


Article

Sustainable Cooperation in the Green Supply Chain under Financial Constraints

Guangyuan Xing ¹, Bing Xia ^{2,*}  and Jue Guo ²¹ School of Economics and Finance, Xi'an Jiaotong University, Xi'an 710049, China; xinggy@mail.xjtu.edu.cn² School of Management, Xi'an Jiaotong University, Xi'an 710049, China; guojue@mail.xjtu.edu.cn

* Correspondence: xiabin0721@126.com

Received: 16 September 2019; Accepted: 24 October 2019; Published: 28 October 2019



Abstract: Investment on product greenness in green supply chain is always restricted by the emerging supplier's financial constraints, so manufacturers always share the suppliers' investment to encourage the suppliers' green innovation. Based on the two-stage cooperation model between one manufacturer and one emerging supplier, and the assumption that emerging suppliers need to reach a certain survival threshold at the end of each period, this paper studies investment on product greenness and sustainability of cooperation in the supply chain. The impacts of consumers' preference for greenness (CPG), market volatility, financial constraints, and investment-sharing proportion are also examined. It was found that when market volatility and CPG exist at the same time, compared with the deterministic environment, emerging suppliers will improve (or reduce) the wholesale price and greenness at the same time to balance the short-term bankruptcy risk and the long-term profit, and suppliers' green investment would be stimulated by the increasing demand uncertainty. Besides, when suppliers' financial constraints increase, manufacturers will also increase its sharing proportion of green investment. Lastly, there always exists an investment-sharing proportion that optimizes the sustainability of cooperation and profits jointly.

Keywords: green supply chain; financial constraints; investment-sharing contracts; emerging suppliers; uncertain investment

1. Introduction

Product greenness, meaning the friendly degree of the products to people and nature [1], such as product harmful substance content, energy consumption level, recyclability, etc., has great impacts on consumers' purchasing decisions. Enterprises always take active measures to invest in green products, and provide resource-saving and environment-friendly green products to the market, in order to maintain long-term market competitiveness [2,3]. For example, Apple and Sony, have already implemented green supply chain management, enhanced their environmental image and brought competitive advantages [4]. The process of "green supply chain" is often hampered because the suppliers fail to achieve green level. In the supply chain, as the target of the core manufacturing enterprises' procurement activities, the suppliers directly relate to the greenness of product and procurement cost of the manufacturing enterprise, and has great impacts on the production and the realization of environmental goals [5]. However, the cooperation between suppliers and manufacturers in green supply chain is more difficult to keep. For example, Tesla, the representative of electric vehicle companies with latest technologies, is facing a major problem that his suppliers are applying for bankruptcy currently because of not receiving payment for components. As many of Tesla's components are from single supplier, Tesla might face significant supply risks [6]. In fact, sustainability of the cooperation in green supply chain is mainly affected by two reasons.

First, green technology always costs highly that emerging enterprises cannot afford [7]. For example, in the early stage of emission regulation in the United States, automakers mainly install emission control devices to produce green products. However, as the regulations become stricter, US Environmental Protection Agency has issued Level 3 standard [8] by 2014, more disruptive innovative technologies such as Tesla's electric vehicle technologies, that can fundamentally change the equipment design become necessary. This type of technological innovation is unaffordable for emerging suppliers, which most likely take on debts to support normal operations and might face bankruptcy risk while facing payment defaults [9]. It is advised by Tencent Technology [10] that the manufacturer could pay for the supplier's product improvement and incentive contracts could be adopted. Therefore, this paper introduces the investment-sharing contract to investigate how the finance-constrained supplier makes its investment on product greenness with the manufacturer's help.

Second, the enterprises must face demand uncertainties when making investment on product greenness. As green products in the market are sometimes not up to standard or worse than ordinary products, and green consumption concept of consumers has not yet formed, consumers' environmental awareness could be low. Consumers could be hard to accept the high price of green products and the market size of green products might be much smaller than expected [11]. If this happens, orders from downstream manufacturers would be reduced, and large amount of R & D investment of suppliers might be vain, which makes their cash flow tight and makes the supply chain cooperation easily broken. Therefore, this paper considers the impacts of demand uncertainties on the supplier's operational decisions and the sustainability of supply chain cooperation.

Thus, while taking on debts and facing demand uncertainties, how the emerging suppliers make operational decisions (including wholesale price, greenness, etc.) to reduce the bankruptcy risk? Besides, in cooperation between the supplier and the manufacturer, how to set a proper investment-sharing proportion that can effectively stimulate the emerging suppliers' green investment, meanwhile maximize the manufacturer's profit? Aiming at these questions, this paper conducts modeling derivation and computational stimulation.

The remainder of this paper is organized as follows. Section 2 reviews the related literature. Section 3 presents the two-period model and makes analysis in the basic case. In Section 4, the demand uncertainties are introduced and discussions are made in the stochastic environment. Section 5 concludes this paper. All proofs in this paper are provided in Appendix A.

2. Literature Review

This paper tackles the joint price and greenness decisions of the finance-constrained supply chain. Three streams of literature are related with our work, namely, green supply chain management (GSCM), green supply chain collaboration and coordination, and emerging enterprises' operational strategies under financial constraints.

Mathu [12] pointed that when focusing on lean and agile supply chains, closed-loop supply chains, reverse logistics, and the practice of just in time, the operation is transformed to GSCM. GSCM can be seen as an environmental innovation, which integrates environmental thinking into supply chain management (SCM). It aims to minimize or eliminate wastages including hazardous chemical, energy and emissions along supply chain. As reviewed by Ashby et al. [13], Green product development has been long recognized as one of the main themes in GSCM. Enterprises apply tools such as design for environment, design for disassemble, and life cycle analysis in order to reduce the product's environmental impact [14]. It is believed that enterprises implementing GSCM practices can benefit from cost savings, better public image and decreased environmental liability [15]. What is more, it is supported that GSCM is closely related to the participants' financial performance. Feng et al. [16] suggest that GSCM as an integral supply chain strategy is positively associated with both environmental and financial performance. Flammer [17] finds that enterprises' ecofriendly behavior is closely related to significant stock price increases, whereas enterprises with eco-harmful behavior face decreases in stock price. Zhang et al. [18] proposes social control as an effective mechanism to strengthen the impact

of GSCM on enterprises' financial performance. Following these researches, this paper pays attention to the green products, investigates the relationship between product greenness and the enterprises' utilities. Different from previous literatures, this paper considers not only the relationship between product greenness and the enterprise' profits, but also the relationship between product greenness and the finance-constrained enterprise's survival probability.

Among the issues in GSCM, collaboration is the most important. Chin et al. [19] indicate that environmental collaboration is a key relational capability to facilitate the GSCM strategic formulation and execution. Further, from the perspective of supply chain coordination and the development of economic models, green supply chain coordinating issues are also developed and discussed widely [20–24]. Zhang and Liu [24] study the decisions in a three-level supply chain with market demand and product greenness related. It is pointed out that revenue-sharing mechanism, Shapley-value coordination mechanism, and asymmetric Nash negotiation mechanism can all improve the performance in a decentralized supply chain. Zhu and He [25] introduce quality (greenness) as a decision variable, and study the green product design in the competitive supply chain. Ghosh and Shah [20] compare the pricing, greenness, and supply chain revenue in the decentralized channel structure, and propose that two-part tariff contracts can coordinate the green supply chain and cooperation can improve product greenness. Ghosh and Shah [21] study the manufacturer-retailer supply chain where consumers have preference for greenness, and find that cooperation with cost-sharing contracts can improve the greenness and revenue of supply chains, but bargaining between manufacturer and retailer would not increase the retailer's revenue. Swami and Shah [23] focus on channel conflicts between manufacturers and retailers in green supply chains, and study coordination problems among green supply chain members. Contributing to this stream of literatures, this paper (i) constructs a two-stage cooperative analytical framework between the supplier and the manufacturer for the long-term, and cross-stage R & D process of green products; (ii) examines the impact of investment-sharing contract on green innovation in the sustainable supply chain cooperation.

Recently, an increasing of scholars have paid attention to the emerging enterprises' operational strategies under financial constraints [26–29]. Babich [30] argues that only when the enterprises survive in the market, can they make profits in the long term. Under the financial constraints, the emerging enterprises would be exposed to bankruptcy risk, should the market fail as expected. Therefore, studies on emerging enterprises' innovating activities also focus on the emerging enterprises' survival probability. According to Cefis and Marsili [31,32], emerging enterprises can increase their survival probability through innovations. Criscuolo et al. [33] find that emerging enterprises in the service industry have a higher probability of innovation. In contrast, Shane [34] finds that most emerging enterprises start from ordinary industries without special creativity. Bhidé [35] argues that only 6% of the giant enterprises began by offering unique products or services, while 58% began by offering alternatives of existing products and services. Thus, different from the empirical researches, this paper (i) adopts a two-stage analytical framework to conduct theoretical researches on green innovation decisions of the emerging enterprises, and (ii) expands the research of financial constraints from a single enterprise level into the supply chain level.

3. Problem Descriptions and Basic Case

Consider a two-stage model where the emerging supplier cooperates with the manufacturer for investment on green products. In the first stage, the supplier borrows cash, and starts the production from a common product. After obtaining the revenue and obtaining the manufacturer's investment support by the investment-sharing contract, the supplier invests in R&D activities so that the green product can be introduced into market in the second stage. In the second stage, the emerging supplier adjusts the wholesale price and the manufacturer adjusts the selling price according to the innovative green product. One important assumption should be proposed to set up the model.

Assumption 1. *The emerging supplier goes bankrupt and gets liquidated unless it reaches a survival threshold (minimum profit level) of α at the end of each stage.*

The hypothesis is based on the fact that emerging suppliers are subject to financial constraints. First, the fragile capital chain is a well-known feature of emerging suppliers, so emerging suppliers might deeply depend on short-term bank loans, and regard it as a major source of external financing [36]. With these funds, emerging suppliers are able to hire employees, lease land, and organize production and product innovation. Emerging suppliers must first repay these debts after making a profit, otherwise they will go bankrupt and exit the industry [37]. Second, many high-tech emerging suppliers raise money from the market to support business operations. For these enterprises, reaching a certain profit target in each stage becomes an important indicator to judge whether it can obtain the next round financing from banks or venture capital institutions. As a target profit parameter, α is affected by many factors, such as market competition, wage levels, economies of scale, etc. [38]. The target value changes with different enterprises and development stages. For the sake of simplicity, this model assumes that α is given as a fixed exogenous parameter.

Specific event description and the timeline model of enterprise decision are demonstrated in Figure 1. Let $p_i, w_i, d_i, \pi_{Si}, \pi_{Mi}$ represent retail price, wholesale price, market demand, supplier profit and retailer profit in stage i ($i = 1, 2$), respectively.

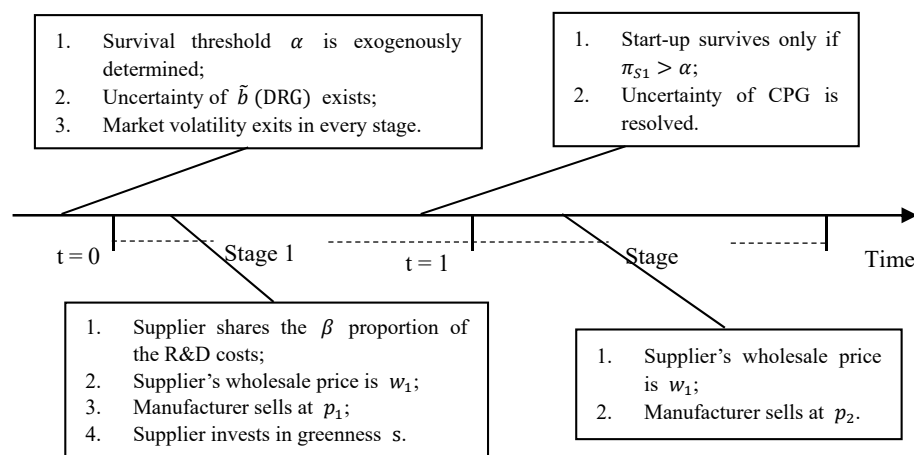


Figure 1. Sequence of events and decisions of the emerging supplier in a two-stage model.

Following Banker et al. [39], we treat the quality investing decision as a “demand-enhancing effort”, therefore impacts of price and quality on demand are denoted as $d_i = \theta_i - p_i + b_i s_i$, where a and b_i describe the demand responsiveness to price and consumers’ preference for greenness (CPG). The R&D cost for greenness s is set as ks^2 , and the coefficient k measures the complexity of the development process. Besides, unit production cost is simplified as zero (Research focuses on R&D-intensive green innovations such as plug-in electric vehicles, solar paper, and green products that are spawned by other emerging technologies. For R&D-intensive products, unit manufacturing costs are negligible compared to fixed R&D input costs, which explains the high gross margins of these industries.). Considering that emerging suppliers start with common products in the first stage, it can be assumed that $s_1 = 0$, $s_2 = s$. So the demand faced by the manufacturer in every stage can be written as $d_1 = \theta - p_1$ and $d_2 = \theta - p_2 + bs$. The analysis can be started from the basic case without demand uncertainties and incentive contracts.

The manufacturer’s profit can be written as follows:

$$\pi_M^* = \max_{p_1, p_2} (p_1 - w_1)(\theta - p_1) + (p_2 - w_2)(\theta - p_2 + bs) \quad (1)$$

The emerging supplier’s profit is:

$$\pi_S^* = \max_{w_1, s} w_1(\theta - p_1) - ks^2 + \pi_{S2}(s, b), \quad (2)$$

$$\text{s.t. } w_1(\theta - p_1) - ks^2 \geq \alpha, \quad (3)$$

where

$$\pi_{S2}(s, b) = \max_{w_2} w_2(\theta - p_2 + bs). \quad (4)$$

Inequality (3) indicates that emerging suppliers can survive through the first stage only if $\pi_{S1} \geq \alpha$.

3.1. Deterministic Environment

In the deterministic environment, as long as the emerging firm can achieve a profit above the survival threshold through the pricing strategy, it can completely avoid the bankruptcy risk. In this case, it only needs to maximize the profit of each stage. By backward induction, the optimal product price of the manufacturer at each stage is $p_1 = \frac{\theta + w_1}{2}$, $p_2 = \frac{\theta + w_2 + bs}{2}$. Anticipating the manufacturer's pricing strategy, suppliers optimize their wholesale price and greenness decisions. The emerging supplier's optimal green investment and profits under the deterministic environment are characterized in Proposition 1. (Proofs of all propositions can be seen in the Appendix A).

Proposition 1. *In a deterministic environment, emerging suppliers will maximize their profit levels by setting the optimal wholesale price $w_1^* = w_m = \theta/2$. The optimal greenness s^* and the profit level π_S^* are described as follows:*

$$s^* = \begin{cases} s_n & \text{if } \Delta_0 \leq 0 \text{ and } 8k > b^2 \\ s_m & \text{o/w} \end{cases}, \quad (5)$$

$$\pi_S^* = \begin{cases} \frac{\theta^2(b^2 - 16k)}{8b^2 - 64k} & \text{if } \Delta_0 \leq 0 \text{ and } 8k > b^2 \\ \alpha + \frac{(\theta - ac + bs_m)^2}{4a} & \text{o/w} \end{cases}. \quad (6)$$

where $s_n = \frac{b\theta}{8k - b^2}$ is the optimal greenness without financial constraint, $s_m = \sqrt{\frac{1}{k}(\frac{\theta^2}{8} - \alpha)}$ is the maximum greenness when the financial constraint is binding, that is, all the profits in the first stage above the survival threshold will be invested in green innovation. And $\Delta_0 = \alpha - \frac{\theta^2(b^4 - 24b^2k + 64k^2)}{8*(b^2 - 8k)^2}$.

Proposition 1 indicates that the supplier function is concave on wholesale price, and the profit of the first stage can be maximized by the wholesale price w_{m1} .

Δ_0 , as a condition of greenness segmentation, can be used to judge the motivations of emerging suppliers for green innovation. Note that $\Delta_0 \geq 0 \Leftrightarrow s_m \leq s_n$. If $\Delta_0 < 0$, the green products are not attractive enough to consumers, and the supplier can obtain the largest profit π_S^* by positioning small greenness s_n . The surplus profit in the first stage is enough to support the small green investment. However, when CPG is gradually increasing and $\Delta_0 \geq 0$ happens, green innovation becomes so attractive that the supplier keeps enhancing the investment until the surplus profit runs out. Then, it will invest in the maximum greenness s_m . Parametric analysis of Δ_0 demonstrates that the emerging supplier reduces green investment as the innovation difficulty (k) increases, and increases green investment as CPG (b) increases. Besides, the expansion of market size (θ) weakens the supplier's enthusiasm for green investment because it weakens the positive effect of green innovation on market improvement. Last, the supplier will also reduce its green investment if the survival threshold (α) increases, because it must allocate more cash flow for the debt repayment.

3.2. Uncertainty of CPG

Thus far, it is assumed that green innovation improves the future market share by a deterministic amount. However, the failure of many business cases is attributed to the lack of estimates of consumers' preferences. Some innovative products are considered popular in design, but they are actually not attractive. For example, Nokia used to be a giant in the mobile phone industry, with a variety of products, including straight, flip, slider, screw cap, full keyboard and so on. However, when the iPhone

began to lead the era of smart phones, Nokia still obsessed with the changes in the shape of the mobile phone, even the solid degree, and eventually it gradually withdrew from the market. For green cars, they are most likely not being paid by the market because of short battery life, inconvenient charging and fast depreciation. Tesla is leading a wave of electric vehicles through a series of technological innovations, but the investment returns of the newest green technologies are inherently uncertain. Therefore, it is assumed that for every dollar invested, the second-stage demand is improved by a random amount \tilde{b} , with a known distribution function, $\psi(\tilde{b})$, with a mean of b and variance of σ^2 .

Compared with the model expressions in the deterministic environmental, relevant values in the environment with uncertain CPG are represented by the following label “ u ”. So, the operational decisions and profits of the emerging supplier can be provided as:

Proposition 2. When CPG is a random variable, the optimal pricing for the first stage of the emerging supplier is still $w_1^* = w_m = \theta/2$. Besides, the optimal greenness and maximum expected profit are described as follows:

$$s^* = \begin{cases} s_u & \text{if } \Delta_u \leq 0 \text{ and } 8k > b^2 + \sigma^2 \\ s_m & \text{o/w} \end{cases}, \quad (7)$$

$$\pi_{su}^* = \begin{cases} \frac{\theta^2(b^2+2\sigma^2-16k)}{8b^2+8\sigma^2-64k} & \text{if } \Delta_u \leq 0 \text{ and } 8k > b^2 + \sigma^2 \\ \alpha + \frac{(b^2+\sigma^2)s_m^2+2b\theta s_m+\theta^2}{8} & \text{o/w} \end{cases}. \quad (8)$$

Here, $s_u = \frac{b\theta}{8k-b^2-\sigma^2}$ is the optimal greenness without financial constraints, and $\Delta_u = \alpha - \frac{\theta^2[b^4+(2\sigma^2-24k)b^2+(8k-\sigma^2)^2]}{8(b^2+\sigma^2-8k)^2}$.

As $\Delta_u \geq 0 \iff s_u \geq s_m$, the increase of Δ_u also represents the emerging supplier's willingness to make green investment. the supplier will invest all surplus profit if $\Delta_u \geq 0$. Proof of Proposition 2 shows that $\Delta_u - \Delta_0 = \frac{(16k-2b^2-\sigma^2) \cdot k\theta^2 b^2 \sigma^2}{(b^2-8k)^2 \cdot (b^2+\sigma^2-8k)^2}$, as $8k > b^2 + \sigma^2$, it can be known that $\Delta_u - \Delta_0 > 0$. That is, with the uncertainty of CPG, green innovation becomes more attractive to the supplier. Particularly, $s_u > s_m$ and $\pi_u^* \geq \pi_0^*$ represent that, with only uncertain CPG, the supplier will position higher greenness and obtain a higher expected profit at the same time.

3.3. Investment-Sharing Contract

It is considered that the investment-sharing contract could help innovative technology increase speed, dissemination and coverage, reduce entry barriers and mitigate investment risk [40]. Investment-sharing contracts are widely used to coordinate the innovation-intensive industries effectively [41]. For example, Daimler invested €100 million to TAAP in Thailand to support the development of its electric cars, and Volkswagen invested €20 billion to CATL in China for battery improvement.

With an investment-sharing contract, the manufacturer agrees with the emerging supplier that the supplier only afford the investment ratio “ β ”. As β decreases, the emerging supplier suffers less burden of green innovation, which then provides it an incentive to position higher greenness.

In the deterministic environment, manufacturer's total profit is:

$$\pi_M^* = \max_{p_1, p_2} (p_1 - w_1)(\theta - p_1) - (1 - \beta)ks^2 + (p_2 - w_2)(\theta - p_2 + bs) \quad (9)$$

Supplier's total profit is:

$$\pi_S^* = \max_{w_1, s} w_1(\theta - p_1) - \beta ks^2 + \max_{w_2} w_2(\theta - p_2 + bs), \quad (10)$$

$$\text{s.t. } w_1(\theta - p_1) - \beta ks^2 \geq \alpha, \quad (11)$$

Let subscript “ β ” indicates relevant parameters under the investment sharing-contracts. According to the proof of Proposition 1, the supplier’s optimal wholesale price remains unchanged, $w_{\beta m} = w_m$. Optimal greenness can be expressed as:

$$s_{\beta}^* = \begin{cases} s_{\beta n} & \text{if } \Delta_{0\beta} \leq 0 \text{ and } 8\beta k > b^2 \\ s_{\beta m} & \text{o/w} \end{cases}, \quad (12)$$

where, $s_{\beta n} = \frac{b\theta}{8\beta k - b^2}$, $s_{\beta m} = \sqrt{\frac{1}{\beta k}(\frac{\theta^2}{8} - \alpha)}$, and $\Delta_{0\beta} = \alpha - \frac{\theta^2(b^4 - 24b^2\beta k + 64\beta^2 k^2)}{8*(b^2 - 8\beta k)^2}$.

Further results can be listed as:

$$\pi_M^* = \begin{cases} \frac{\theta^2(128\beta^2 k^2 - 16kb^2 + b^4)}{16(8\beta k - b^2)^2} & \text{if } \Delta_{0\beta} \leq 0 \text{ and } 8\beta k > b^2 \\ \frac{b\theta}{16} \cdot \sqrt{\frac{\theta^2 - 8\alpha}{2\beta k}} + \frac{b^2(\theta^2 - 8\alpha)}{128\beta k} + \frac{\theta^2 - 4\alpha}{4} - \frac{\theta^2 - 8\alpha}{8\beta} & \text{o/w} \end{cases}, \quad (13)$$

$$\beta^* = \begin{cases} 1 - \frac{b^2}{16k} & \text{if } \Delta_{0\beta} \leq 0 \text{ and } 8\beta k > b^2 \\ \frac{(\theta^2 - 8\alpha)(16k - b^2)^2}{8\theta^2 b^2 k} & \text{o/w} \end{cases}. \quad (14)$$

It can be seen from Equation (12) that, in the deterministic environment, the impact of the investment-sharing contract on the supplier is generally reflected in reducing the effect of R&D coefficient k . The overall green technology innovation and willingness of suppliers will increase as the difficulty of R&D decreases. However, excessive R&D sharing will reduce the manufacturer’s own profits, therefore if considering the manufacturer’s own profits, there is an optimal contract ratio, as shown in Equation (14).

By monotonic analysis of β^* , it can be found that regardless of the range in which β^* is taken, it monotonically increases with k , and monotonically decreases with b . That is, the higher the difficulty of green technology R&D is, the less manufacturers are willing to take R&D. Only when the potential return of green products is high, manufacturers are willing to increase R&D support. On the other hand, if the financial constraints are strong, manufacturers are more willing to increase their support.

4. Supply Chain Cooperation in a Completely Stochastic Environment

In this section, by introducing the market volatilities, we examine the implications of totally stochastic demand for the supply chain cooperation. The deterministic survival requirement of the basic case is replaced with a probabilistic survival constraint. By a stochastic model, Section 4.1 derives the supplier’s wholesale price and greenness decisions. These derived decisions are also influenced by demand uncertainties, survival threshold, and investment-sharing proportion. However, given both uncertain CPG and market volatilities, the stochastic model is not analytically tractable, so we resort to numerical analysis in Section 4.2.

4.1. The Model with Uncertain CPG and Market Volatilities

Consider that a random volatility $\tilde{\varepsilon}_t$ (mean is 0 and variance is v^2). exists in the market at the beginning of each operation stage, where t ($t = 1, 2$) is the operational stage. The probability density of this volatility is $\omega(\cdot)$ and obeys the distribution function $\vartheta(\cdot)$. It is assumed that volatilities in two stages are independent and are symmetrically distributed. The manufacturer needs to set the optimal investment-sharing proportion and selling pricing to optimize the total profit:

$$E\pi_M^* = \max_{p_1, \beta \geq 0} E_{\tilde{\varepsilon}_1} \{ (p_1 - w_1)(\theta + \tilde{\varepsilon}_1 - p_1) - (1 - \beta)ks^2 \} + E_{\tilde{\varepsilon}_1, \tilde{b}} \pi_{M2}(\beta; \tilde{\varepsilon}_1, \tilde{b}), \quad (15)$$

where

$$\pi_{M2}(\beta; \tilde{\varepsilon}_1, \tilde{b}) = \max_{p_2} E_{\tilde{\varepsilon}_2} \{ (p_2 - w_2)(\theta + \tilde{\varepsilon}_2 + \tilde{b}s - p_2) \}. \quad (16)$$

As $\tilde{\varepsilon}_2$ doesn't influence the pricing decision of the second stage, $p_2 = \frac{\theta + w_2 + \tilde{b}s}{2}$. Meanwhile, it can be obtained that $p_1 = \frac{\theta + w_1}{2}$. The profit for the emerging supplier is:

$$E\pi_S^* = \max_{w_1, s \geq 0} E_{\tilde{\varepsilon}_1} \{ w_1(\theta + \tilde{\varepsilon}_1 - p_1) - \beta ks^2 \} + E_{\tilde{\varepsilon}_1, \tilde{b}} \pi_{S2}(s; \tilde{\varepsilon}_1, \tilde{b}), \quad (17)$$

$$\text{s.t.} \quad \pi_{S1}(\tilde{\varepsilon}_1) - \alpha \geq 0. \quad (18)$$

$$\pi_{S2}(s; \tilde{\varepsilon}_1, \tilde{b}) = \max_{w_2} E_{\tilde{\varepsilon}_2} \{ w_2(\theta + \tilde{\varepsilon}_2 + \tilde{b}s - p_2) \}. \quad (19)$$

Supplier's expected profit can be further simplified as:

$$E\pi_S^* = \max_{w_1, s \geq 0} E_{\tilde{\varepsilon}_1} \left\{ \frac{w_1(\theta + 2\tilde{\varepsilon}_1 - w_1)}{2} - \beta ks^2 \right\} + E_{\tilde{\varepsilon}_1, \tilde{b}} \left\{ \frac{(\theta + \tilde{b}s)^2}{8} | \pi_{S1}(\tilde{\varepsilon}_1) \geq \alpha \right\}. \quad (20)$$

Adopting w^* and s^* to describe the optimal wholesale price and greenness positioning of the supplier in the first stage, the following proposition can be obtained:

Proposition 3. Compare with the deterministic environment, with both uncertain CPG and market volatility, if the emerging supplier increases (decreases) the greenness (i.e., $s^* \geq s_{\beta m}$ ($s^* \leq s_{\beta m}$)), he will increase (decrease) the wholesale price (i.e., $w^* \geq w_{\beta m}$ ($w^* \leq w_{\beta m}$)).

The survival probability of emerging supplier in the first stage is $F(\pi_{S1} \geq \alpha) = 1 - \Phi_{\tilde{\varepsilon}_1} \left[\frac{(\beta ks^2 + \alpha)/w + (w - \theta)/2}{\sigma_{\tilde{\varepsilon}_1}} \right]$. This is also the probability that the supply chain will continue to cooperate in the second stage. It can be found that if the market volatility $\tilde{\varepsilon}_1$ obeys a symmetric distribution, the survival probability based on the operational decisions in the deterministic environment (w_m, s_m) is exactly 0.5, so joint operational decisions (w_m, s_m) can be taken as a benchmark for the adjustment of operational decisions in the stochastic environment. The supplier survives with a probability of less (more) than 0.5 if $q^* \geq q_m$ ($q^* \leq q_m$) and $p^* \geq p_m$ ($p^* \leq p_m$). Obviously, the risk of operational decisions increases if the survival probability decreases. Therefore, decisions in cases where the survival probability is greater than (less than) 0.5 can be considered as conservative (radical) strategies.

Proposition 3 shows that the correlation between supplier's wholesale price and product greenness in the completely uncertain market. If the potential return of green products is high, the supplier will adopt a radical innovation strategy $s^* \geq s_{\beta m}$, at the same time, he will also increase the wholesale price of the product $w^* \geq w_{\beta m}$ to provide sufficient cash flow for green innovation. In contrast, if the potential return of green products is low, the supplier will adopt a conservative strategy $s^* \leq s_{\beta m}$, and reduce the wholesale price $w^* \leq w_{\beta m}$ to ensure a stable wholesale volume.

4.2. Computational Analysis

In this section, considering the uncertain CPG and market volatility, a set of numerical analyses are conducted to characterize the optimal wholesale price and greenness investment for the emerging supplier. In our numerical analysis, survival probability of the emerging supplier, an endogenous variable determined by the supplier's operational decisions, is used to measure risks exposed in its operational decisions and measure the sustainability of the green investment cooperation.

To prepare for the analysis, manufacturer's expected profit is formulated:

$$\pi_M^* = \max_{\beta} \left[\frac{(\theta - w)^2}{4} - (1 - \beta)ks^2 \right] + E_{\tilde{\varepsilon}_1, \tilde{b}} \left\{ \frac{(\theta + \tilde{b}s)^2}{16} \mid \pi_{S1}(\tilde{\varepsilon}_1) \geq \alpha \right\}. \quad (21)$$

It can be simplified as

$$\pi_M^* = \frac{(\theta - w)^2}{4} - (1 - \beta)ks^2 + \frac{(\theta + bs)^2 + \sigma^2 s^2}{16} \cdot \left(1 - \Phi \left(\frac{\beta ks^2 + \alpha}{w} + \frac{w - \theta}{2} \right) \right). \quad (22)$$

Supplier's expected profit can be simplified by Equation (20):

$$\pi_S^* = \max_{w, s \geq 0} \left\{ \frac{w(\theta - w)}{2} - \beta ks^2 + \frac{(\theta + bs)^2 + \sigma^2 s^2}{8} \left(1 - \Phi \left(\frac{\beta ks^2 + \alpha}{w} + \frac{w - \theta}{2} \right) \right) \right\}. \quad (23)$$

Here, supplier's bankruptcy probability just represents the sustainability of the green chain supply cooperation, $F = 1 - \Phi \left(\frac{\beta ks^2 + \alpha}{w} + \frac{w - \theta}{2} \right)$.

It is assumed that the potential market size θ and quality innovation R&D difficulty coefficient are constant ($\theta = 6, k = 1$) throughout the numerical analysis. Unless otherwise stated, we set $b = 3.3, \alpha = 4, \sigma = 1$ and $v = 1$. At the same time, it is assumed that the market volatilities obey the normal distribution. Impacts of CPG (\tilde{b}), survival threshold (α), and investment-sharing proportion (β) are studied respectively, so allied variables b, σ, α and β are continuously varying within reasonable ranges. It should be noted that even though a set of representative results are selected and presented, we have also examined and confirmed similar results with a wider range of parameters, selected from the following sets of data: $k \in \{0.2, 0.4, 0.6, 0.8, 1\}$, $v \in \{0, 0.3, 0.6, 0.9, 1.2\}$, and $\alpha \in \{1, 2, 3, 4, 5\}$.

(1) Uncertain CPG

On the one hand, how the mean of CPG influences the emerging supplier's operating strategies and cooperation sustainability is shown in Figure 2. Compared with the operational decisions in the deterministic environment (w_m, s_m), supplier's optimal wholesale price and greenness go through a process from conservatism to radicalism in the completely uncertain environment. Unlike the segmentation function feature in the deterministic environment, the operational decisions are continuously changing in the completely uncertain environment. Similar results are also found by Zhu and He (2017), that the higher CPG, driven by profits, the higher product greenness the enterprise would invest in and the higher product price it would set to cover increased green investments.

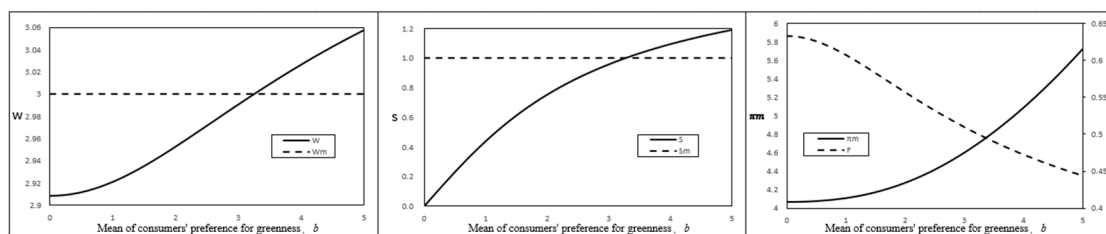


Figure 2. Impacts of b on the optimal operational decisions and cooperation sustainability ($\alpha = 4$).

In particular, when $b = 3.25$, the supplier's strategy is the same with the strategy in the deterministic environment, and when $b \geq 3.25$, the operational strategy will change from conservative to radical. That is, as CPG increases, manufacturers and suppliers will seize the opportunity of the market to pursue higher profits, leading to radical strategies that threaten the sustainability of supply chain cooperation. The cooperation between suppliers and manufacturers has an increasing probability to end in the first stage.

On the other hand, how the uncertainty of CPG influences the supplier's operating decisions and cooperation sustainability is shown in Figure 3. Recall that the uncertainty of CPG will promote emerging suppliers to improve the green innovation of their products, as demonstrated in Proposition 2. Figure 3 confirms this positive effect. Actually, the uncertainty of CPG not only increases the supplier's expected profit, but also increase the manufacturer's expected profit. However, allocating large cash flow on green investment will also make the cooperation of green supply chain more fragile.

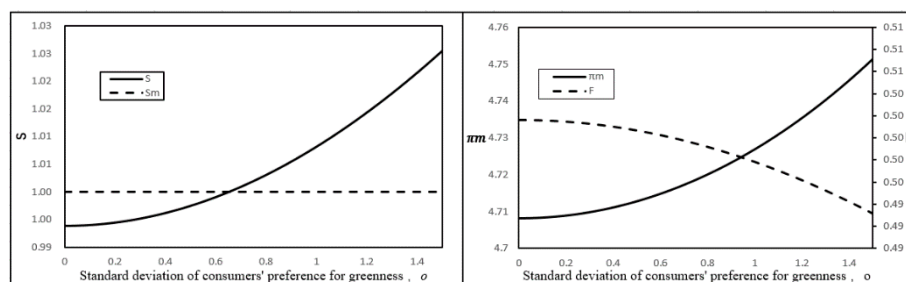


Figure 3. Impact of σ on the optimal green innovation and cooperation sustainability ($\alpha = 4$).

(2) Survival Threshold

Because of the survival thresholds, the production operations of emerging suppliers are subject to financial constraints. Figure 4 depicts that financial constraints can inhibit suppliers' investment in green innovation. As survival threshold increases, the green investment under stochastic environment reduces much slower than that under deterministic environment. This is because that suppliers want to pursue higher returns in a risky environment. Of course, financial constraints will inevitably reduce the profits of both corporations as they limit the resource allocation of enterprises. What's more, the supplier's operation risk will greatly increase and the cooperation has a higher probability to end in the first stage.

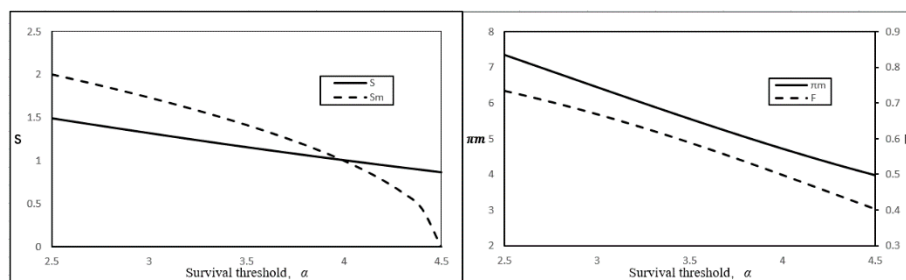


Figure 4. Impacts of α on the optimal operational decisions and cooperation sustainability ($b = 3.3$).

(3) Investment-sharing proportion

The investment-sharing proportion β measures the level that emerging supplier bears the green investment. It is easily understood that the more the supplier affords, the less motivations for green innovation it has. So that the green innovation is monotonously weakened as the investment sharing ratio increases, which shows in Figure 5. However, change of the supplier's wholesale price does not present such monotonicity. It is determined by two competing forces: (1) the emerging supplier's demand for cash flow is also reducing. (2) the increasing proportion that the suppliers bear the investment challenges the supplier's cash flow. Finally, the supplier's wholesale price increases first and then decreases with the increasing investment-sharing proportion. Figure 5 also describes that even the supplier reduces its green investment give lesser support from manufacturer, its conservative strategy allows him a higher survival chance, which makes the cooperation more sustainable.

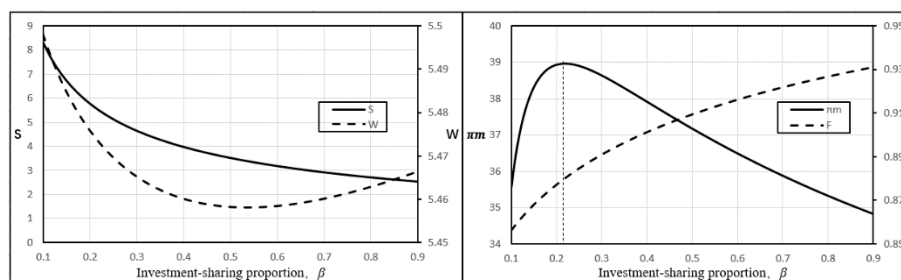


Figure 5. Impacts of β on the optimal operational decisions and cooperation sustainability ($b = 3.3$).

The optimal investment-sharing proportion β^* deserves further discussion. It is also determined by two competing forces. On the one hand, as the investment-sharing proportion increases, the supplier reduces its green investment. Lower product greenness leads to lower revenue of the manufacturer. On the other hand, lower investment also means larger cash flow for supplier, which means larger cooperation sustainability. Therefore, the manufacturer can obtain larger expected sustainable profit if the emerging supplier survives into the second stage. Thus, positive impact of the increasing sustainability and negative impact of the decreasing greenness jointly determine that the optimal investment-sharing proportion is about $\beta^* \approx 0.22$.

5. Conclusions

Choosing a proper contract to stimulate green innovation of the finance-constrained emerging supplier is an important issue in green supply chain. Referring to the problem, this study constructs a two-stage model to analyze the greenness decisions and the cooperation sustainability in green supply chain under the influence of uncertain CPG, survival threshold, market volatility and investment-sharing contract. This paper first provides operational decisions in the deterministic environment as benchmark. Second, uncertainty of CPG and investment-sharing contract are sequentially introduced. Last, to make our research much more applicable to real life, market volatility is also considered and operational decisions are studied in a totally stochastic environment by both model derivation and numerical analysis.

Our results reveal how the finance-constrained emerging supplier coordinates wholesale price and greenness decisions to against the bankruptcy risk and achieve sustainable cooperation with the manufacturer. In detail, given only the uncertain CPG, the supplier is more willing to invest in product greenness than that in the deterministic environment. Further, given both uncertain CPG and market volatility, compared with the benchmark operational decisions in the deterministic environment, the supplier would improve (or reduce) the wholesale price and product greenness at the same time. Numerical analysis also elaborates that these strategies are also influenced by survival threshold and investment-sharing proportion.

In practice, like the “green supply chain project” launched by GM, the cooperation for green innovation is often initiated by large downstream manufacturers. The manufacturer has the initiative to promote green innovation and realizes it mainly through incentive contracts. This paper demonstrates that when the supplier faces strong financial constraints, the manufacturer is more willing to increase its financial support to the supplier. When the manufacturer determines the specific investment-sharing proportion, it must realize the core impact of the supplier’s financial constraints on green supply chain: the improvement of the participants’ profits originated from green innovation is at the expense of the increase of the supplier’s bankruptcy risk, which also means the decrease of the manufacturer’s sustainable profit.

What’s more, even though Equation (14) and Figure 5 determine the optimal investment-sharing proportion from the perspective of profit maximization, profit is not always the only target of the manufacturer. Especially with some encouraging policies, manufacturers may sacrifice some profits to improve the product greenness. In this way, the optimal investment-sharing proportion in Figure 5

will be in the range of $\beta < 0.22$, in other words, the manufacturer will improve its funding to support the supplier's green innovation.

Finally, this study also has some limitations which deserve further research. First, it is assumed that the improvement of product greenness mainly originates from the fixed investment such as R&D innovation activities in the early stage, which mainly applies to green products with disruptive innovation, such as electric vehicles. However, conventional vehicles can also achieve certain environmental protection effects by adding exhaust gas purification equipment. The total cost for the green attribute in this product mainly falls on the variable cost and is closely related to output. Future research can focus on how the green supply chain coordination changes under this cost structure. Second, although symmetrical distributions like normal distribution are taken as classic assumptions for the uncertainty of DRQ and market shocks in the literature and used in our research, some other asymmetrical distributions should also be examined because they may affect the monotonicity of functions shown in the figures. Last, even though some anecdotal evidences regarding start-ups' quality investment decisions have been provided in the introduction and the literature review, further empirical study referring to our numerical results will strengthen the validity of our findings.

Author Contributions: Conceptualization, B.X., J.G. and G.X.; Methodology, B.X.; Software, B.X.; Validation, J.G.; Numerical analysis, B.X. and J.G.; Writing—original draft preparation, G.X.; Writing—review and editing, B.X.; Supervision, J.G.; Project administration, G.X. and J.G.; Funding acquisition, G.X.

Funding: National Science Foundation of China (Grant No. 71904153).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Proof of Proposition 1.

$$\pi_{S2}(s, b) = \max_{w_2} w_2(\theta - p_2 + bs)$$

$$s.t. w_1(\theta - p_1) - ks^2 \geq \alpha.$$

We find that $w_2 = \frac{\theta + bs}{2}$ and $\pi_{S2}^*(s, b) = \frac{(\theta + bs)^2}{8}$. Therefore, the supplier's profit can be restated as follows: $\pi_S^* = \max_{w_1, s} w_1(\theta - p_1) - ks^2 + \frac{(\theta + bs)^2}{8}$. Because the total profit of the first stage is dependent to p_1 and s , the expression can be written as: $\pi_S^* = \max_{w_1, s} f(w_1) + g(s)$, where $f(w_1) = \frac{w_1(\theta - w_1)}{2}$ and $g(s) = -ks^2 + \frac{(\theta + bs)^2}{8} = \frac{(b^2 - 8k)s^2 + 2b\theta s + \theta^2}{8}$. Given that the profit of the first stage $f(w_1) = \frac{w_1(\theta - w_1)}{2}$ is concave, then the profit can be maximized by setting $w_1^* = \frac{\theta}{2}$. Therefore the upper bound of the investment on green technology in the first stage is $\pi_m - \alpha$, where $\pi_m = \frac{\theta^2}{8}$, and $s_m = \sqrt{\frac{1}{k}(\frac{\theta^2}{8} - \alpha)}$. However, the discussion on $g(s)$ is complex.

The relationship between $8k$ and b^2 should be analyzed. It can be found that $g(s)$ is concave if $8k > b^2$, convex if $8k < b^2$, and linearly increasing otherwise.

If $g(s)$ is concave. The supplier obtains the maximized value $s_n = \frac{b\theta}{8k - b^2}$ by greenness when $s_n < s_m$, which equates to $\Delta_0 = \alpha - \frac{\theta^2(b^4 - 24b^2k + 64k^2)}{8*(b^2 - 8k)^2} < 0$. $\Delta_0 - \alpha < \Delta_0 \leq 0$, means that $b^2 < 12k - 4\sqrt{5}k$ or $b^2 > 12k + 4\sqrt{5}k$ (the latter does not exist because $8k > b^2$). Otherwise, if $\Delta_0 > 0$ and $8k > b^2$, this expression obtains the maximized profit by greenness $s^* = s_m = \sqrt{\frac{1}{k}(\frac{\theta^2}{8} - \alpha)}$.

If $g(s)$ is convex, the optimal investment is a boundary solution, and it can be obtained by evaluating the $g(s)$ function for values of 0 and s_m . Specifically, $g(s_m) = -ks_m^2 + \frac{(\theta + bs_m)^2}{8}$ and $g(0) = \frac{\theta^2}{8}$. Because $g(s_m) - g(0) = \frac{(b^2 - 8k)s_m^2 + 2abs_m}{8}$ and $b^2 > 8k$, it can be proved that $g(s_m) > g(0)$. The supplier will position the greenness s_m .

Finally, if $b^2 = 8k$, the supplier can obtain the maximized profit $g(s_m) = -ks_m^2 + \frac{(\theta + bs_m)^2}{8}$ by s_m . Therefore, Proposition 1 is supported. \square

Proof of Proposition 2. Given the stochastic variable \tilde{b} , $f(w_1) = \frac{w_1(\theta-w_1)}{2}$ remains unchanged, and $g(s) = -ks^2 + \int \frac{(\theta+\tilde{b}s)^2}{8} \psi(\tilde{b}) d\tilde{b}$. Following developments in the proof of Proposition 1, Proposition 2 can be proved. \square

Proof of Proposition 3. For the manufacturer

$$\pi_M^* = \max_{p_1 \geq 0} E_{\tilde{\varepsilon}_1} \{ (p_1 - w_1)(\theta + \tilde{\varepsilon}_1 - p_1) - (1 - \beta)ks^2 \} + E_{\tilde{\varepsilon}_1, \tilde{b}} \pi_2(\beta; \tilde{\varepsilon}_1, \tilde{b}),$$

where $\pi_{M2}(\beta; \tilde{\varepsilon}_1, \tilde{b}) = \max_{p_2} E_{\tilde{\varepsilon}_2} \{ (p_2 - w_2)(\theta + \tilde{\varepsilon}_2 + \tilde{b} - p_2) \}$.

For the supplier

$$\pi_S^* = \max_{w_1, s \geq 0} E_{\tilde{\varepsilon}_1} \{ w_1(\theta + \tilde{\varepsilon}_1 - p_1) - \beta ks^2 \} + E_{\tilde{\varepsilon}_1, \tilde{b}} \pi_2(s; \tilde{\varepsilon}_1, \tilde{b}).$$

The manufacturer's profit in the second stage can be written as $\pi_{M2}(\beta; \tilde{\varepsilon}_1, \tilde{b}) = \max_{p_2} E_{\tilde{\varepsilon}_2} \{ (p_2 - w_2)(\theta + \tilde{b} - p_2) \}$, then $p_2 = \frac{\theta + w_2 + \tilde{b}s}{2}$, and $p_1 = \frac{\theta + w_1}{2}$. By substituting it into the supplier's profit function, π_S^* can be restated as

$$\pi_S^* = \max_{w_1, s \geq 0} E_{\tilde{\varepsilon}_1} \left\{ \frac{w_1(\theta + 2\tilde{\varepsilon}_1 - w_1)}{2} - \beta ks^2 \right\} + E_{\tilde{\varepsilon}_1, \tilde{b}} \left\{ \frac{(\theta + \tilde{b}s)^2}{8} | \pi_{S1}(\tilde{\varepsilon}_1) \geq \alpha \right\}.$$

Write w_1 as w , supplier's profit can be further simplified,

$$\begin{aligned} \pi_S^* &= \max_{w, s \geq 0} \{ E_{\tilde{\varepsilon}_1} \left\{ \frac{w(\theta + 2\tilde{\varepsilon}_1 - w)}{2} - \beta ks^2 \right\} + \int_G \int_0^\infty \frac{(\theta + \tilde{b}s)^2}{8} \psi(\tilde{b}) w(\tilde{\varepsilon}_1) d\tilde{b} d\tilde{\varepsilon}_1 \} \\ \pi_S^* &= \max_{w, s \geq 0} \left\{ \frac{w(\theta - w)}{2} - \beta ks^2 + \int_G \int_0^\infty \frac{(\theta + \tilde{b}s)^2}{8} \psi(\tilde{b}) w(\tilde{\varepsilon}_1) d\tilde{b} d\tilde{\varepsilon}_1 \right\} \\ \pi_S^* &= \max_{w, s \geq 0} \left\{ \frac{w(\theta - w)}{2} - \beta ks^2 + \frac{(\theta + bs)^2 + \sigma^2 s^2}{8} \left(1 - \Phi \left(\frac{2(\beta ks^2 + \alpha)}{w} + w - \theta \right) \right) \right\}. \end{aligned}$$

where $G = \{ \theta | \pi_{S1}(\tilde{\varepsilon}_1) \geq \alpha \}$. At the optimality, the following equation holds:

$$\frac{\partial \pi_S^*}{\partial w} = \frac{\theta - 2w}{2} - \frac{(\theta + bs)^2 + \sigma^2 s^2}{8} \cdot \Phi \left(\frac{2(\beta ks^2 + \alpha)}{w} + w - \theta \right) \cdot \left(1 - \frac{2(\beta ks^2 + \alpha)}{w^2} \right) = 0.$$

Under the investment sharing cooperation $w_{\beta m} = \theta/2$, $s_{\beta m} = \sqrt{\frac{1}{\beta k} \left(\frac{\theta^2}{8} - \alpha \right)}$.

Note that $\frac{\partial \pi_S^*}{\partial w} \Big|_{w \rightarrow 0} > 0$, $\frac{\partial \pi_S^*}{\partial w} \Big|_{w \rightarrow \infty} < 0$ and $\frac{\partial \pi_S^*}{\partial w}$ is continuous. So $w^* > w_{\beta m} \Leftrightarrow 1 - \frac{2(\beta ks^2 + \alpha)}{w^2} < 0 \Leftrightarrow s^* > s_{\beta m}$, and $w^* < w_{\beta m} \Leftrightarrow 1 - \frac{2(\beta ks^2 + \alpha)}{w^2} > 0 \Leftrightarrow s^* < s_m$. \square

Appendix B

To help readers check the exact values of the represented models, we supplement the figures with numerical data by tables.

Table A1. Numerical Data of Figure 2.

b	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50
w	2.91	2.92	2.94	2.95	2.97	2.99	3.01	3.03	3.04
s	0.23	0.44	0.62	0.76	0.87	0.96	1.04	1.10	1.15
F	0.63	0.61	0.58	0.56	0.53	0.51	0.49	0.47	0.46
π_m	4.07	4.11	4.17	4.25	4.41	4.60	4.82	5.08	5.38

Table A2. Numerical Data of Figure 3.

b	0.15	0.30	0.45	0.60	0.75	0.9	1.05	1.20	1.35
s	0.9942	0.9951	0.9968	0.9990	1.0020	1.0055	1.0096	1.0144	1.0197
F	0.5016	0.5013	0.5009	0.5003	0.4995	0.4985	0.4974	0.4961	0.4947
π_m	4.7086	4.7099	4.712	4.7149	4.7187	4.7234	4.7290	4.7355	4.7430

Table A3. Numerical Data of Figure 4.

α	2.50	2.80	3.1	3.4	3.7	4.0	4.3	4.5
s	1.49	1.39	1.29	1.19	1.10	1.01	0.92	0.87
F	0.73	0.70	0.65	0.61	0.55	0.50	0.44	0.40
π_m	7.34	6.80	6.26	5.73	5.22	4.73	4.27	3.99

Table A4. Numerical Data of Figure 5.

β	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
w	5.50	5.48	5.47	5.46	5.46	5.46	5.46	5.46	5.47
s	8.34	5.78	4.65	3.98	3.52	3.18	2.92	2.71	2.54
F	0.86	0.88	0.89	0.90	0.91	0.92	0.92	0.93	0.93
π_m	35.52	38.94	38.64	37.91	37.17	36.49	35.87	35.32	34.82

References

1. Dangelico, R.M.; Pontrandolfo, P. From green product definitions and classifications to the Green Option Matrix. *J. Clean. Prod.* **2010**, *18*, 1608–1628. [CrossRef]
2. Golden, J.S.; Subramanian, V.; Zimmerman, J.B. Sustainability and commerce trends: Industry consortia as the drivers for green product design. *J. Ind. Ecol.* **2011**, *15*, 821–824. [CrossRef]
3. Pan, F.; Xi, B.; Wang, L. Analysis on environmental regulation strategy of local government based on evolutionary game theory. *Syst. Eng. Theory Pract.* **2015**, *35*, 1393–1404.
4. Wati, Y.; Koo, C. The green IT practices of Nokia, Samsung, Sony, and Sony Ericsson: Content analysis approach. In Proceedings of the 2010 43rd Hawaii International Conference on System Sciences, Honolulu, HI, USA, 5–8 January 2010; pp. 1–10.
5. Liu, M. Study on the Core Manufacture's Supplier Selection and Coordination Strategy in Green Supply Chain. Master's Thesis, Southwest Jiaotong University, Chengdu, China, 2010. (In Chinese)
6. Tencent Technology. Tesla Faces a Deep Supply Chain Crisis Some Suppliers are Filing for Bankruptcy. 2018. Available online: <http://tech.qq.com/a/20181022/012487.htm> (accessed on 9 August 2019).
7. Zhu, Q.; Sarkis, J. The moderating effects of institutional pressures on emergent green supply chain practices and performance. *Int. J. Prod. Res.* **2007**, *45*, 4333–4355. [CrossRef]
8. EPA. Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards; Technical Report; Environmental Protection Agency: Washington, DC, USA, 2014.
9. Reid, G.C. Complex actions and simple outcomes: How new entrepreneurs stay in business. *Small Bus. Econ.* **1999**, *13*, 303–315. [CrossRef]
10. Tencent Technology. Supply Chain is Disrupted: Crises Faced on Foxconn and Apple Inc. 2012. Available online: <http://tech.qq.com/a/20121019/000021.htm> (accessed on 10 August 2019).
11. Zheng, L. Explore the Cycle of “Applauding Well But not Selling Well” of Energy-Saving Products. 2011. Available online: <http://tech.163.com/11/0324/17/6VU712SH00093L13.html> (accessed on 8 August 2019).

12. Mathu, K. Green supply chain management: A precursor to green purchasing. In *Green Practices and Strategies in Supply Chain Management*; IntechOpen: London, UK, 2019.
13. Ashby, A.; Leat, M.; Hudson-Smith, M. Making connections: A review of supply chain management and sustainability literature. *Supply Chain Manag. Int. J.* **2012**, *17*, 497–516. [[CrossRef](#)]
14. Kara, S.; Ibbotson, S.; Kayis, B. Sustainable product development in practice: An international survey. *J. Manuf. Technol. Manag.* **2014**, *25*, 848–872. [[CrossRef](#)]
15. Wisner, J.D.; Tan, K.-C.; Leong, G.K. *Supply Chain Management: A Balanced Approach*; Thomson South-Western: Mason, OH, USA, 2012.
16. Feng, M.; Yu, W.; Wang, X.; Wong, C.Y.; Xu, M.; Xiao, Z. Green supply chain management and financial performance: The mediating roles of operational and environmental performance. *Bus. Strategy Environ.* **2018**, *27*, 811–824. [[CrossRef](#)]
17. Flammer, C. Corporate social responsibility and shareholder reaction: The environmental awareness of investors. *Acad. Manag. J.* **2013**, *56*, 758–781. [[CrossRef](#)]
18. Zhang, M.; Tse, Y.K.; Dai, J.; Chan, H.K. Examining green supply chain management and financial performance: Roles of social control and environmental dynamism. *IEEE Trans. Eng. Manag.* **2017**, *66*, 20–34. [[CrossRef](#)]
19. Chin, T.A.; Tat, H.H.; Sulaiman, Z. Green supply chain management, environmental collaboration and sustainability performance. *Procedia Cirp* **2015**, *26*, 695–699. [[CrossRef](#)]
20. Ghosh, D.; Shah, J. A comparative analysis of greening policies across supply chain structures. *Int. J. Prod. Econ.* **2012**, *135*, 568–583. [[CrossRef](#)]
21. Ghosh, D.; Shah, J. Supply chain analysis under green sensitive consumer demand and cost sharing contract. *Int. J. Prod. Econ.* **2015**, *164*, 319–329. [[CrossRef](#)]
22. Jacobs, B.W.; Subramanian, R. Sharing responsibility for product recovery across the supply chain. *Prod. Oper. Manag.* **2012**, *21*, 85–100. [[CrossRef](#)]
23. Swami, S.; Shah, J. Channel coordination in green supply chain management. *J. Oper. Res. Soc.* **2013**, *64*, 336–351. [[CrossRef](#)]
24. Zhang, C.T.; Liu, L.P. Research on coordination mechanism in three-level green supply chain under non-cooperative game. *Appl. Math. Model.* **2013**, *37*, 3369–3379. [[CrossRef](#)]
25. Zhu, W.; He, Y. Green product design in supply chains under competition. *Eur. J. Oper. Res.* **2017**, *258*, 165–180. [[CrossRef](#)]
26. Tanrısever, F.; Erzurumlu, S.S.; Joglekar, N. Production, process investment, and the survival of debt-financed startup firms. *Prod. Oper. Manag.* **2012**, *21*, 637–652. [[CrossRef](#)]
27. Joglekar, N.R.; Levesque, M. Marketing, R&D, and startup valuation. *IEEE Trans. Eng. Manag.* **2009**, *56*, 229.
28. Swinney, R.; Cachon, G.P.; Netessine, S. Capacity investment timing by start-ups and established firms in new markets. *Manag. Sci.* **2011**, *57*, 763–777. [[CrossRef](#)]
29. Yang, Z.J.; Luo, P.F. Optimal investment and financing with credit guarantee. *J. Syst. Eng.* **2017**, *32*, 233–240.
30. Babich, V. *Dealing with supplier bankruptcies: Costs and benefits of financial subsidies*; Working Paper; University of Michigan: Ann Arbor, MI, USA, 2007.
31. Cefis, E.; Marsili, O. A matter of life and death: Innovation and firm survival. *Ind. Corp. Chang.* **2005**, *14*, 1167–1192. [[CrossRef](#)]
32. Cefis, E.; Marsili, O. Survivor: The role of innovation in firms' survival. *Res. Policy* **2006**, *35*, 626–641. [[CrossRef](#)]
33. Criscuolo, P.; Nicolaou, N.; Salter, A. The elixir (or burden) of youth? Exploring differences in innovation between start-ups and established firms. *Res. Policy* **2012**, *41*, 319–333. [[CrossRef](#)]
34. Shane, S.A. *The Illusions of Entrepreneurship: The Costly Myths that Entrepreneurs, Investors, and Policy Makers Live by*; Yale University Press: New Haven, CT, USA, 2008.
35. Bhidé, A.V. *The Origin and Evolution of New Businesses*; Oxford University Press: Oxford, UK, 2003.
36. Gordini, N. A genetic algorithm approach for SMEs bankruptcy prediction: Empirical evidence from Italy. *Expert Syst. Appl.* **2014**, *41*, 6433–6445. [[CrossRef](#)]
37. Archibald, T.W.; Thomas, L.C.; Betts, J.M.; Johnston, R.B. Should start-up companies be cautious? Inventory policies which maximise survival probabilities. *Manag. Sci.* **2002**, *48*, 1161–1174. [[CrossRef](#)]
38. Wei, M.M.; Yao, T.; Jiang, B.; Young, S.T. Profit seeking vs. survival seeking: An analytical study of supplier's behavior and buyer's subsidy strategy. *Prod. Oper. Manag.* **2013**, *22*, 269–282. [[CrossRef](#)]
39. Banker, R.D.; Khosla, I.; Sinha, K.K. Quality and competition. *Manag. Sci.* **1998**, *44*, 1179–1192. [[CrossRef](#)]

40. Ribeiro, V.M. Exclusion and regulatory intervention in investment sharing agreements. *Telecommun. Policy* **2016**, *40*, 1032–1051. [[CrossRef](#)]
41. Chakraborty, T.; Chauhan, S.S.; Ouhimmou, M. Cost-sharing mechanism for product quality improvement in a supply chain under competition. *Int. J. Prod. Econ.* **2019**, *208*, 566–587. [[CrossRef](#)]



© 2019 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).