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A Cross-Channel Return Policy in a Green Dual-Channel Supply Chain Considering Spillover Effect

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Abstract: With the advent of the era of "New Retail", many manufacturers and retailers have begun to provide cross-channel return services to increase competitiveness. Our study takes return policy into a green dual-channel supply chain, wherein a manufacturer creates and sells green products simultaneously. We investigate the pricing and greening strategies for the supply chain players in the cases of providing and not providing cross-channel return service by employing the Stackelberg model under the hypothesis of a consistent pricing strategy. By comparing the equilibrium results of two cases, we find that the retailer will cooperate with the manufacturer to employ the cross-channel return policy when the spillover effect is greater than a threshold. Additionally, the green level of products is higher than before. The threshold decreases with consumers' sensitivity to green products, which implies that the manufacturer is motivated to conduct marketing programs to enhance consumers' willingness to buy green products. Moreover, we propose a contract to coordinate the supply chain. Finally, we discuss the scenarios if the supply chain implements a differential pricing strategy. Interestingly, the green level and the profits of the whole supply chain are greater than that under a consistent pricing strategy. However, the profits of the retailer are lower than profits in the other scenario, which is not beneficial to creating a stable green supply chain.

Keywords: green manufacturing; dual-channel supply chain; return policy; cross-channel return

1. Introduction

With the advent of the era of "New Retail", online retailers are competing over returns. A growing number of online retailers are teaming up with brick-and-mortar stores to try to make returns less of a hassle. Even some smaller online brands now offer in-store returns a product purchased from their online store may be returned to their physical store. These illustrate the fact that a flexible return policy has been an important means of market competition. One of Hybris' studies pointed out that nearly one-third of consumers selected in-store returns as most valuable for online purchases [1]. An appropriate return policy potentially increases market share and consumers' willingness to purchase [2], which creates a competitive advantage for firms. The cross-channel return policy increases sales and customer loyalty and creates additional cross-selling opportunities for physical stores [3]. Generally, the refund term is shortened, and the postage of the return is saved if consumers return products to brick-and-mortar stores rather than to e-stores. Hence, a portion of consumers prefer to return through the offline channel. While in the era of sustainable economy, many of the returned products are green products.

Guided by the concept of sustainable development, many organizations attempt to minimize their environmental impact by taking environmental concerns into account in their supply chain operations, such as green innovation, green design, green manufacturing, recycling, and reusing products [4]. Green manufacturing plays a pivotal part in creating an environmentally friendly supply chain [5]. Nowadays, a growing number of environmentally aware customers prefer to buy and pay an additional price for organic and environment-friendly products. The government has also introduced several policies and regulations to encourage manufacturers and retailers to produce and sell green products. Furthermore, green supply chain behaviors are beneficial in boosting companies' business performance [6]. Therefore, green manufacturing has increasingly become necessary for a firm to fulfill the demand of consumers. For example, Lenovo started using closed-loop consumer-recycled plastics to produce environmentally friendly products from 2007. Many other manufacturers in China, such as Huawei, Gree, and Haier, also implement green supply chain management (GSCM) practices.

By combining "flexible return strategy" and "green manufacturing" in a supply chain, we try to explore the cross-channel return policy in the green supply chain in this paper, which is largely an underexplored domain. Consequently, we take the cross-channel return policy into account when the supply chain produces and sells green products.

Several studies have considered return policies into the green supply chain or the dual-channel supply chain (DCSC). However, to the best of our knowledge, no researcher has investigated the green supply chain with a cross-channel return policy and has determined the impact of the return policy on the green level of products yet. Our study combines the DCSC, consumer return, and green manufacturing and investigates the difference between same-channel returns and cross-channel returns under a green supply chain. The introduction of the direct channel can help manufacturers to gain additional profits from the increasing demand for green products. Moreover, the cross-channel return policy, as a competitive strategy, can encourage consumers to purchase products. Given the spillover effect caused by dual channels, the return policy likewise impacts demand in two distribution channels.

Based on the above analysis of previous studies, we try to find answers to the following questions:

1. In what circumstance does a retailer decide to provide a cross-channel return service with no subsidy when the spillover effect is taken into consideration?
2. How does the cross-channel return policy affect a manufacturer and a retailer's decisions?
3. How is the green supply chain influenced by consumers' sensitivity to green products and the degree of spillover effect?
4. How should the dual-channel green supply chain be managed?

To solve these questions, we apply the Stackelberg game model to investigate the dual-channel green supply chain implementing different return policies. First, we compare between the manufacturer and the retailer's profits in the cases of adoption and non-adoption of the cross-channel return policy, which are analyzed under a consistent pricing strategy. We determine that the retailer would like to provide a cross-channel return service despite the lack of subsidy when the degree of spillover effect is greater than a threshold. Furthermore, we discuss the optimal decisions in two cases. Interestingly, the green level is higher than before. Subsequently, we analyze the correlation between decision variables and certain parameters. We also examine a coordination model for the dual-channel green supply chain with a cross-channel return policy to achieve a "win-win" scenario. Finally, we investigate the applicability of the cross-channel return policy under the differential pricing strategy as a further extension.

The remainder of our study is organized as follows. The following section provides a brief overview of the recent history of related literature. Section 3 describes the methodology and lists certain assumptions used for this study. We formulate and analyze the model in Section 4, whereas Section 5 presents numerical analysis and the sensitivity of certain key parameter results. Section 6 discusses the scenarios under the differential pricing policy. Lastly, Section 7 summaries the study by discussing conclusions and future research directions.

2. Literature Review

Our research is related to two streams of supply chain management literature, namely, product return policy and green supply chain. The majority of product return literature in B2C (Business-to-Customer) relationships focuses on refund policy. These studies have examined the effect of a refund contract (e.g., no-refund, partial-refund, full-refund policy) on pricing strategy, order decision, performance, and coordination contract by considering different factors [7–11]. The trend of the refund policy is directed from partial refund to full refund. The scale of refund is gradually increased, and the refund policy is gradually lenient. Besides, Pei, Paswan, and Yan [9] conducted empirical examinations and found that full-refund policy influences consumers' perceived fairness and purchase intention. Thus, we consider a full-refund policy in our study, which is extremely common in literature and in practice. However, limited literature on return channel policies is available. Similar to our research, Ji et al. [12] concentrated on return channel choice and investigated four return channels under a DCSC, but their study was not conducted in the context of GSCM. Radhi and Zhang [13,14] considered a cross-channel return in a dual-channel retailing system from the perspective of ordering and pricing. However, the two papers merely considered one player in the supply chain, whereas our study investigates the effect of cross-channel return in a supply chain that involves a manufacturer and a retailer.

GSCM has drawn emerging attention in the existing literature. Such management encompasses green designation, green manufacturing, green purchasing, green marketing, and so forth [15,16]. We mainly reviewed literature related to green manufacturing in this part. There were a substantial number of papers on different situations related to this topic, such as single product or multiproduct, single chain or multichain, single channel or multichannel, and risk-averse behaviors to investigate the quality or green level and pricing decisions, ordering, and coordination. For example, Zhang et al. [17] and Jamali and Rasti-Barzoki [18] studied a supply chain consisting of green and non-green products and focused on order quantities, channel coordination, pricing, and determination of the degree of greenness. Moreover, Ghosh and Shah [19], Li, Zhu, Jiang, and Li [5], and Chen et al. [20] studied pricing and greening strategies and compared single-channel and DCSC and found that a newly introduced channel would improve quality in certain conditions. To coordinate the green supply chain, Ghosh and Shah [21] and Song and Gao [22] proposed a revenue-sharing contract and cost-sharing contract, respectively, and discovered that both contracts could effectively improve the green level of products and the profits of the whole supply chain.

Although green supply chains and return strategies have been widely studied in previous literature, only a few studies note the effect of return channel policy to green manufacturing. Similar to our study, Li et al. [23] combined the two topics, simultaneously considered return policy and quality in a supply chain, and examined the relationships among return policy, product quality, and pricing strategy in online direct selling. They found that the manufacturer was willing to improve product quality and raise selling price under the full refund policy if the influence of price on consumer's purchase decisions was at a low level. The main differences between our study and Li, Xu, and Li [23] are as follows: first, Li, Xu, and Li [23] focused on the effect of refund policy, whereas we focused on return channel policy. Second, we devoted attention to the green supply chain. Third, Li, Xu and Li [23] merely considered a manufacturer who owns a direct distribution channel, whereas we considered a supply chain that involves a manufacturer and a retailer.

Generally, our study differs from existing papers in two aspects. First, we integrated the green level of products with return channel policy. This study posits that customer returns are false failure returns [12]. That is, returns are due to shopping experience differences between the two channels rather than the poor quality of products. Second, we considered the spillover effect of the return policy in a green supply, which has never been studied to our best knowledge. Several studies related to GSCM, including that of Chen et al. [24], considered the spillover effect. Similarly, the performance of a lenient and friendly return policy can produce positive spillover effects on another channel.

3. Model Formulation

We considered a two-echelon dual-channel green supply chain involving a manufacturer and a retailer in this study. To obtain a competitive advantage and reduce the destruction of pollution, the manufacturer produces only one kind of green product and distributes them through direct channels and a retailer's brick-and-mortar store. Multichannel returning can stimulate consumers to buy products and reduce high return costs. Thus, the manufacturer looks forward to utilizing a cross-channel return policy, wherein a direct channel consumer can return products to direct or retail channels freely. In this supply chain, the manufacturer wholesales the product w, and the direct and retail channels sell the green product to consumers at a consistent price. After the product is received, and if it does not meet consumers' expectations due to poor quality, it will then be returned.

Considering the impact of the cross-channel return policy on the supply chain, we built a traditional dual-channel green supply chain as a baseline of the supply chain model with a cross-channel return policy (shown in Figure 1). Accordingly, we considered whether the retailer provides a cross-channel return service and how it affects the decision of supply chain players. In the first model, we assumed that the supply chain operates traditionally, where the retailer does not provide cross-channel return service, such that customers need to return products through the purchase channel. In the second model, the retailer provides cross return service, such that direct channel customers can return products to the retailer's store. By comparing the first two models, we determined the condition when the retailer would like to provide the cross-channel return service. Subsequently, we designed a contract to coordinate the supply chain.

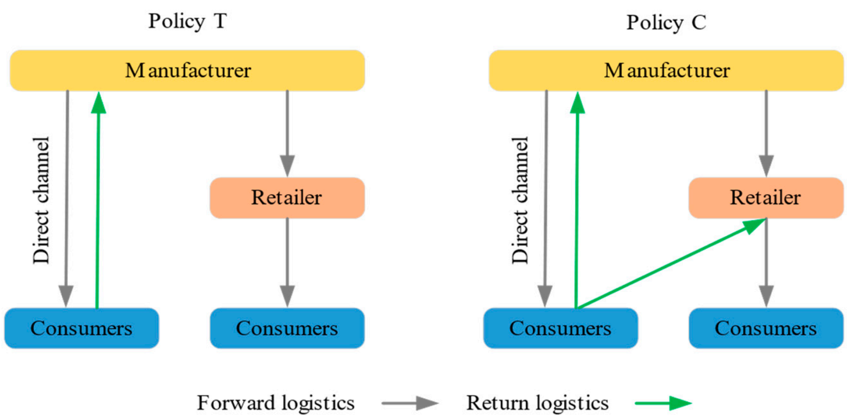

Figure 1. Different return policies under dual-channel green supply chain.

We postulated the following assumptions:

1. The potential market demand is sufficiently large and is greater than the other parameters in the article, which is affected by non-price factors such as corporate image, brand influence, and customers' intrinsic preference. For simplicity, we assumed the basic market demands of the two channels were equal. This similar assumption can be found in Mukhopadhyay et al. [25].
2. The return rate of the retail channel is zero, given that the return caused by poor quality will not occur in consumers' first-hand experience in the store. Our study concentrated on the cooperation of the direct and retail channel based on the cross-channel return policy rather than on two channels' return activity;
3. We only considered the green manufacturing practice to increase product greenness with increasing production costs, which is a common assumption [26,27]. It is different from the scenario of taking lean production and remanufacturing into the supply chain, and the production costs are decreased [28]. The relationship between price and greenness is different in different situations, which can be seen in [5,29];

4. We suppose that returned products can be resold in the same selling season with simple adjustments, such as repacking.

3.1. Demand Functions

We used a linear function of the green level and the sale price of the green products to express the basic demand function of the manufacturer and the retailer, which is similar in the literature, such as in Ghosh and Shah [19]. The price has a negative impact on consumer demand, while the green level has a positive impact. We assumed that consumers have environmental preferences. The subscript d and r represent the direct channel and retail channel, respectively.

Thus, in a green DCSC without a cross-channel return policy, the demand functions of the direct and retail channels can be depicted as follows (Equations (1) and (2)):

$$D_d = a - k \times p_d + \gamma \times p_r + \beta \times g \tag{1}$$

$$D_r = a - k \times p_r + \gamma \times p_d + \beta \times g \tag{2}$$

where D_d and D_r are the demands for green products in two distribution channels. p_r and p_d represent the prices decided by the retailer and the manufacturer for their own channel. Furthermore, a consistent pricing strategy can alleviate channel conflict, which is widely observed in multichannel retailing [5,30]. Therefore, we assume that $p_r = p_d = p$ and $(k - \gamma)$ is normalized to 1. Consequently, after adopting the uniform pricing strategy, the demand functions under policy T can be rewritten as Equation (3):

$$D_d = D_r = a - p + \beta \times g, \tag{3}$$

and $0 < \beta < 1$ represents the price effect on demand is larger than the green level. Consumers' increasing awareness of environmental protection leads to society's growing attention to environmental issues, thereby encouraging consumers to buy environmentally friendly products. Therefore, as β increases, consumers will purchase more green products.

Similarly, in a green DCSC with strategy C, the market demand is price-sensitive in each channel. We assume that the increased potential demand by the cross-channel return policy in the direct channel is v. Return policy adoption also influences market demand in the retail channel because of the spillover effect caused by an outstanding brand image. Therefore, the increased potential demand by a cross-channel return policy in the retail channel is tv, where t represents the degree of the spillover effect. Similar to the demand functions in Mukhopadhyay et al [25], the demand in the online and offline channels under policy C are, respectively, as follows (Equations (4) and (5)):

$$D_d = a - p + \beta \times g + v \tag{4}$$

$$D_r = a - p + \beta \times g + t \times v \tag{5}$$

3.2. Cost Structure

We used a second-order function of green level as the cost related to green level improvement, which is expressed as $C_g = \frac{n}{2} g^2$, where n is a scaling parameter used in the green supply chain [5,22]. The return cost of the manufacturer and the retailer are assumed to be the same, which is seen as a particular case; otherwise, the manufacturer can gain more profits. For brevity, we normalized the production cost to be zero, and costs that had no direct or significant impact on the decisions of chain members were omitted, such as set-up cost and communication cost between channels.

3.3. Profit Functions

Under policy T, the manufacturer is responsible for producing and selling green products and subsequently handling return business, whereas the retailer sells green products through his physical store with no return. Therefore, the profit of the manufacturer and the retailer can be formulated as Equations (6) and (7):

$$\pi_r^T = (p - w) \times D_r \tag{6}$$

$$\pi_m^T = w \times D_r + p \times D_d - \frac{n}{2} \times g^2 - r \times D_d \times c \tag{7}$$

Under policy C, the retailer sells green products through his physical store and handles the return business from the direct channel with the apportion at f when the retailer provides the cross-channel return service. Therefore, the profit function of the manufacturer and the retailer can be expressed as Equations (8) and (9):

$$\pi_r^C = (p - w) \times D_r - f \times r \times D_d \times c \tag{8}$$

$$\pi_m^C = w \times D_r + p \times D_d - \frac{n}{2} \times g^2 - (1 - f) \times r \times D_d \times c \tag{9}$$

The model parameters and decision variables used in this study are shown in Table 1.

Table 1. Model parameters and decision variables.

Parameters	Definition
a	Market base in direct and retail channels
r	The return rate of green products from the online channel's customer, $0 < r < 1$
n	Green investment parameter
β	Consumer sensitivity to green level improvement on the demand
f	Percentage of consumers who prefer to return products to the physical channel, $0 < f < 1$
t	Spillover rate of cross-channel return policy to the retail channel, $0 < t < 1$
v	Increased demand due to added return channels
c	Retailer/manufacturer's unit return cost
k	Demand sensitivity to self-price when adopting a differentiated pricing strategy
γ	Demand sensitivity to cross-price when adopting a differentiated pricing strategy
w	The wholesale price of the manufacturer to the retailer (Decision variable)
p	The selling price of the retailer in dual channel (Decision variable)
g	Green level of the products (Decision variable)
Superscript T, C	The decentralized scenario under policy T, policy C
Superscript $C - cen$	The centralized scenario under policy C
Superscript S', S	The scenario under coordination contract $\left(w^S, p^{C-cen}, g^{C-cen}\right)$ and contract (w^S, F)

4. Model Analysis

In this section, we analyze the traditional return policy and the cross-channel return policy in a decentralized, dual-channel green supply chain, wherein the manufacturer and the retailer decide independently to maximize their profit. We compared the optimal decision under the two return strategies to find which one was of value to build a green supply chain.

We applied the Stackelberg game led by the manufacturer to process two models under policies T and C. This game model is widely used in supply chain management. Both parties in the supply chain choose their strategies based on the other's possible strategies to ensure that their benefits are maximized, thereby achieving a Nash equilibrium. Specifically, in our study, the manufacturer firstly sets the green level and wholesale price, then produces green products based on the retailer's pricing strategy. Subsequently, the retailer purchases the product and determines the sales price. Finally, the manufacturer and the retailer sell to consumers on their channels.

4.1. Traditional Return Policy

In this model, we hypothesized that the retailer implements the traditional return policy (policy T), which is denoted by a superscript T. That is, customers can buy from the direct channel and return to the retail channel. The model will serve as a benchmark to help retailers in making decisions.

First, to determine the optimal pricing strategy of the retailer, we have $p^T = \frac{\beta\times g+a+w}{2}$. By substituting p^T into Equation (7), the expression for π_m^T in terms of g^T and w^T can be derived. The profit function of the retailer is strictly concave, whereas the profit function of the manufacturer is concave under the condition that $n > \frac{2\beta^2}{3}$. From the first-order condition for π_m^T, the optimal green level and wholesale price can be calculated as Equation (10):

$$\begin{cases} g^T = \frac{\beta(2\times a-c\times r)}{3\times n-2\times\beta^2} \\ w^T = \frac{c\times r(n-\beta^2)+a\times n}{3\times n-2\times\beta^2} \\ p^T = \frac{c\times r(n-2\times\beta^2)+4\times a\times n}{2(3\times n-2\times\beta^2)} \end{cases}. \tag{10}$$

Then we can determine the demands of each channel and the profits of each party by substituting Equation (10) into Equations (3), (6) and (7). To ensure the non-negative nature of p^T g^T, and w^T we have $a > \frac{c\times r}{2}$ and $n > \beta^2$.

The price of green products increases as the green level increases under policy T. That is, a higher green level of products results in a higher selling price. Although the manufacturer does not set the sale price in this model, they can improve the sale price through the mediating effect of wholesale price when high cost occurs.

4.2. Cross-Channel Return Policy

Generally, owing to the complexity of the online return process and high management costs, the manufacturer tends to ask the retailer to provide the cross-channel return service to pass on return costs. In this subsection, we investigated the scenario where the retailer agrees to provide the cross-channel return service without subsidy (policy C). A percentage of people who prefer to return products to a physical store is present when a product bought from a direct channel can meet their expectations, and this ratio is set to f.

Similar to the condition in the first model, the profit functions of the manufacturer and the retailer are concave if $n > \frac{2\beta^2}{3}$. By the same means to optimize the profit function, we can obtain the optimal value of the decision variables as shown in Equation (11):

$$\begin{cases} g^C = \frac{\beta\times(2\times a+2\times v-c\times r)}{3\times n-2\times\beta^2} \\ w^C = \frac{(n-\beta^2)(1-2\times f)\times c\times r+(a+v-c\times r\times f)\times n}{3\times n-2\times\beta^2} \\ p^C = \frac{(r\times c+t\times v+v)(n-2\times\beta^2)+4\times\beta^2\times v+2\times(t\times v+2\times a)\times n}{2(3\times n-2\times\beta^2} \end{cases} \tag{11}$$

To ensure the non-negative nature of p^C, g^C and w^C we have $a > \frac{c\times r}{2}$. At this time, D_r^C, D_d^C, π_r^C, π_m^C and π_{sc}^C can be obtained.

4.3. Comparative Analysis

To reflect the impact of the cross-channel return policy on supply chain members' decision behavior, we compared the green level, retail price, wholesale price, and demand between two strategies in the decentralized scenario. Thus, the following propositions can be realized.

Proposition 1. *The optimal green level under different return policies is related to $g^C > g^T$, given that the manufacturer produces products at a high green level in a decentralized supply chain under policy T.*

Proof. Comparing the optimal green level between the two models, we have Equation (12):

$$\Delta g = g^C - g^T = \frac{2\times\beta\times v}{3\times n-2\times\beta^2} > 0 \tag{12}$$

□

Proposition 1 indicates that the green level in a green DCSC with a cross-channel return policy is higher than that without a cross-channel return policy. Maybe it is because of the increased demand and profits. If the retailer agrees to provide the cross-channel return service, then the manufacturer initiates to produce green products with a high green level. Therefore, the cooperation between supply chain participants is beneficial in promoting the greenness of products, which is consistent with the findings of Ghosh and Shah [19]. The cross-channel return policy helps to improve reputation and brand value. Consumers not only could purchase a greener product but also enjoy the hassle-free returns service. The manufacturers gain more competitive advantages than others. When considering the market competition, this may potentially increase the overall green level of this product. Moreover, the return rate does not affect the improvement of the green level.

Conversely, products with a low green level are harmful to the ecological environment. By 2020, China aims to establish an efficient and comprehensive damage compensation system to protect and improve the country's ecosystem. This system may impose an additional fee for manufacturers in China to compensate for environmental damages.

Proposition 2. *The wholesale price under the different return policies satisfies the following conditions.*
If $0 < f \leq \frac{n\times v}{c\times r(3\times n-2\times\beta^2)}$, *then* $w^C \geq w^T$;
If $\frac{n\times v}{c\times r\times(3\times n-2\times\beta^2)} < f < 1$, *then* $w^C < w^T$.

Proof. By comparing the optimal wholesale price between the two models, we have $\Delta w = w^C - w^T = \frac{n\times v-c\times f\times r\times\left(3\times n-2\times\beta^2\right)}{3\times n-2\times\beta^2}$, then solving f, we can obtain Proposition 2. □

Proposition 2 indicates that the wholesale price under policy C increases more compared with that under policy T when the value of f is low. Moreover, the wholesale price under policy C decreases more compared with that under policy T when the value of f is high. The bargaining power of a retailer is strong with a high value of f. Therefore, a retailer can ask for a low wholesale price to gain additional profits from the manufacturer. By contrast, the bargaining power of the manufacturer is stronger than the retailer if the value of f is low. Thus, the manufacturer can increase the wholesale price to nibble the profit of the retailer.

Proposition 3. *The optimal sale price under different return policies is related to* $p^T < p^C$.

Proof. By comparing the optimal retail price and the total demand between the two models, we have Equation (13):

$$\Delta p = p^C - p^T = \frac{v\times\left[3\times n\times t + 2\beta^2\times(1-t) + n\right]}{2(3n-2\beta^2)} > 0. \tag{13}$$

□

Proposition 3 indicates the optimal sale price in a dual-channel green supply chain with a cross-channel return policy is higher than that without a cross-channel return policy. Although the cost related to the added return channel is not considered, the price of the green products is still increasing. Evidently, the growth of the green level is positive to the sale price, whether under policy T or policy C by $\frac{\partial p^T}{\partial g^T} = \frac{\partial p^C}{\partial g^C} = \frac{\beta}{2} > 0$. The phenomenon can easily be understood considering the growth of the green level shown in Proposition 1. Furthermore, consumers are willing to pay an additional cost for green products if they actively pursue them. Therefore, the manufacturer should raise the selling price while improving product quality if the selling price has less impact on customer demand. This result is similar to many previous studies.

Proposition 4. *The total demand of the supply chain satisfies $D_{sc}^{T} < D_{sc}^{C}$; however, the demand of both channels increases only when* $\max(\frac{n-2\times\beta^2}{3\times n-2\times\beta^2}, 0) < t < 1$.

Proof. Comparing the demand function among the two models, we have Equations (14) and (15):

$$\Delta D = D_{sc}^{C} - D_{sc}^{T} = \frac{2\times n\times v}{3\times n-2\times\beta^2} > 0 \tag{14}$$

$$\Delta D_r = D_r^C - D_r^T = \frac{v(2\times\beta^2\times t-2\times\beta^2-3\times n\times t+n)}{2\times(2\times\beta^2-3\times n)}, \tag{15}$$

If $\Delta D_r > 0$, then the condition $t > t_1 = \frac{n-2\times\beta^2}{3\times n-2\times\beta^2}$ must be satisfied (Equation (16)):

$$\Delta D_d = D_d^C - D_d^T = \frac{v\times(2\times\beta^2\times t-2\times\beta^2-3\times n\times t+5\times n)}{2\times(3\times n-2\times\beta^2)}. \tag{16}$$

If $\Delta D_d > 0$, then the following condition must be satisfied: $t < t_2 = \frac{5\times n-2\times\beta^2}{3\times n-2\times\beta^2}$. □

Evidently, $t_2 > 1$. Considering the condition $0 < t < 1$, we can accept Proposition 4.

Proposition 4 indicates that although the total demand of the supply chain under policy C is higher than that under policy T, the demand for the direct and retail channels only increases if certain conditions are satisfied. The demand of the retail channel under policy C is higher than that under policy T with no condition, whereas the demand for the retail channel increases when *t* exceeds a certain threshold. That is, the effect of reduced demand caused by a high price may exceed the effect of increased demand due to rising green levels.

Based on the two strategies' differences, we will attempt to determine when the retailer will agree to provide the cross-channel return service with no subsidy.

Proposition 5. *When $t' < t < 1$, the retailer would like to cooperate with the manufacturer that applies policy C rather than policy T, which is expressed as (Equation (17)):*

$$t' = \frac{\sqrt{4\times c^2\times r^2\times f^2\times A^2+4\times c\times r\times f\times A\times n\times(B+2v)+n^2\times B^2}-2\times c\times r\times f\times A-n\times B+v\times(n-2\times\beta^2)}{v\times A} \tag{17}$$

where $A = 3n - \beta^2$ and $B = 2a - cr$.

Proof. By solving $\Delta\pi_r = {\pi_r}^C - {\pi_r}^T$, we can obtain:

$$\Delta\pi_r = \frac{v\left\{[36c\times f\times r\times(t-1)+(3\times t-1)\times\Psi_1]n^2-\Psi_2\times(t-1)\times\beta^2\times n+\Psi_3\right\}}{4(3\times n-2\times\beta^2)^2},$$

where $\Psi_1 = 4a-2\times r\times c+(3t-1)\times v$, $\Psi_2 = 4\times v\times(3\times t-1)+4\times r\times(12\times f-1)\times c+8\times a$, $\Psi_3 = 4(4\times c\times f\times r+t\times v-v)\times(t-1)\times\beta^4$. Given that $\frac{\partial^2\Delta\pi_r}{\partial t^2} > 0$, the function image of $\Delta\pi_r$ is upward, then let $\Delta\pi_r = 0$, and t' is then obtained (the other solution is omitted because it is negative). □

From the perspective of the manufacturer, $\Delta\pi_m = {\pi_m}^C - {\pi_m}^T > 0$ holds for the reason of return cost reduction. Thus, Proposition 5 can be proven.

Proposition 5 has provided instruction under the condition that adding the cross-channel to return is beneficial for the retailer to gain additional profit. This assumption is reasonable given that the retailer faces a high cost for adding return business. Proposition 5 explains that if the threshold is relatively large, then the retailer less likely agrees to provide a cross-channel return service because it is unlikely to come true. The manufacturer needs to pay extra fees to the retailer to implement the cross-channel return policy, which is easy when the threshold is small. Thus, the changes of t' are crucial for the supply chain to become greener and more convenient to consumers than before. Subsequently, we study sensitivity analyses between certain parameters and t'.

Owing to the complexity of t', we explain how t' changes with certain related parameters through numerical analysis. By analyzing the relationship between related parameters and t', we find that β has a remarkably negative effect t'. Figure 2 reveals that the manufacturer takes the initiative to enhance consumer preferences for green products to decrease the level of t'. Therefore, environmental propaganda can be organized by the manufacturer to reduce the cost related to return.

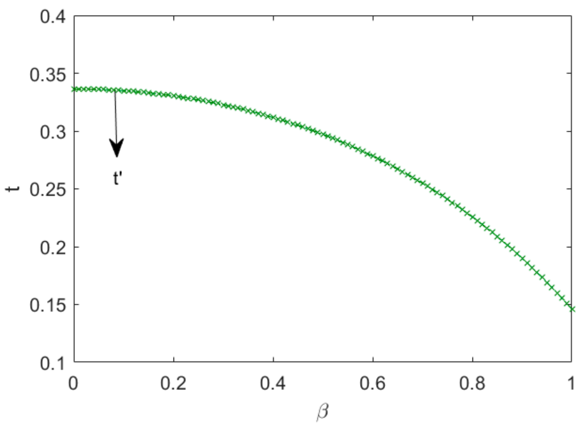

Figure 2. The trend of t' with β.

In summary, through the five propositions, we could evaluate the green supply chain with a cross-channel return strategy in terms of greenness, price, demand, and profit. For consumers, they can buy greener products at a slightly higher price and get more flexible return services. For the manufacturer, he can encourage retailers to cooperate at a meager cost considering the spillover effect. Furthermore, Proposition 5 provides a way for the manufacturer to eliminate this cost.

4.4. Coordination Contract

We focus on the coordination of the dual-channel green supply chain in this subsection. A number of previous studies have used contracts to coordinate the supply chain. Similar to [5,31], we examined whether a simple contract (w^S, p^{C-cen}, g^{C-cen}) can coordinate this supply chain and determined how to correct it if not.

First, we investigated the scenario in which the manufacturer and the retailer are vertically integrated in a supply chain under policy C (denoted by a superscript $C - cen$). The problem is how to maximize the profit of the whole supply chain (Equation (18)):

$$\max \pi_{sc}{}^{C-cen} = p \times (D_r + D_d) - \frac{n \times g^2}{2} - r \times D_d \times c \tag{18}$$

The optimal decisions are derived as follows (Equations (19) and (20)):

$$g^{C-cen} = \frac{\beta \times (2 \times a - c \times r + t \times v + v)}{2 \times (n - \beta^2)} \tag{19}$$

$$p^{C-cen} = \frac{[c \times r + (t+1) \times v + 2 \times a] \times n - 2 \times \beta^2 \times c \times r}{4 \times (n - \beta^2)}. \tag{20}$$

By substituting the optimal decisions to Equation (18), the profit of the whole supply chain can be obtained. Comparing it with ${\pi_{sc}}^{C}$, the manufacturer's profit is evidently higher than the retailer's. This finding suggests that a decentralized green DCSC weakens supply chain efficiency.

We also examined whether the contract (w^{S}, g^{C-cen}, g^{C-cen}) is more advantageous than a decentralized green DCSC for the manufacturer and the retailer. Under this contract, the profit functions are as follows (Equations (21) and (22)):

$$
{\pi_r}^{S\prime} = (p - w) \times D_r - f \times r \times D_d \times c \tag{21}
$$

$$
{\pi_m}^{S\prime} = w \times D_r + p \times D_d - \frac{n}{2} \times g^2 - (1 - f) \times r \times D_d \times c. \tag{22}
$$

We calculated the value of w^{S} by using the optimal decision g^{C-cen} and p^{C-cen} in the centralized scenario. In a decentralized green DCSC for a given wholesale price and green level, the profit function of the retailer is concave. Subsequently, the optimal sale price can be expressed as $p = \frac{c \times f \times r + \beta \times g + t \times v + a + w}{2}$; then, by substituting the optimal decision into it, the expression of the parameter w^{S} in the contract can be derived as (Equation (23)):

$$
w^{S} = \frac{(1 - 2f) \times r \times c + v \times (1 - t)}{2}. \tag{23}
$$

w^{S}, p^{C-cen}, and g^{C-cen} are substituted into Equations (21) and (22) and compared with ${\pi_r}^{C}$ and ${\pi_m}^{C}$. If the contract (w^{S}, p^{C-cen}, g^{C-cen}) is efficient for this supply chain, then the following conditions must be satisfied (Equation (24)):

$$
\begin{cases} {\pi_r}^{S\prime} > {\pi_r}^{C} \\ {\pi_m}^{S\prime} > {\pi_m}^{C} \end{cases} \tag{24}
$$

Based on Equation (24), it is easy to find that the retailer gains additional profits, whereas the manufacturer loses profits because the wholesale price is drastically reduced. Consequently, the contract (w^{S}, p^{C-cen}, g^{C-cen}) cannot coordinate our dual-channel green supply chain considering the cross-channel return, which is different from the findings of [5,31].

Based on this result, we attempted to correct the contract by using a lump sum fee (denoted by a superscript S), which is considered a revenue-sharing contract wherein the manufacturer's wholesale green products at a low level consequently gain a portion of the profit from the retailer. In this scenario, the manufacturer charges a lump sum fee F to the retailer to support green production and maintain the low wholesale price that is called "transfer payment." Both parties can benefit from the dual-channel green supply chain, thereby achieving the goal of coordination. Based on these assumptions, the profit functions of the manufacturer and the retailer can be depicted as ${\pi_r}^{S} = {\pi_r}^{S\prime} - F$, ${\pi_m}^{S} = {\pi_m}^{S\prime} + F$. To meet the conditions $\pi_r^{S} > \pi_r^{C}$ and ${\pi_m}^{S} > {\pi_m}^{C}$, the range of F can be calculated as (Equation (25)):

$$
\begin{cases} F > F_1 = \frac{n \times (5 \times n - 4 \times \beta^2) \times [2 \times v \times \beta^2 \times (1-t) + n \times (2 \times a - c \times r + 3 \times t \times v - v)]^2}{16 \times (3 \times n - 2 \times \beta^2)^2 \times (n - \beta^2)^2} \\ F < F_1 = \frac{n \times \{[(3 \times t - 1) \times v + 2 \times a - c \times r] \times n - 2 \times v \times \beta^2 \times (1-t)\}^2}{16 \times (n - \beta^2)^2 \times (3 \times n - 2 \times \beta^2)} \end{cases}. \tag{25}
$$

Proposition 6. *When the lump sum fee that the retailer pays to the manufacturer falls within the range $[F_1, F_2]$, the contract (w^{S}, F) can coordinate the decentralized dual-channel green supply chain wherein the retailer provides the cross-channel return service, and the supply chain achieves a win-win scenario.*

Under the contract (w^S, p^{C-cen}, g^{C-cen}), the wholesale price decided by the manufacturer is smaller than the scenario under policy C. Therefore, the profit margin of the retailer is improved, which motivates the retailer to provide a low sale price. However, an extremely wholesale price leads the manufacturer to lose profit. When the retailer pays a lump sum fee to the manufacturer to share revenue, both parties in the supply chain gain additional profits. Thus, the contract (w^S,F) can coordinate the dual-channel green supply chain with a cross-channel return policy. In addition, the final size of F depends on the bargaining power of the manufacturer and the retailer in the negotiation.

5. Numerical Analysis

In this section, we present the numerical analysis to explain the results obtained above. The following values are assumed: $a = 10, n = 3, c = 0.5, f = 0.3, r = 0.1, v = 2$. Their values meet the conditions $a > \frac{c \times r}{2}$ and $n > \beta^2$ to ensure that all decision variables are non-negative. To illustrate the effect of the coordination contract, we assume that the value of F is at a medium level, which is expressed as Equation (26):

$$F = \frac{\left\{[(3 \times t - 1) \times v - c \times r + 2 \times a] \times n + 2 \times v \times \beta^2 \times (1 - t)\right\}^2 \times (4 \times n - 3 \times \beta^2) \times n}{16 \times (3 \times n - 2 \times \beta^2)^2 \times (n - \beta^2)^2}. \quad (26)$$

5.1. Impact of the Degree of the Spillover Effect

We investigated how the degree of the spillover effect t influenced the dual-channel green supply chain. Here, we set $\beta = 0.7$. Figure 3a–c shows the optimal decisions under policy T, policy C, and the coordination scenario. The optimal green level in a supply chain with the cross-channel return policy is constant. That is, the green level is not relative to t. Nonetheless, the green level is at the highest, and the sale price is at the lowest. This finding implies that the coordination contract can build a sustainable supply chain wherein the manufacturer produces the most environmentally friendly product and sells it at the most competitive price. Moreover, the lowest wholesale price means that the contract with no lump sum fee is not beneficial to the manufacturer, and the contract with a lump sum fee is necessary to ensure an improved green supply chain. Figure 4a,b illustrates that the manufacturer constantly gains profits through the cross-channel return policy, whereas the retailer earns profit when t is greater than a threshold, thereby proving Proposition 5.

Figure 5 depicts how the upper and lower boundaries of the lump sum fee F of the contract (w^S,F) change with t. As t increases, F_2 grows faster than F_1. Particularly, the range space of F expands when t increases.

5.2. Impact of the Degree of Consumer Sensitivity to Green Products

We studied how consumer sensitivity to green products impacted the dual-channel green supply chain with a cross-channel return policy. We assumed that $t = 0.2$. Figure 6a–c shows the effect of β on three optimal decision variables. Commonly, β has a positive impact on decision variables and apart from the wholesale price under the coordination model. Figure 7a,b reveals that the profits of the manufacturer and the retailer follow similar trends. That is, consumer sensitivity to green products significantly influences the efficiency of the dual-channel green supply chain. If consumers are sensitive to green products, then the manufacturer is motivated to produce high green-level products and to implement cross-channel return strategies because of low costs. Moreover, Figure 6 indicates that the increase rate of the green level is greater than the sale price to β. Therefore, the manufacturer should actively conduct environmental protection propaganda to increase consumer sensitivity to the green product. Furthermore, the increase of consumer sensitivity to green products is an essential drive to an improved green supply chain.

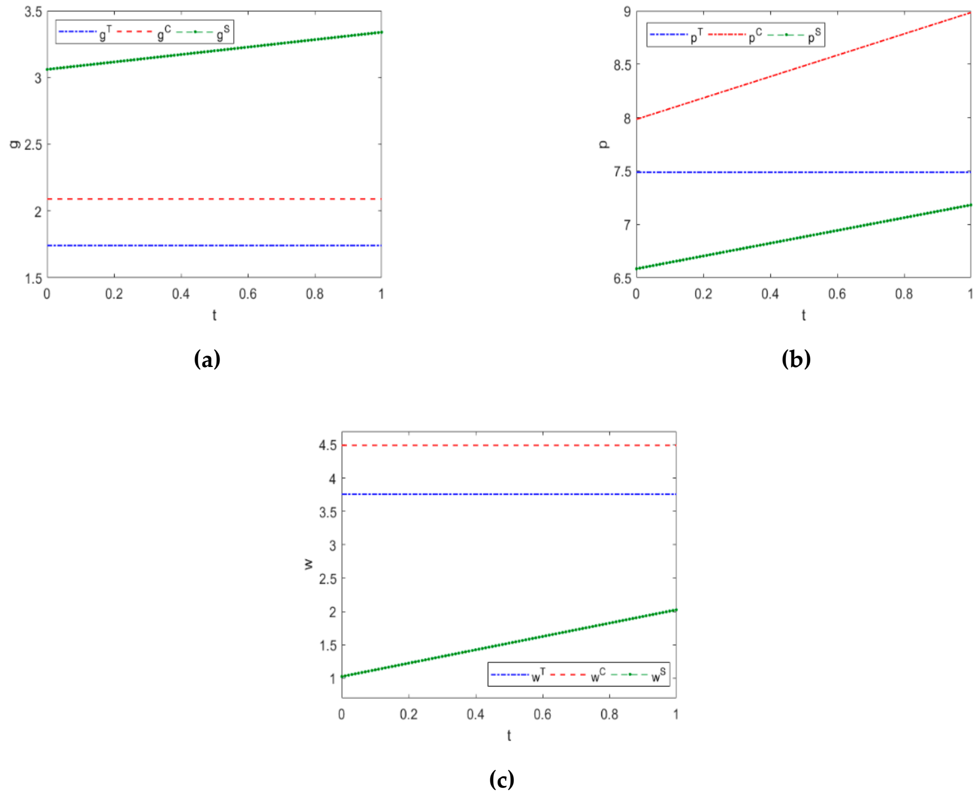

Figure 3. Trends of green level (**a**), sale price (**b**), and wholesale price (**c**) with t.

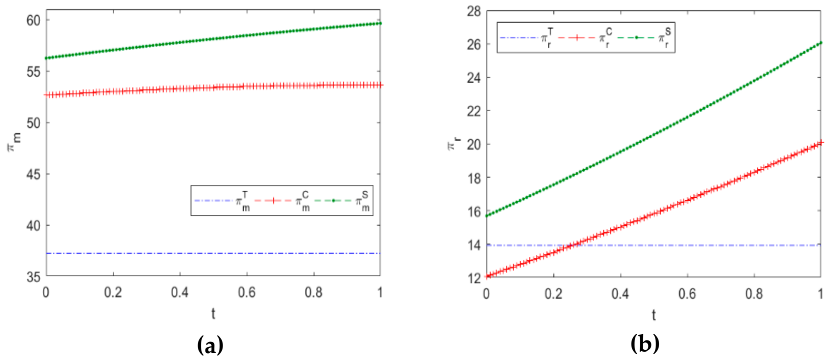

Figure 4. Trends of the manufacturer's profits (**a**) and the retailer's profits (**b**) with t.

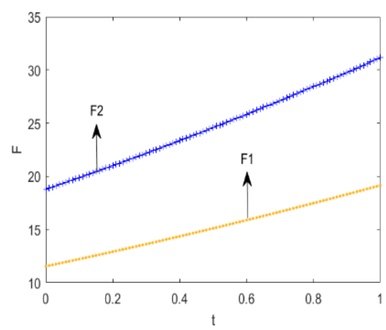

Figure 5. Lump-sum fee F with t.

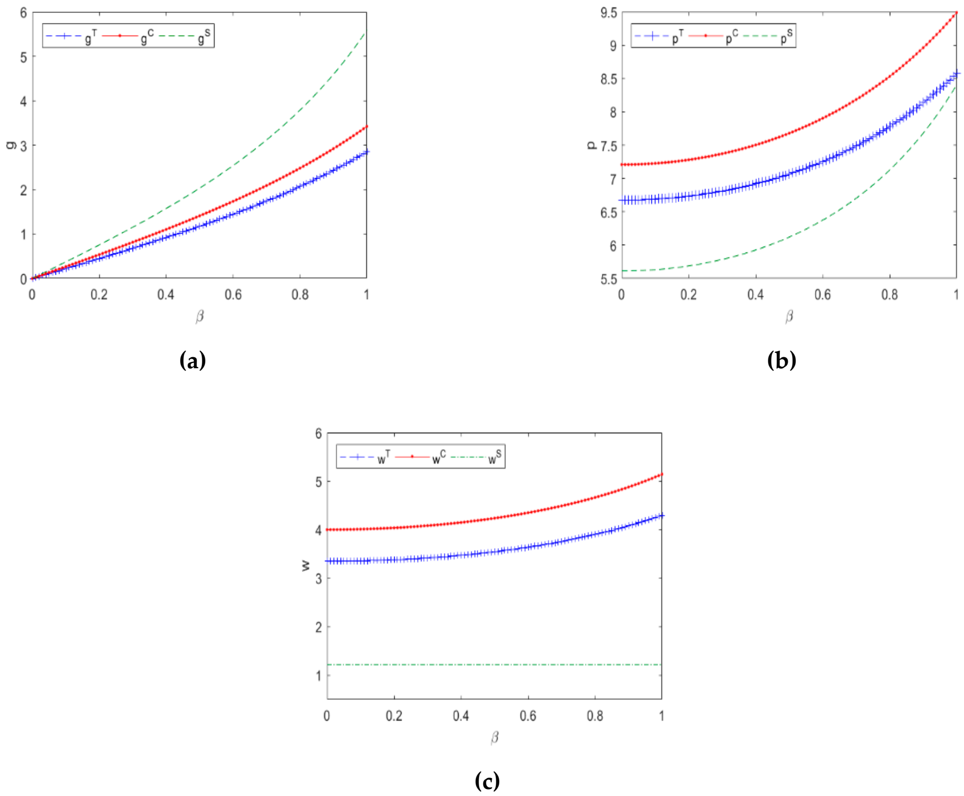

Figure 6. Trends of green level (**a**), sale price (**b**), and wholesale price (**c**) with β.

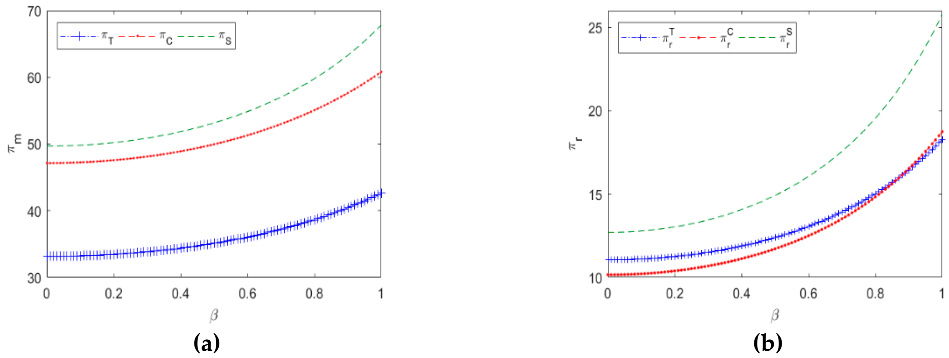

Figure 7. Trends of the manufacturer's profits (**a**) and the retailer's profits (**b**) with β.

Figures 6c and 8 show how the parameters (w^S, F_1, F_2) of the contract (w^S,F) change as the value of β changes. Evidently, w^S is constant. That is, given other parameters, the value of the wholesale price set by the manufacturer and the retailer is a fixed fee. No matter how β changes, the wholesale price under the coordination contract that we proposed remains unchanged. Nonetheless, the manufacturer could earn profits by sharing revenue. Figure 8 illustrates that the boundaries of F significantly increase with β compared with Figure 5, and the range space of F also expands when t increases. This finding is beneficial to the manufacturer; thus, consumer sensitivity to the green product should be increased.

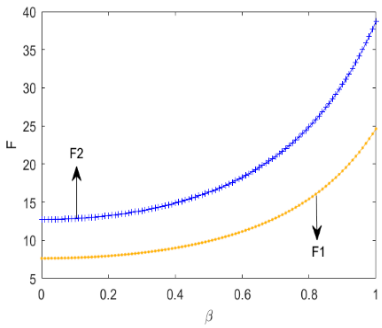

Figure 8. Lump sum fee F with β.

6. Extended Discussion

Previous results and analyses in this article are based on the consistent pricing strategy. In this subsection, we extend the discussion on the situation under the differential pricing strategy (indicated by the subscript e), which means that the sale prices of two channels are decided by the retailer and the manufacturer, respectively, despite that green products are at the same level. Similarly, the pricing and greening strategies are discussed under policy T and policy C by using a two-stage optimization method to analyze them. We initially determined the retailer's optimal prices for any given green level and wholesale price. Subsequently, we derived the optimal green degrees based on the previous results.

Based on Equations (1) and (2), let $k = \gamma + 1$, and the demand functions under policy T are (Equations (27) and (28)):

$$D_{ed}{}^{T} = a - (\gamma + 1) \times p_d + \gamma \times p_r + \beta \times g, \tag{27}$$

$$D_{er}{}^{T} = a - (\gamma + 1) \times p_r + \gamma \times p_d + \beta \times g, \tag{28}$$

and the demand functions under policy T are (Equations (29) and (30)):

$$D_{ed}{}^{C} = a - (\gamma + 1) \times p_d + \gamma \times p_r + \beta \times g + v, \tag{29}$$

$$D_{er}{}^{C} = a - (\gamma + 1) \times p_r + \gamma \times p_d + \beta \times g + t \times v, \tag{30}$$

where γ represents the cross effect of the other channel's price. Thus, the profit functions of the manufacturer and the retailer under policy T are (Equations (31) and (32)):

$$\pi_{er}{}^{T} = (p_r - w) \times D_{er}{}^{T}, \tag{31}$$

$$\pi_{em}^{T} = w \times D_{er}^{T} + p_d \times D_{ed}^{T} - \frac{1}{2} n \times g^2 - r \times D_{ed}^{T} \times c. \tag{32}$$

The profit functions of the manufacturer and the retailer under policy C are (Equations (33) and (34)):

$$\pi_{er}{}^{C} = (p_r - w) \times D_{er}{}^{C} - r \times D_{ed}{}^{C} \times f \times c, \tag{33}$$

$$\pi_{em}^{C} = w \times D_{er}^{C} + p_d \times D_{ed}^{C} - \frac{n \times g^2}{2} - (1 - f) \times r \times D_{ed}^{C} \times c \tag{34}$$

6.1. Traditional Return Policy under the Differential Pricing Policy

In this scenario, the manufacturer does not plan to adopt the cross-channel return policy and therefore faces the green manufacturing cost and return business, whereas the retailer does not need to pay for any of them.

Evidently, $\pi_{er}{}^{T}$ is strictly concave, $\pi_{em}{}^{T}$ is strictly concave with p_d and w, and $\pi_{em}{}^{T}(g)$ is concave when $(\beta^2 + 4n) \times \gamma + 3 \times \beta^2 - 4 \times n < 0$ is satisfied.

Then, we can derive the optimal sale price and the wholesale price of the supply chain players by using the two-stage optimization method, and the results are below (Equation (35)):

$$\begin{cases} w_e^T = \frac{\beta\times g+a}{2} \\ p_{ed}^T = \frac{r\times c+\beta\times g+a}{2} \\ p_{er}^T = \frac{(2\times\beta\times g+c\times r+2\times a)\times\gamma+3\times(\beta\times g+a)}{4\times\gamma+4} \end{cases}. \tag{35}$$

By subsequently substituting Equation (35) into Equation (32) and differentiating it, we can obtain the optimal greening decision (Equation (36)):

$$g_e^T = \frac{\beta\times(4\times a\times\gamma-3\times c\times\gamma\times r-2\times c\times r+3\times a)}{4\times(n-\beta^2)\times\gamma-3\times\beta^2+4\times n}. \tag{36}$$

Consequently, with the final optimal sale price in the direct and retailer channels, the wholesale price and the profit of the two players can be determined.

6.2. Cross-Channel Return Policy under the Differential Pricing Policy

In this scenario, the supply chain implements the cross-channel return, and the consumer can freely return products to the direct or the retail channel. Thus, the retailer and the manufacturer will likewise pay a part of the return cost. Similarly, we have Equation (37),

$$\begin{cases} w_e^C = \frac{[(t+1)\times v+2\times(c\times f\times r+\beta\times g+a)]\gamma^2+[(2\times t+1)\times v+c\times f\times r+3\times\beta\times g+3a]\gamma+\beta\times g+t\times v+a}{4\times\gamma^2+6\times\gamma+2} \\ p_{ed}^C = \frac{\{2r\times(1-f)\times c+(t+1)\times v+2\times\beta\times g+2\times a]\gamma+r\times(1-f)\times c+\beta\times g+a\times v}{4\times\gamma+2} \\ p_{er}^C = \frac{2[(t+1)\times v+(1-2f)\times r\times c+2\times(\beta\times g+a)]\gamma^2+[(6t+2)\times v+(1-2f)\times r\times c+8(\beta\times g+a)]\gamma+3(\beta\times g+t\times v+a)}{8\times\gamma^2+12\times\gamma+4} \end{cases} \tag{37}$$

By substituting and the optimal decisions into $\pi_m{}^C$ and differentiating it, we can obtain the optimal greening decision (Equation (38)):

$$g_e^C = \frac{\beta\times\{[c\times r\times(4f-3)+(2t+2)\times v+4a]\times\gamma+2r\times(f-1)\times c+(t+2)\times v+3a\}}{4\times(n-\beta^2)\times\gamma-3\times\beta^2+4\times n} \tag{38}$$

By comparing the obtained results, Proposition 7 is accepted.

Proposition 7(a). *The comparison of the optimal greenness in the two cases is as follows:*

$$\Delta \mathrm{g_e} = g_e^C - g_e^T = \frac{\beta\times[(2\times c\times r\times f+t\times v)\times(2\gamma+1)+2v\times(\gamma+1)]}{4\times\gamma\times n+4\times n-4\times\beta^2\times\gamma-3\times\beta^2}$$

Proposition 7(b). *For any given green degree of the products, the prices have the following properties:*

$$\frac{\partial p_{er}{}^C}{\partial g_e{}^C} = \frac{\partial p_{er}{}^T}{\partial g_e{}^T} = \frac{\beta\times(2\times\gamma+3)}{4\times(\gamma+1)} > \frac{\partial p_{ed}{}^C}{\partial g_e{}^C} = \frac{\partial p_{ed}{}^T}{\partial g_e{}^T} = \frac{\beta}{2} > 0.$$

Proposition 7(a) indicates that the optimal green level under policy C is lower than that under policy T when the supply chain implements the differential price strategy, which means that the cross-channel return is not beneficial in manufacturing green products. This finding is unlike the result that we obtained in which the supply chain implements a consistent price strategy.

Proposition 7(b) indicates the rates of changes of $p_{er}{}^C$ and $p_{ed}{}^C$ are equal to those of $p_{er}{}^T$ and $p_{ed}{}^T$, respectively. Additionally, the rates of change of the retail price are always greater than that of the direct channel with respect to the green level. Therefore, the retail price is more sensitive to the increase in green level than the direct channel. Whether the supply chain uses a cross-channel return policy or not, the principle of "high greenness, high price" follows.

Owing to complexity, we investigated the profit changes of the manufacturer and the retailer and the spillover effect through numerical analysis. We assumed that the value of parameters is similar to the fifth part, $a = 10, n = 3, c = 0.5, f = 0.3, r = 0.1, v = 2, \gamma = 0.4, t \in (0, 1), \beta \in (0, 1)$.

We initially tried to identify the critical conditions when the retailer decides to offer cross-channel return services. Previous analysis revealed that the degree of the spillover effect is a key parameter that affects the retailer's decision to provide cross-channel return service. Let t_e' denote the threshold of green DCSC based on differential pricing strategy. Similar to the result shown in Proposition 5, Figure 9 implies that the threshold of t_e' decreases with β. Interestingly, by comparing Figures 2 and 9, the value of the threshold is evidently lower than the scenario wherein the supply chain implements a consistent pricing strategy. However, this finding can be explained given that the profit difference of the retailer before and after implementing cross-channel return policy under differential pricing strategy is higher than the scenario under differential pricing strategy.

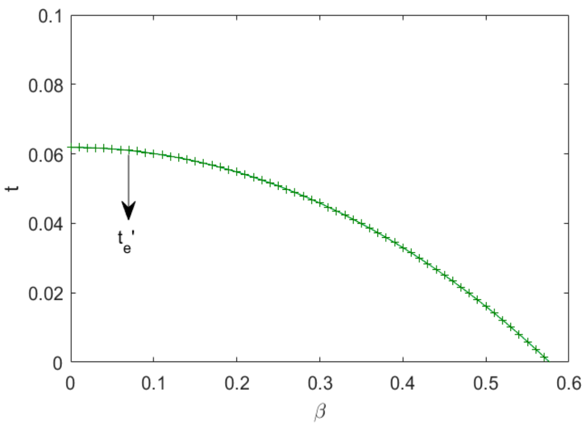

Figure 9. The trend of t_e' with respect to β.

We subsequently analyzed the spillover effect on the manufacturer and the retailer's profits under a differential price strategy. We assumed that $\beta = 0.7$. Figure 10 shows that the cross-channel return policy can improve the green level and increase the manufacturer and the retailer's profits under certain assumptions. However, based on the analysis above, which pricing strategy is the better approach to build a green supply chain, consistent price, or differential price? From the profits view, Figure 11a implies that the whole supply chain earns more profit than before the cross-channel return policy is implemented, whether under the differential pricing or consistent pricing strategy, and the profits of the whole supply chain are higher under differential pricing strategy than under the consistent pricing strategy. Form the green manufacturing perspective, Figure 11b indicates that implementing the differential price can increase the green level of products. However, the conflict between the manufacturer and the retailer increases with the price difference between the two channels, which may be harmful to a multichannel retail system. Thus, high total profits do not mean a better strategy. Furthermore, more attention should be paid to achieving supply chain coordination if the supply chain implements the differential pricing strategy.

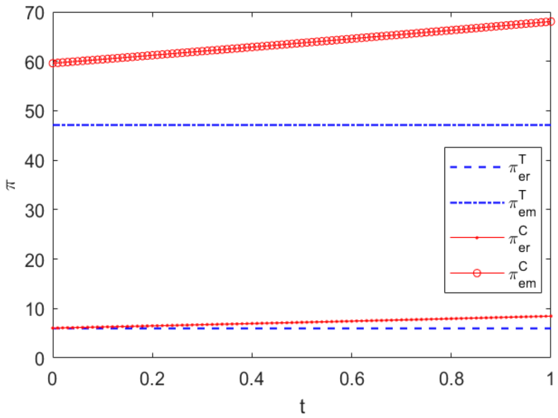

Figure 10. Trends of profits with t under differential pricing strategy.

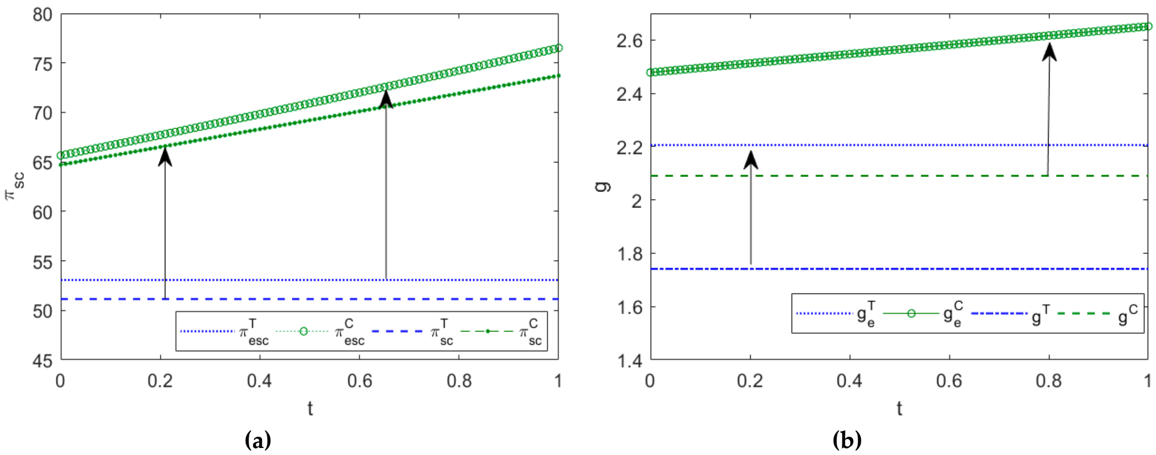

Figure 11. Comparison of the supply chain's profit (**a**), green level (**b**) under consistent and differential pricing strategies.

7. Conclusions

This study considers the return business into the dual-channel green supply chain and discusses how it affects the decisions of supply chain players. We determined the circumstance when the retailer will cooperate with the manufacturer to provide cross-channel return service by comparing the retailer's profit in the cases of providing and not providing cross-channel return service. In addition, we analyzed the spillover effect and the greening sensitivity of consumers and proposed a contract to coordinate the supply chain. Afterward, we extensively investigated the scenarios wherein the supply chain implements the differential pricing strategy.

Through the above analyses, we find the answers to the main questions about the cross-channel return policy in a green DCSC.

First, the retailer will cooperate with the manufacturer to implement a cross-channel return policy under a consistent pricing strategy when the spillover effect is greater than a threshold. Through numerical analysis, we find that this threshold is not difficult to reach. Interestingly, the threshold is highly relative to the greening sensitivity of consumers. Therefore, this finding can provide management advice to the manufacturer, such as proposing marketing programs (e.g., consumer education and green advertising) to increase the consumer sensitivity to green level improvement, which could reduce the cost of encouraging retailers to support this return policy.

Second, after adopting the cross-channel return policy, the manufacturer improved the consumer experience of customers, thereby increasing market demand in both channels. Thus, the manufacturer continually benefits from the cross-channel return policy. Furthermore, the optimal green level of the product is improved whenever the supply chain adopts the consistent pricing strategy or the differential pricing strategy. From the perspective of the retailer, when customers' preference for cross-channel is relatively high, the wholesale price charged to the manufacturer is lower than before because of its increased bargaining power.

Third, our numerical experiments demonstrate that the optimal decisions and the profits of the manufacturer and the retailer increase as the greening sensitivity increases. When introducing a cross-channel return policy into the green supply chain, the spillover effect only affects the selling price, and the optimal green level and the wholesale price is not related to it. Moreover, the retailer's profits significantly increase with the degree of spillover effect, while the manufacturer's profits rise slightly. It means the existence of spillover effects can alleviate a certain degree of supply chain conflict, and it is beneficial for a stable supply chain.

Fourth, the contract (w^S,F) can coordinate the dual-channel green supply chain with a cross-channel return policy efficiently. Under this contract, consumers can buy green products at a low price, which means that the coordination scenario is the most environment-friendly among the three scenarios. Moreover, the manufacturer can achieve high profits through a lump sum fee. Therefore, applying the contract creates a multi-win situation.

Although we are the first to consider the return channel policy into the dual-channel green supply chain, and this study has a certain contribution to the literature related to the dual-channel green supply chain, there also are shortcomings, and we can extend in several ways. First, readers should bear in mind that the study is based on information symmetry. Thus, late-stage research can be studied based on asymmetric information settings, which are close to actual situations. Another extension direction is to examine a green supply chain consisting of some competitive green products, whereas we considered one type of green product. Finally, future research can consider supply chain players' behavior and characteristics, such as risk preference or fair concern.

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Conflicts of Interest: The authors declare that they have no conflicts of interest.

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