategy. This is because of the platform retailing's free return strategy, which raises p_e. Additionally, Proposition 6 demonstrates that when r is relatively small, owing to the discrepancy between consumers buying products from online retailers and the smaller compensation received by consumers for returning products, there is less incentive for consumers to buy products from online retailers, and fewer consumers buy products from online retailers, so online retailers gain more profit under the *MN* strategy. At the same time, the offline retailer also has a greater market share under the *MR* strategy compared to the *MN* strategy, so at this point, the offline retailer should set a greater p_r, which ultimately results in the offline retailer gaining greater profits under the *MR* strategy.

According to Proposition 6, consumers may be more inclined to purchase items from online retailers when they receive a greater r. This can stimulate D_e under the *MR* strategy compared to the *MN* strategy and boost their profitability. In order to draw in more customers, offline retailers use the *MR* strategy to offer lower p_r, but this lowers their profitability. Online retailers are more profitable under the *MR* strategy than the *MN* strategy when consumers' travel costs per unit distance is lower, while the *MN* strategy is more profitable when x is greater. These data indicate that x is a significant factor affecting both the *MN* strategy and the *MR* strategy. In contrast to the results of Ren et al. [54], here, when the online retailer offers a return strategy, r is a key factor influencing whether the online retailer offers return insurance.

Proposition 7.

(1) *When* $0 < r < \frac{t}{1-\theta}$, $p_r^{MC} > p_r^{MN}$, $p_e^{MC} < p_e^{MN}$, $D_r^{MC} > D_r^{MN}$, $D_e^{MC} < D_e^{MN}$; *when* $r > \frac{t}{1-\theta}$, $p_r^{MC} < p_r^{MN}$, $p_e^{MC} > p_e^{MN}$, $D_r^{MC} < D_r^{MN}$, $D_e^{MC} > D_e^{MN}$.

(2) *When* $0 < c < \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{k(1-\theta)}$ *or* $c > \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{k(1-\theta)}$ *and* $t > \frac{2ck(1-\theta)}{k(1-\theta)+\theta} - 2(1-\theta)(s+v) - 6h$, *if* $0 < r < \min\{\frac{t}{1-\theta}, \frac{6h+t+2(v+s)(1-\theta)}{1-\theta} - \frac{2ck}{k(1-\theta)+\theta}\}$ *or* $r > \max\{\frac{t}{1-\theta}, \frac{6h+t+2(v+s)(1-\theta)}{1-\theta} - \frac{2ck}{k(1-\theta)+\theta}\}$, *the paper has* $\pi_r^{MC} > \pi_r^{MN}$; *if* $\min\{\frac{t}{1-\theta}, \frac{6h+t+2(v+s)(1-\theta)}{1-\theta} - \frac{2ck}{k(1-\theta)+\theta}\} < r < \max\{\frac{t}{1-\theta}, \frac{6h+t+2(v+s)(1-\theta)}{1-\theta} - \frac{2ck}{k(1-\theta)+\theta}\}$, *we have* $\pi_r^{MC} < \pi_r^{MN}$.
When $c > \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))}{k(1-\theta)}$ *and* $0 < t < \frac{2ck(1-\theta)}{k(1-\theta)+\theta} - 2(1-\theta)(s+v) - 6h$, *if* $0 < r < \frac{t}{1-\theta}$, $\pi_r^{MC} < \pi_r^{MN}$; *if* $r > \frac{t}{1-\theta}$, $\pi_r^{MC} > \pi_r^{MN}$.

(3) *When* $0 < h < \overline{h}_{\mathrm{C-N}}$, $\pi_e^{MC} > \pi_e^{MN}$; *when* $h > \overline{h}_{\mathrm{C-N}}$, $\pi_e^{MC} < \pi_e^{MN}$, *where* $\overline{h}_{\mathrm{C-N}}$ *is the solution of* $\frac{1}{18\theta}\begin{pmatrix} (ck(1-\theta) + (k(1-\theta)+\theta)(3h+(1-\theta)r - s - t - v + \theta(s+v)))^2/(h(k(1-\theta)+\theta)) \\ -6ck(1-\theta) - 6(k(1-\theta)+\theta)(3h-(1-\theta)(s+v)) \end{pmatrix} = 0$

From Proposition 7, the offline retailer should establish a higher p_r when the offline demand is larger under the *MC* strategy, and the online retailer should set a lower p_e when the c is modest. Under the *MC* strategy compared to the *MN* strategy, the offline retailer should set a lower p_r, and the online retailer should set a higher p_e when the r is greater. The profit of offline retailers under the *MC* strategy is greater than that under the *MN* strategy in the case of a smaller or larger c and larger t, which indicates that c and r are favorable for offline retailers under the *MC* strategy, and vice versa under the *MN* strategy. However, the profit of the offline retailer under the *MN* strategy is better than that under the *MC* strategy if r is lower when c is higher but t is lower, and vice versa for the offline retailer under the *MC* strategy. The online retailer is more profitable under the *MC* strategy than the *MN* strategy when h is below a critical value, indicating that when the h is low, a critical value can be found for the online retailer, making the online retailer better under the strategy where the consumer buys their own return insurance. However, when h exceeds a critical value, the *MN* strategy is more profitable.

Proposition 8.

(1) $p_r^{MC} > p_r^{MR}$, $p_e^{MC} < p_e^{MR}$; $D_r^{MC} > D_r^{MR}$, $D_e^{MC} < D_e^{MR}$.

(2) *When* $0 < t < \frac{2ck(1-\theta)-2(k(1-\theta)+\theta)(3h-(1-\theta)(r-s-v))}{k(1-\theta)+2\theta}$, $\pi_r^{MC} < \pi_r^{MR}$; *when* $t > \max\{0, \frac{2ck(1-\theta)-2(k(1-\theta)+\theta)(3h-(1-\theta)(r-s-v))}{k(1-\theta)+2\theta}\}$, $\pi_r^{MC} > \pi_r^{MR}$.

(3) *When* $0 < t < \frac{2ck(1-\theta)+2(k(1-\theta)+\theta)(3h+(1-\theta)(r-s-v))}{k(1-\theta)+2\theta}$, $\pi_e^{MC} < \pi_e^{MR}$; *when* $t > \max\{0, \frac{2ck(1-\theta)+2(k(1-\theta)+\theta)(3h+(1-\theta)(r-s-v))}{k(1-\theta)+2\theta}\}$, $\pi_e^{MC} > \pi_e^{MR}$.

According to Proposition 8, the *MR* strategy has higher pricing and market demand for online retailers than the *MC* strategy. This is because under the *MR* strategy, the online retailer offers insurance services to customers. These services generate premiums while safeguarding the customer's return, which raises the demand for the market as a whole. The truth that online retailers offer insurance is an effective form of competition for offline retailers, forcing them to compete only by raising prices. However, at the moment, the market demand for offline retailers is still declining and is below the overall demand in the *MC* strategy. Because the online retailer covers t under the *MR* strategy, the online retailer covers less when t is modest and generates more profits; nevertheless, when t is high, the *MC* strategy is preferable because the customer covers t. With regard to offline retailers, while t is relatively low, the new customer attraction of the *MR* strategy in which online retailers offer insurance is lower. At this time, offline retailers see higher profits when utilizing the *MR* strategy of online retailers. However, as t starts to climb, the customer appeal of online retailers' *MR* strategies also increases, which causes a drop in their profitability.

6. Numerical Analysis

Owing to the impact of the transportation process and after-sales, the residual value of products is different. This section analyzes the effect of the residual value ratio of returned products on pricing, demand, and profitability through numerical experiments. Referring to the numerical analysis framework of Fan and Chen [53] and Ren et al. [54], the parameters were set as follows: $v = 1$, $c = 0.25$, $r = 0.2$, $t = 0.02$, $\theta = 0.5$, $s = 0.5$, and $h = 0.25$. The paper analyzed the impact of the proportion of residual value after the reduction of unit returned product value on the optimal decision.

Figure 1 analyzes the effect of the proportion of residual value on the most available demand by setting different values of r for the diminished value of the returned product per unit. Comparing the different strategies, the paper found that the demand for all strategies except under the *NN* strategy was influenced by the consumer unit product return compensation and the proportion of residual value per unit of returned product value after impairment; regardless of the value of consumer unit product return compensation, as the proportion of residual value per unit of returned product value after impairment increased, the online demand for the three strategies *MN*, *MR*, and *MC* increased, and the offline demand decreased.

When the consumer unit product return compensation was low, at 0.2, the initial demand for the *MR* strategy was the highest, close to 1; the initial demand for *MR* and *MC* was slightly less, at around 0.95; and the initial demand for *NN* was the lowest, slightly over 0.8. As the unit product return compensation rose, the initial demand for both the *MR* and *NN* strategies remained the same, and the initial demand for *MR* and *MC* fell to the same level as that for the *NN* initial demand.

By comparing online demand with offline demand, the paper found that consumers preferred to buy products offline. With the highest proportion of residual value still occupying more than four-fifths of the overall market demand, online demand had less than one-fifth of the share. As the proportion of residual value increased, online demand tended to decrease, and offline demand tended to increase; when consumer unit product returns were compensated differently, the *MR* and *MC* strategy demand changed more significantly with the proportion of residual value per unit of returned product value after impairment.

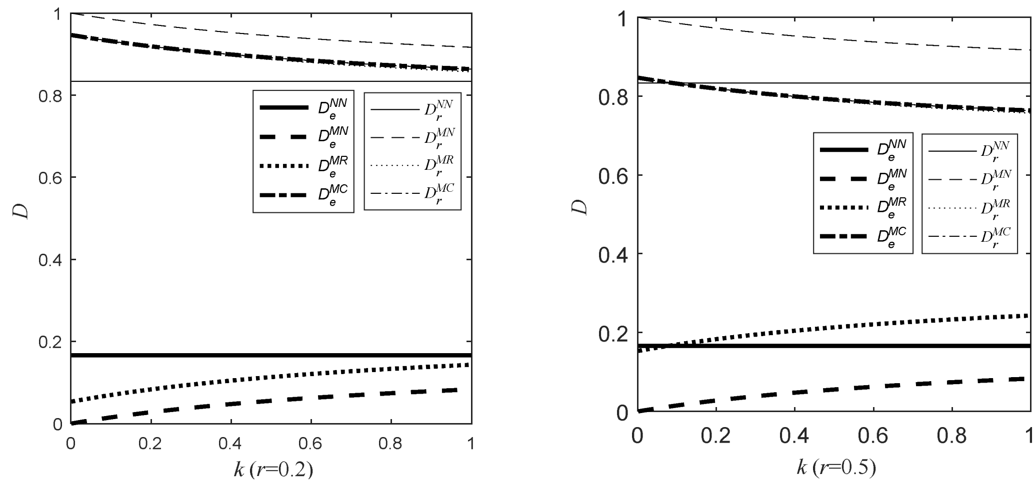

Figure 1. The impact of the proportion of residual value on optimal demand after the diminution of the value of the returned product per unit.

Figure 2 analyzes the impact of the proportion of residual value per unit of returned product value impairment and return compensation on the profit of offline retailers. The profit of offline retailers decreased as the loss of returned products became smaller; that is, when the residual value per unit of returned product value after impairment became larger, the advantage of offline retailers not having to return products decreased at this time, which led to a decrease in profit. Comparing the profits under different strategies, the paper found that the profits of offline retailers were the highest under the *MN* strategy, at which time the competitive advantage of online retailers was reduced, owing to the returns being borne by consumers, which was beneficial to offline retailers. At $r = 0.2$, profits under the *MC* strategy were higher than those under the *NN* strategy, and at $r = 0.5$, profits under the *NN* strategy were higher than those under the *MC* strategy.

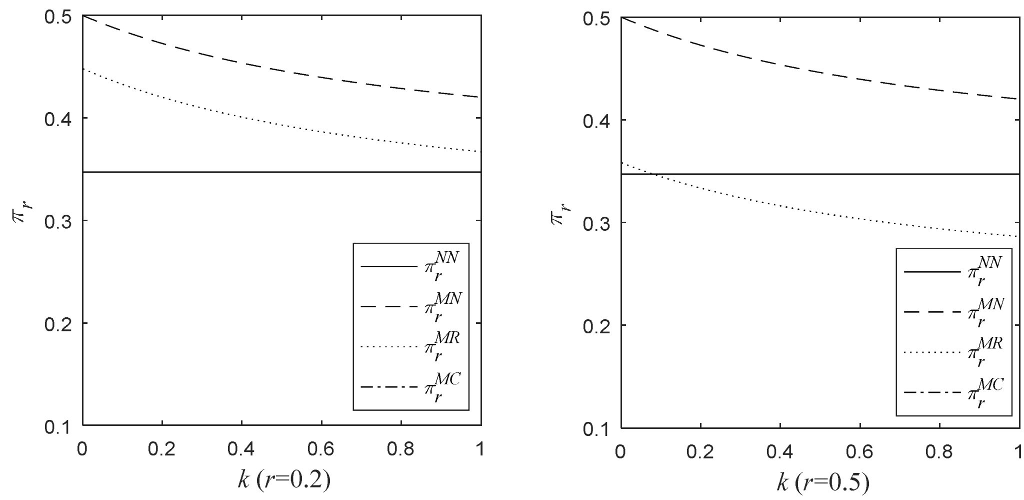

Figure 2. The impact of the percentage of residual value per unit of returned product value impairment on the profit of offline retailers.

Figure 3 analyzes the impact of the percentage of residual value per unit of returned product value impairment and return compensation on the profit of the online retailers. As the residual value per unit of returned product value increased, the profit of the online retailers increased, and it was more beneficial for the online retailers when the loss from the returned product was lower. Comparing the four strategies, the paper showed that the profit of online retailers was highest under the *NN* strategy when k was extremely low, indicating that the online retailers prefer not to offer returns when the loss from returns is extremely high (i.e., the *NN* strategy). At $r = 0.2$, the profits of online retailers under the *MN* strategy were higher than those under the *MR* and *MC* strategies, indicating that when the compensation given to consumers for returns is low, it is much less attractive to consumers, so choosing the *MN* strategy instead saves the loss of paying return insurance, and profits are higher. In contrast, the profit under the *MR* strategy was higher than that under the *MC* strategy because the return insurance was borne by the online retailers and could attract more consumers. At $r = 0.5$, when k was lower, the profit of online retailers under the *MR* and *MC* strategies was higher than under the *MN* strategy, indicating that despite the lower value of impaired unit returns, it is more attractive to offer returns to consumers at this time owing to the higher compensation to consumers under the *MR* and *MC* strategies. As k increased, profits under the *MN* strategy increased significantly above profits under the *MR*, *MC,* and *NN* strategies, indicating that online retailers prefer to return products rather than offer a return fee when the unit residual value after impairment of the returned product is higher.

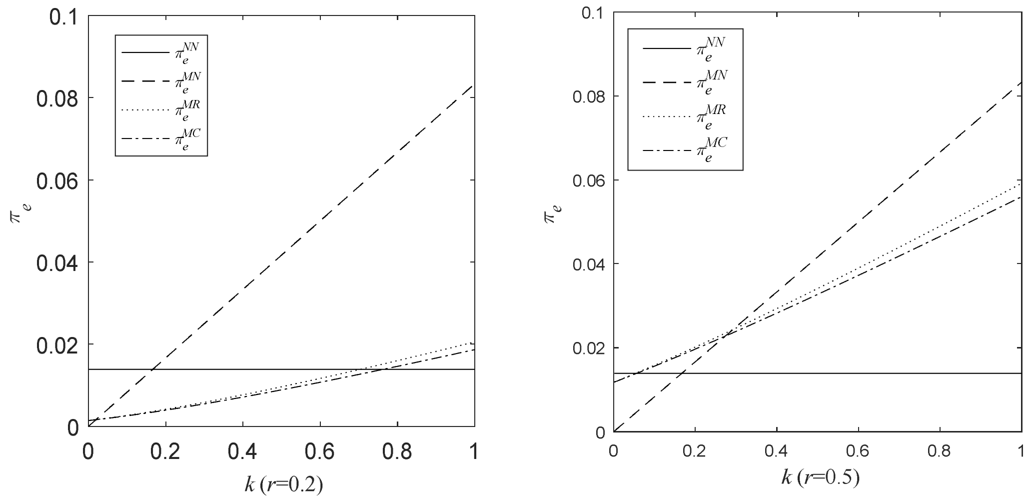

Figure 3. The impact on online retailers of the proportion of residual value after reduction of unit returned product value.

7. Conclusions

This paper constructed a game model of duopoly competition with channel competition between offline retailers and online retailers and investigated the optimal pricing decisions under four scenarios: online retailers do not offer returns; online retailers offer returns but do not provide return insurance; online retailers offer returns and provide return insurance; and online retailers offer returns, but consumers purchase return insurance. It also answered the three core questions of whether to offer returns, whether to provide return insurance, and who should bear the return insurance. Specifically, the main findings are reflected in the following three issues.

First is the problem of whether to provide return service. The statute of limitations for sales varies by product, such as cosmetics and food. Online retailers tend not to offer returns for products that cannot be resold after opening or whose value decreases significantly immediately after the sale when the return loss is too high. Then, online retailers may offer returns for products such as clothing that do not affect secondary sales after return, given the higher residual value per unit of returned product after impairment. The findings of this study are consistent with reality.

Second is the problem of whether to provide return insurance. The provision of return insurance allows consumers to purchase products without worries when there is a return policy in place and when the insurance company has the maximum amount to cover the shipping costs. Moreover, when the e-retailer provides free return insurance to consumers, it can increase the sales of products and contribute to the profits of the e-retailer. Therefore, online retailers should offer free return insurance to consumers when the compensation per unit of product returned is considerable.

Third is the issue of who should purchase the return insurance. Suppose online retailers are willing to provide return and return shipping insurance services. In that case, customers can return the product at no additional cost if the product does not match after purchase, reducing the uncertainty of consumers' purchase and thus attracting more consumers. The increase in sales improves online retailers' profits. This is consistent with the fact that in reality, most online merchants offer shipping insurance.

Our article provides an analytical framework for online retailers' pricing strategies and return strategies in competitive situations and reveals the conditions for online retailers to provide return strategies and return insurance strategies, which is similar to the research of Lin et al. [50], Fan and Chen [53], and Ren et al. [54]. However, we have expanded the above research. In particular, our paper considers such factors as consumer distance cost and return insurance compensation and expands the research situation to the competition situation of online and offline retailers. The research conclusion is more universal. At the same time, the research can provide management insights for online retailers. Under the competition with offline retailers, online retailers need to design return strategies for different products, and they do not provide return for products with large losses after return, which explains why Pinduoduo (www.pinduoduo.com) does not provide return for fresh products but only refund. In order to reduce consumers' concern about product matching, online retailers should provide return service to consumers, but whether it is free should be further considered. This explains why online stores of well-known brands, such as Uniqlo (www.uniqlo.cn), Decathlon (www.decathlon.com), and JD (www.jd.com), do not provide free return insurance to consumers but provide 7 days' return service without any reason. Under the return insurance service, the purchase of consumers can be improved. Many enterprises such as Nike will provide a return insurance service to share the return cost.

However, our research had some limitations, which can be further considered in depth in future research. First, the paper did not consider the impact of consumer return services. The impact of introducing return services on consumer purchase intentions and the interaction behavior between consumer purchase intentions and return services for different types of products in the study of return issues will be a topic for future research. Second, online retailers did not consider their own sales model when formulating their return strategy. Thus, issues such as the offline return model for online sales or the impact of different sales channels online on return policies are topics worthy of future research.

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Appendix A

Proof of Lemma 1. When $x < x_r^{NN} = \frac{v-p_r}{h}$, there is $U_e^{NN} \geq 0$, and when $x > x_e^{NN} = \frac{h+p_e-\theta v}{h}$, there is $U_r^{NN} \geq 0$. When $x_{re}^{NN} = \frac{h+p_e-p_r+v(1-\theta)}{2h}$, there is $U_e^{NN} = U_r^{NN}$, i.e., the consumer's utility of purchasing a product from an offline retailer and an online retailer is the same, since the consumer will purchase the product at the offline retailer when and only when $U_r^{NN} \geq 0$ and $U_r^{NN} \geq U_e^{NN}$. Similarly, when $U_e^{NN} \geq 0$ and $U_e^{NN} \geq U_r^{NN}$, consumers will purchase the product at the online retailer. Without loss of generality, suppose $v \geq \frac{h+p_e+p_r}{1+\theta}$, getting $x_e^{NN} < x_{re}^{NN} < x_r^{NN}$; then, both the offline and online markets exist.

Since when $U_r^{NN} \geq 0$ and $U_r^{NN} \geq U_e^{NN}$, that is, consumers in the interval $\left[0, x_{re}^{NN}\right]$ will buy from an offline retailer and consumers in the interval $\left[x_{re}^{NN}, 1\right]$ will buy from an online retailer, it follows that the demands for online retailer and offline retailer are $D_r^{NN} = x_{re}^{NN} = \frac{h+p_e-p_r+v(1-\theta)}{2h}$ and $D_e^{NN} = 1 - x_{re}^{NN} = \frac{h-p_e+p_r-v(1-\theta)}{2h}$, respectively. The same can be proofed for Lemmas 2–4. □

Proof of Proposition 1. Second-order derivatives of the profit functions of the offline and online retailers with respect to p_r and p_e, respectively, are $\frac{\partial^2 \pi_r^{NN}}{\partial (p_r^{NN})^2} = -\frac{1}{h} < 0$ and $\frac{\partial^2 \pi_e^{NN}}{\partial (p_e^{NN})^2} = -\frac{1}{h} < 0$. It is easy to prove that the Hessian matrix is $\begin{vmatrix} \partial^2 \pi_r^{NN} / \partial (p_r^{NN})^2 & \partial^2 \pi_r^{NN} / \partial p_r^{NN} \partial p_e^{NN} \\ \partial^2 \pi_e^{NN} / \partial p_e^{NN} \partial p_r^{NN} & \partial^2 \pi_e^{NN} / \partial (p_e^{NN})^2 \end{vmatrix} = \frac{3}{4h^2} > 0$. From the first-order derivative conditions $\frac{\partial \pi_r^{NN}}{\partial p_r^{NN}} = 0$ and $\frac{\partial \pi_e^{NN}}{\partial p_e^{NN}} = 0$, it can obtain $p_r^{NN} = \frac{3c+3h+(1-\theta)v}{3}$ and $p_e^{NN} = \frac{3c+3h-(1-\theta)v}{3}$. The optimal demand and profit functions are obtained by substituting the offline and online retailers' optimal selling prices into the demand and profit functions. Propositions 2–4 can be proven in the same way. End proof. □

Proof of Corollary 1. Optimal selling price, demand, and optimal profit for offline and online retailers can be obtained by taking derivatives with respect to θ, respectively: $\frac{\partial p_r^{NN}}{\partial \theta} = -\frac{v}{3} < 0$, $\frac{\partial p_e^{NN}}{\partial \theta} = \frac{v}{3} > 0$, $\frac{\partial D_r^{NN}}{\partial \theta} = -\frac{v}{6h} < 0$, $\frac{\partial D_e^{NN}}{\partial \theta} = \frac{v}{6h} > 0$, $\frac{\partial \pi_r^{NN}}{\partial \theta} = -\frac{v(3h+v-\theta v)}{9h} < 0$, and $\frac{\partial \pi_e^{NN}}{\partial \theta} = \frac{v(3h-(1-\theta)v)}{9h}$.

The optimal selling price, demand and optimal profit for offline and online retailers can be obtained by taking derivatives with respect to h, respectively: $\frac{\partial p_r^{NN}}{\partial h} = 1 > 0$, $\frac{\partial p_e^{NN}}{\partial h} = 1 > 0$, $\frac{\partial D_r^{NN}}{\partial h} = -\frac{(1-\theta)v}{6h^2} < 0$, $\frac{\partial D_e^{NN}}{\partial h} = \frac{(1-\theta)v}{6h^2} 0$, $\frac{\partial \pi_r^{NN}}{\partial h} = \frac{1}{2} - \frac{(1-\theta)^2 v^2}{18h^2}$, and $\frac{\partial \pi_e^{NN}}{\partial h_r} = \frac{1}{2} - \frac{(1-\theta)^2 v^2}{18h^2}$. Corollaries 3, 5, 6, and 8 can be proven in the same way. End proof. □

Proof of Corollary 2. Optimal selling price, demand, and optimal profit for offline and online retailers can be obtained by taking derivatives with respect to θ, respectively: $\frac{\partial p_r^{MN}}{\partial \theta} = -\frac{1}{3}\left(\frac{ck}{(k(1-\theta)+\theta)^2} - s - v\right)$, $\frac{\partial p_e^{MN}}{\partial \theta} = \frac{s+v-3h}{3\theta^2} - \frac{c(k^2(1-\theta)^2+2k(1-2\theta)\theta+3\theta^2)}{3\theta^2(k(1-\theta)+\theta)^2}$, $\frac{\partial D_r^{MN}}{\partial \theta} = \frac{ck-(k(1-\theta)+\theta)^2(s+v)}{6h(k(1-\theta)+\theta)^2}$, $\frac{\partial D_e^{MN}}{\partial \theta} = \frac{(k(1-\theta)+\theta)^2(s+v)-ck}{6h(k(1-\theta)+\theta)^2} > 0$, $\frac{\partial \pi_r^{MN}}{\partial \theta} = \left(\frac{-ck+(k(1-\theta)+\theta)^2(s+v))(ck(1-\theta)-(k(1-\theta)+\theta)(3h+(1-\theta)(s+v)))}{9h(k(1-\theta)+\theta)^3}\right)$, and $\frac{\partial \pi_e^{MN}}{\partial \theta} = \frac{(k+(1-k)\theta^2)(s+v)-ck-3hk}{3\theta^2}$.

The optimal selling price, demand, and optimal profit for the offline and online retailers can be obtained by taking derivatives with respect to h, respectively: $\frac{\partial p_r^{MN}}{\partial h} = 1 > 0 \frac{\partial p_e^{MN}}{\partial h} = \frac{1}{\theta} > 0$, $\frac{\partial D_r^{MN}}{\partial h} = \frac{(1-\theta)(ck-(k(1-\theta)+\theta)(s+v))}{6h^2(k(1-\theta)+\theta)}$, $\frac{\partial D_e^{MN}}{\partial h} = \frac{(1-\theta)(ck-(k(1-\theta)+\theta)(s+v))}{6h^2(k(1-\theta)+\theta)}$, $\frac{\partial \pi_r^{MN}}{\partial h} = \frac{(k(1-\theta)+\theta)(3h+(1-\theta)(s+v))-ck(1-\theta)(ck(1-\theta)+(k(1-\theta)+\theta)(3h-(1-\theta)(s+v)))}{18h^2(k(1-\theta)+\theta)^2}$, and $\frac{\partial \pi_e^{MN}}{\partial h} = \frac{k(1-\theta)+\theta}{\theta} > 0$. Corollaries 4 and 7 can be proven in the same way. End proof. □

Proof of Proposition 5. According to Propositions 1 and 2, the difference in sales price between offline and online retailers in the MN and NN cases are $p_r^{MN} - p_r^{NN} = \frac{(1-\theta)(k(1-\theta)s-ck+\theta s)}{3(k(1-\theta)+\theta)}$ and $p_e^{MN} - p_e^{NN} = \frac{c(k(1-\theta)+3\theta)}{3\theta(k(1-\theta)+\theta)} + \frac{3h-(1-\theta)(s+v)}{3\theta} - \frac{3(c+h)-v(1-\theta)}{3}$, respectively, the difference in market share in the two cases are $D_r^{MN} - D_r^{NN} = -\frac{(1-\theta)(ck-s(k(1-\theta)+\theta))}{6h(k(1-\theta)+\theta)}$ and $D_e^{MN} - D_e^{NN} = \frac{(1-\theta)(ck-s(k(1-\theta)+\theta))}{6h(k(1-\theta)+\theta)}$, respectively, and the difference in optimal profits are $\pi_r^{MN} - \pi_r^{NN} = \frac{((k(1-\theta)+\theta)(3h+(1-\theta)(s+v))-ck(1-\theta))^2-(3h+v(1-\theta))^2(k(1-\theta)+\theta)^2}{18h(k(1-\theta)+\theta)^2}$ and $\pi_e^{MN} - \pi_e^{NN} = \frac{ck(1-\theta)+(k(1-\theta)+\theta)(3h-(1-\theta)(s+v))}{3\theta} - \frac{(3h-(1-\theta)v)^2}{18h}$, respectively. Propositions 6–8 can be proven in the same way. □

References

1. National Bureau of Statistical. *Annual Data of China in 2021*; National Bureau of Statistical: Beijing, China, 2021.
2. Akçay, Y.; Boyacı, T.; Zhang, D. Selling with money-back guarantees: The impact on prices, quantities, and retail proftability. *Prod. Oper. Manag.* **2013**, *22*, 777–791. [CrossRef]
3. Heydari, J.; Choi, T.M.; Radkhah, S. Pareto improving supply chain coordination under a money-back guarantee service program. *Serv. Sci.* **2017**, *9*, 91–105. [CrossRef]
4. Securities Daily. The Chaos behind the High Return Rate of "Double 11". 2021. Available online: https://baijiahao.baidu.com/s?id=1717297600588183567&wfr=spider&for=pc (accessed on 17 November 2022).
5. Li, Y.M.; Li, G.; Cheng, T.C.E. Return freight insurance: Implications for online platforms, third-party retailers and consumers. In Proceedings of the 8th International Conference on Logistics, Informatics and Service Sciences, Toronto, ON, Canada, 3–6 August 2018; IEEE: Piscataway, NJ, USA, 2018; pp. 1–6. [CrossRef]
6. Peking University Finance Law Research Venter. Birth, Advance and Development—Analysis of Taobao Return Freight Insurance. 2017. Available online: https://www.finlaw.pku.edu.cn/zxzx/zxwz/239619.htm (accessed on 17 November 2022).
7. The Return and Exchange Freight Insurance of JD, PICC Successfully Won the Bid to Take Advantage of the Opportunity. 2013. Available online: http://money.sohu.com/20131125/n390715093.shtml (accessed on 17 November 2022).
8. Gu, Z.J.; Tayi, G.K. Consumer mending and online retailer fit-uncertainty mitigating strategies. QME-Quant. *Mark. Econ.* **2015**, *13*, 251–282. [CrossRef]
9. Geng, S.D.; Li, W.L.; Chen, H. Complimentary return-freight insurance serves as quality signal or noise? In Proceedings of the 28th Australasian Conference on Information Systems, Sydney, Australia, 3–6 December 2017; pp. 1–10. Available online: https://aisel.aisnet.org/acis2017/47 (accessed on 17 November 2022).
10. Hess, J.D.; Mayhew, G.E. Modeling merchandise returns in direct marketing. *J. Direct Mark.* **1997**, *11*, 20–35. [CrossRef]
11. Ma, S.; Li, G.; Sethi, S.P.; Zhao, X. Advance selling in the presence of market power and risk-averse consumers. *Decision Sci.* **2019**, *50*, 142–169. [CrossRef]
12. Wood, S.L. Remote purchase environments: The influence of return policy leniency on two-stage decision processes. *J. Mark. Re.* **2001**, *38*, 157–169. [CrossRef]
13. Minnema, A.; Bijmolt, T.H.A.; Gensler, S.; Wiesel, T. To keep or not to keep: Effects of online customer reviews on product returns. *J. Retail.* **2016**, *92*, 253–267. [CrossRef]
14. Ambilkar, P.; Dohale, V.; Gunasekaran, A.; Bilolikar, V. Product returns management: A comprehensive review and future research agenda. *Int. J. Prod. Res.* **2022**, *60*, 3920–3944. [CrossRef]
15. Suwelack, T.; Hogreve, J.; Hoyer, W.D. Understanding money-back guarantees: Cognitive, affective, and behavioral outcomes. *J. Retail.* **2011**, *87*, 462–478. [CrossRef]
16. Griffis, S.E.; Rao, S.; Goldsby, T.J.; Niranjan, T.T. The customer consequences of returns in online retailing: An empirical analysis. *J. Oper. Manag.* **2012**, *30*, 282–294. [CrossRef]
17. Chen, J.; Chen, B.T. Competing with customer returns policies. *Int. J. Prod. Res.* **2016**, *54*, 2093–2107. [CrossRef]
18. Jeng, S.P. Increasing customer purchase intention through product return policies: The pivotal impacts of retailer brand familiarity and product categories. *J. Retail. Consum. Serv.* **2017**, *39*, 182–189. [CrossRef]
19. Oghazi, P.; Karlsson, S.; Hellström, D.; Hjor, K. Online purchase return policy leniency and purchase decision: Mediating role of consumer trust. *J. Retail. Consum. Serv.* **2018**, *41*, 190–200. [CrossRef]
20. Shulman, J.D.; Coughlan, A.T.; Savaskan, R.C. Optimal restocking fees and in-formation provision in an integrated demand-supply model of product returns. *Manuf. Serv. Oper. Manag.* **2009**, *11*, 577–594. [CrossRef]
21. Thieme, J. *Versandhandelsmanagement*; Gabler Verlag Springer Fachmedien Wiesbaden GmbH: Wiesbaden, Germany, 2003.
22. Hess, J.D.; Chu, W.; Gerstner, E. Controlling product returns in direct marketing. *Market. Lett.* **1996**, *7*, 307–317. [CrossRef]
23. Shulman, J.D.; Coughlan, A.T.; Savaskan, R.C. Managing consumer returns in a competitive environment. *Manage. Sci.* **2011**, *57*, 347–362. [CrossRef]
24. De, P.; Hu, Y.; Rahman, M.S. Product-oriented web technologies and product re-turns: An exploratory study. *Inf. Syst. Res.* **2013**, *24*, 998–1010. [CrossRef]
25. Ofek, E.; Katona, Z.; Sarvary, M. "Bricks and clicks": The impact of product re-turns on the strategies of multichannel retailers. *Mark. Sci.* **2011**, *30*, 42–60. [CrossRef]
26. Xia, Y.; Xiao, T.; Zhang, G.P. The impact of product returns and retailer's service investment on manufacturer's channel strategies. *Decision Sci.* **2017**, *48*, 918–955. [CrossRef]
27. Bell, D.R.; Gallino, S.; Moreno, A. Offline showrooms in omnichannel retail: De-mand and operational benefits. *Manag. Sci.* **2018**, *64*, 1629–1651. [CrossRef]

28. Li, G.; Zhang, T.; Tayi, G.K. Inroad into omni-channel retailing: Physical showroom deployment of an online retailer. *Eur. J. Oper. Res.* **2020**, *283*, 676–691. [CrossRef]
29. Lee, D.H. An alternative explanation of consumer product returns from the post-purchase dissonance and ecological marketing perspectives. *Psychol. Mark.* **2015**, *32*, 49–64. [CrossRef]
30. Walsh, G.; Albrecht, A.K.; Kunz, W.; Hofacker, C.F. Relationship between online retailers' reputation and product returns. *Brit. J. Manage.* **2016**, *27*, 3–20. [CrossRef]
31. Cai, X.Y.; Li, J.B.; Dai, B.; Zhou, T. Pricing strategies in a supply chain with multi-manufacturer and a common retailer under online reviews. *J. Syst. Sci. Syst. Eng.* **2018**, *27*, 435–457. [CrossRef]
32. 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]
33. Guo, L.; Lin, 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]
34. Letizia, P.; Pourakbar, M.; Harrison, T. The impact of consumer returns on the multichannel sales strategies of manufacturers. *Prod. Oper. Manag.* **2018**, *27*, 323–349. [CrossRef]
35. Zhang, Q.; Chen, J.; Chen, B.T. Information strategy in a supply chain under asymmetric customer returns information. *Transport. Res. Part E Logist. Transport. Rev.* **2021**, *155*, 102511. [CrossRef]
36. Ertekin, N.; Agrawal, A. How does a return period policy change affect multichannel retailer profitability? *Manuf. Serv. Oper. Manag.* **2021**, *23*, 210–229. [CrossRef]
37. Davis, S.; Gerstner, E.; Hagerty, M. Money back guarantees in retailing: Matching products to consumer tastes. *J. Retailing* **1995**, *71*, 7–22. [CrossRef]
38. Guo, L. Service cancellation and competitive refund policy. *Market. Sci.* **2009**, *28*, 901–917. [CrossRef]
39. Chen, J.; Grewal, R. Competing in a supply chain via full-refund and no-refund customer returns policies. *Int. J. Prod. Econ.* **2013**, *146*, 246–258. [CrossRef]
40. McWilliams, B. Money-back guarantees: Helping the low-quality retailer. *Manag. Sci.* **2012**, *58*, 1521–1524. [CrossRef]
41. Nasiry, J.; Popescu, I. Advance selling when consumers regret. *Manag. Sci.* **2012**, *58*, 1160–1177. [CrossRef]
42. Chen, B.T.; Chen, J. Compete in price or service?—A study of personalized pricing and money back guarantees. *J. Retailing* **2017**, *93*, 154–171. [CrossRef]
43. Li, M.; Liu, Y.C. Beneficial product returns in supply chains. *Prod. Oper. Manag.* **2021**, *30*, 3849–3855. [CrossRef]
44. Mondal, C.; Giri, B.C. Analyzing strategies in a green e-commerce supply chain with return policy and exchange offer. *Comput. Ind. Eng.* **2022**, *171*, 108492. [CrossRef]
45. Wang, J.; He, S.L. Optimal decisions of modularity, prices and return policy in a dual-channel supply chain under mass customization. *Transport. Res. Part E Logist. Transport. Rev.* **2022**, *160*, 102675. [CrossRef]
46. De Roover, F.E. Early examples of marine insurance. *J. Econ. Hist.* **1945**, *5*, 172–200. [CrossRef]
47. John, A.H. The London Assurance company and the marine insurance market of the eighteenth century. *Economica* **1958**, *25*, 126–141. [CrossRef]
48. Geng, S.D.; Li, W.L.; Qu, X.F.; Chen, L.R. Design for the pricing strategy of return-freight insurance based on online product reviews. *Electron. Commer. Res. Appl.* **2017**, *25*, 16–28. [CrossRef]
49. Marotta, A.; Martinelli, F.; Nanni, S.; Orlando, A.; Yautsiukhinb, A. Cyber-insurance survey. *Comput. Sci. Rev.* **2017**, *24*, 35–61. [CrossRef]
50. Lin, J.X.; Zhang, J.L.; Cheng, T.C.E. Optimal pricing and return policy and the value of freight insurance for a retailer facing heterogeneous consumers with uncertain product values. *Int. J. Prod. Econ.* **2020**, *229*, 107767. [CrossRef]
51. Chen, Z.W.; Fan, Z.P.; Zhu, S.X. Extracting values from consumer returns: The role of return-freight insurance for competing e-sellers. *Eur. J. Oper. Res.* **2022**. [CrossRef]
52. Lin, J.L.; 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**. [CrossRef]
53. Fan, Z.P.; Chen, Z.W. When should the e-tailer offer complimentary return-freight insurance? *Int. J. Prod. Econ.* **2020**, *230*, 107890. [CrossRef]
54. Ren, M.L.; Liu, J.Q.; Feng, S.; Yang, A.F. Pricing and return strategy of online retailers based on return insurance. *J. Retail. Consum. Serv.* **2021**, *59*, 102350. [CrossRef]
55. Chen, Z.W.; Fan, Z.P.; Zhao, X. Offering return-freight insurance or not: Strategic analysis of an e-seller's decisions. *Omega* **2021**, *103*, 102447. [CrossRef]
56. Yang, G.Y.; Ji, G.J. The impact of cross-selling on managing consumer returns in omnichannel operations. *Omega* **2022**, *111*, 102665. [CrossRef]
57. Tsay, A.A.; Agrawal, N. Channel conflict and coordination in the e-commerce age. *Prod. Oper. Manag.* **2004**, *13*, 93–110. [CrossRef]
58. Zhang, P.; He, Y.; Zhao, X. "Preorder-online, pickup-in-store" strategy for a dual-channel retailer. *Transport. Res. Part E Logist. Transport. Rev.* **2019**, *122*, 27–47. [CrossRef]
59. Zhang, Z.; Song, H.M.; Shi, V.; Yang, S.L. Quality differentiation in a dual-channel supply chain. *Eur. J. Oper. Res.* **2021**, *290*, 1000–1013. [CrossRef]

60. Shulman, J.D.; Coughlan, A.T.; Savaskan, R.C. Optimal reverse channel structure for consumer product returns. *Mark. Sci.* **2010**, *29*, 1071–1085. [CrossRef]
61. Mandal, P.; Basu, P.; Saha, K. Forays into omnichannel: An online retailer's strategies for managing product returns. *Eur. J. Oper. Res.* **2021**, *292*, 633–651. [CrossRef]