Research on Corporate Social Responsibility Investment Considering "Greenwashing" Behavior

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Abstract. With the introduction of the dual-carbon target and the increasing public attention to green products, companies in the supply chain tend to invest in corporate social responsibility (CSR). In order to deal with the "greenwashing" behavior of upstream suppliers who use CSR inputs to cover up their defaults, downstream manufacturers are motivated to make CSR audit inputs. To address the above issues, a supply chain consisting of a supplier and a manufacturer is constructed, and the optimal decisions of both parties in the Stackelberg game model are analyzed under two scenarios, i.e., when the manufacturer invests in CSR auditing and when no CSR auditing is carried out. The study shows that in the case where the supplier is the leader, the manufacturer will invest more in CSR audits when the supplier is "greenwashing" and the government fines are greater than the profits generated by the current market demand.

Keywords: Greenwashing, Corporate Social Responsibility, Supply Chain

1. Introduction

In recent years, China's economy has developed continuously and its comprehensive national strength has been significantly enhanced.At the same time, environmental problems such as air pollution, soil erosion, land desertification and ecological diversity destruction have attracted more attention.Environmental protection makes consumers more favorable to enterprises that fulfill social responsibility, so the construction of a green supply chain system is conducive to improving corporate image and sustainable development.Although the government and the public attach great importance to sustainable development and the fulfillment of corporate social responsibility, suppliers, out of their own pursuit of economic interests and considering the cost pressure of CSR investment.

2. Literature References

2.1. The manifestation of enterprise "greenwashing"

There are various manifestations of enterprise greenwashing. The academic community believes that "greenwashing" involves selective information disclosure, empty statements and policies, suspicious authentication and labeling, false cooperation with non-governmental organizations, ineffective public welfare projects, misleading language, misleading images, and other forms. Chen Qi and Duan Yongrui (2023) take the clothing industry as an example, pointing out that many companies achieve cost savings and establish brand image through undiscovered "greenwashing" behaviors, such as fictitious investment in energy conservation and environmental protection, exaggerating the promotion of product green levels.

2.2. The concept of supply chain corporate social responsibility

Chinese scholar Chen Yuangao (2015) first proposed supply chain social responsibility, pointing out that members of each node in the supply chain should fulfill moral mandatory obligations to stakeholders including upstream and downstream enterprises, consumers, government, society, and the environment. Cheng and Ding (2021) pointed out that the content of supply chain corporate social responsibility management refers to the specific corporate social responsibility that each enterprise in the supply chain should abide by. Supply chain corporate social responsibility is generally regarded as an extension and expansion of corporate social responsibility, an innovation in management

models, and the supply chain should not only pursue profit maximization, but also pay attention to the interests of other stakeholders and actively assume certain legal, ecological, and moral responsibilities.

2.3. Research on social responsibility investment of supply chain enterprises

In recent years, domestic and foreign scholars have focused more on the CSR investment of suppliers or manufacturers in supply chain enterprises under external supervision. Yang et al. (2018) studied channel selection and emission reduction decisions when considering carbon emission restrictions. Zhang Lu et al. (2022) found that tourism companies should improve their CSR decision-making level when consumer low-carbon preferences increase. Yao Fengmin et al. (2023) constructed differential pricing decision models for supply chains under different scenarios, pointing out that as consumer CSR sensitivity increases, both the bidirectional CSR investment and profits of the original manufacturer and remanufacturer will increase. Guan Zhenzhong and Wang Yiwen (2023) found through empirical research that corporate social responsibility investment helps reduce debt financing costs and default risk, and its effect is negatively correlated with the degree of supply chain concentration.

3. Problem Description and Model Assumptions

A Stackelberg game is played between a closed-loop supply chain system consisting of a single supplier (s) as the leader and a single manufacturer (m) as the follower. This article assumes that both suppliers and manufacturers have a sense of corporate social responsibility (CSR) and will make direct or indirect investments in CSR. Suppliers make CSR investment decisions, and manufacturers conduct CSR audits on their CSR investments. Suppliers, driven by the goal of maximizing their own interests, have the motivation to use the investment originally used for CSR to cover up default and engage in "greenwashing" investment to interfere with the manufacturer's audit results.

The decision variables and other symbols involved in this article are shown in Table 1.

Table 1 . Decision variables and other symbols

Decision variables	
e_m	Manufacturer CSR audit input, $e_m \in [0,1]$
e_s	Supplier CSR investment, $e_s \in [0,1]$
Other symbols	
e_g	Supplier's investment in "greenwashing", $e_g \in [0,1]$
p	Manufacturer's product selling price
w	Product transaction prices of manufacturers and suppliers
c	Supplier product cost
d	Product market demand
k	Market sensitivity coefficient to price, $k \in [0,1]$
B	Government fines for CSR breach
C_{e_m}	Cost of CSR audit investment for manufacturers
C_{e_s}	The cost of supplier CSR investment
C_{e_g}	The cost of supplier's "greenwashing" investment
λ_m	Manufacturer CSR audit cost coefficient
λ_s	Supplier CSR input cost coefficient
λ_g	Supplier's input cost coefficient for "greenwashing"
π_i^j	In the model, the profit function of supply chain members, where $j = \{N, G\}, \ i = \{s, m\}$

Hypothesis 1. The current product market demand is d, and this article standardizes the total market size to 1, k is the sensitivity coefficient of market demand to price. Therefore, the function of market demand is $d = 1 - kp$.

Hypothesis 2. The supplier (s) decides on the level of CSR investment and whether to carry out "greenwashing" investment. The level of audit investment by the manufacturer (m) in determining the CSR performance of upstream suppliers. The values of are all within [0,1]. At the same time, e_s can represent the probability of supplier CSR fulfillment, $1 - e_s$ is the probability of supplier CSR default. At the same time as e_g representing the supplier's "greenwashing" investment, it also serves as the probability of successful supplier interference with the manufacturer's audit, therefore $1 - e_g$ is the probability of supplier interference audit failure. The manufacturer's CSR audit input e_m represents the probability of the manufacturer's audit success without interference, and $1 - e_m$ is considered as the probability of the manufacturer's audit failure.

Hypothesis 3. e_s、e_g、e_m all generate corresponding costs C_{e_s}、C_{e_g}、C_{e_m}. This article assumes without loss of generality that the cost of corporate social responsibility investment is a convex function $C = \frac{1}{2}\lambda e^2$, And C increases with the increase of their respective cost coefficients λ_s、λ_g、λ_m.

Hypothesis 4. Under the circumstances where the supplier does not engage in "greenwashing" investment (N model) and conducts "greenwashing" investment interference audit (G model), there is a probability $e_m(1 - e_s)$ and $e_m(1 - e_g)(1 - e_s)$ that the manufacturer will audit the supplier's CSR breach separately. If the audit confirms that the supplier has a CSR breach, and the manufacturer orders zero from the supplier, then both parties terminate the cooperation.

Hypothesis 5. In the N model and G model, there is a situation where the supplier's CSR defaults but passes the manufacturer's audit, that is, the audit fails, with probabilities of $(1 - e_s)(1 - e_m)$ and $(1 - e_s)\big(1 - e_m(1 - e_g)\big)$ respectively. At this time, government regulatory authorities will impose fines on suppliers and manufacturers, amounting to B.

Hypothesis 6. This article constructs a Stackelberg game model with suppliers as leaders, where both parties make decisions of e_s and e_m based on maximizing their own interests. π_i^j represents the profit function of supply chain members i under the model j, where $j = \{N, G\}$, $i = \{s, m\}$.

4. Analysis of CSR Investment Decision Models for Suppliers and Manufacturers

4.1. Suppliers do not invest in "greenwashing" (N model)

When the supplier does not engage in "greenwashing" investment, the manufacturer's audit results are not disturbed. Both parties only focus on their own profits for e_s and e_m decision-making. The decision-making order between suppliers and manufacturers is as follows: (1) As the leader, the supplier first determines the level of CSR investment; (2) Manufacturers, as followers, decide on the audit investment for the CSR performance level of upstream suppliers based on their level of expertise. The profit functions of suppliers and manufacturers are as follows:

Supplier profit function under the N model:

$$\pi_s^N = (w - c)[e_s + (1 - e_s)(1 - e_m)]d - \frac{1}{2}\lambda_s e_s^2 - B(1 - e_s)(1 - e_m)$$

Manufacturer profit function under the N model:

$$\pi_m^N = (p - w)[e_s + (1 - e_s)(1 - e_m)]d - \frac{1}{2}\lambda_m e_m^2 - B(1 - e_s)(1 - e_m)$$

By using the inverse method to solve optimization problems, Theorem 1 can be obtained.

Theorem 1. The equilibrium decision of the supply chain under the N model is:

$$e_s^{N^*} = \frac{2(B + d(c - w))(B + d(-p + w)) - B\lambda_m}{2(B + d(c - w))(B + d(-p + w)) - \lambda_m\lambda_s}$$

$$e_m^{N^*} = \frac{(B + d(-p + w))(B - \lambda s)}{2(B + d(c - w))(B + d(-p + w)) - \lambda_m\lambda_s}$$

By substituting the equilibrium value $e_s^{N^*}$ and $e_m^{N^*}$ into the profit functions, we can obtain the profits of suppliers and manufacturers as follows:

$$\pi_s^{N^*} = \big(-4Bd^2(c - p)(c - w) + 2B(-cd + dp + \lambda_m)\lambda_s - B^2(4cd - 4dw + \lambda_m + 2\lambda_s) + 2d(c - w)(2d^2(c - w)(p - w) + (d(p - w) + \lambda_m)\lambda_s)\big)/(4(B + d(c - w))(B + d(-p + w)) - 2\lambda_m\lambda_s)$$

$$\pi_m^{N^*} = -\big(\big((B + d(-p + w))^2\lambda_m(B - \lambda_s)^2 + 2B\lambda m(B - \lambda_s)((B + 2d(c - w)) + (B + d(-p + w) - \lambda_m)\lambda_s) - 2d(p - w)(4(B + d(c - w))^2(B + d(-p + w))^2)/(2(-2(B + d(c - w))(B + d(-p + w)) + \lambda_m\lambda_s)^2)\big)$$

4.2. Suppliers engage in "greenwashing" investment (G-model)

When suppliers engage in "greenwashing" investments, the audit results of manufacturers are disrupted. Both suppliers and manufacturers make decisions based on maximizing their own profits, and the profit functions of both parties are as follows:

Supplier profit function under G model:

$$\pi_s^G = (w - c)\big[e_s + (1 - e_s)(1 - e_m(1 - e_g))\big]d - \frac{1}{2}\lambda_g e_g^2 - \frac{1}{2}B(1 - e_s)(1 - e_m(1 - e_g))$$

Manufacturer profit function under G model:

$$\pi_m^G = (p - w)\big[e_s + (1 - e_s)(1 - e_m(1 - e_g))\big]d - \frac{1}{2}\lambda_m e_m^2 - B(1 - e_s)(1 - e_m(1 - e_g))$$

By using the inverse method to solve optimization problems, Theorem 2 can be obtained.

Theorem 2. The equilibrium decision of the supply chain under the G model is:

$$e_s^{G^*} = \frac{2(-1 + e_g)^2(B + d(c - w))(B + d(-p + w)) - B\lambda_m}{2(-1 + e_g)^2(B + d(c - w))(B + d(-p + w)) - \lambda_m\lambda_s}$$

$$e_m^{G^*} = \frac{(-1 + e_g)(B + d(-p + w))(B - \lambda s)}{2(-1 + e_g)^2(B + d(c - w))(B + d(-p + w)) - \lambda_m\lambda_s}$$

By substituting the equilibrium value into the profit function, the profits of suppliers and manufacturers can be obtained as:

$$\pi_s^{G^*} = (4c^2d^3(-1 + e_g)^2(p - w) + 2d^2(-1 + e_g)^2(p - w)w(2dw - e_g^2\lambda_g) + (-2d^2(-1 + e_g)^2(p - w)w - 2dw\lambda_m + e_g^2\lambda_g\lambda_m)\lambda_s - B^2(2(-1 + e_g)^2(2cd - 2dw + e_g^2\lambda_g))/(4(-1 + e_g)^2(B + d(c - w))(B + d(-p + w)) - 2\lambda_m\lambda_s)$$

$$\pi_m^{G^*} = -\big(\big((-1 + e_g)^2(B + d(-p + w))^2\lambda_m(B - \lambda s)^2 + 2B\lambda_m(B - \lambda s)(2(-1 + e_g)^2(B + d(c - w))(B + d(-p + w)) - (-1 + e_g)^2(B + d(-p + w))(B - \lambda_s) - \lambda_m\lambda_s) - (B + d(-p + w))^2)/(2(-2(-1 + e_g)^2(B + d(c - w))(B + d(-p + w)) + \lambda_m\lambda_s)^2)\big)$$

4.3. Comparative analysis of N model and G model

Proposition 1. When $[B - d(p - w)] > 0$, $e_m^{G^*} > e_m^{N^*}$, the optimal CSR audit investment of manufacturers in G mode is significantly greater than their optimal CSR audit investment in N mode.

Proof. $e_m^{G^*} - e_m^{N^*} = [B - d(p - w)](((B - dp)^2\lambda_m + 2B\lambda m(B - \lambda_s)(+(B + d(-p + w) - \lambda_m)\lambda_s) - 4(B + d(c - w))(B + d(-p + w))\lambda_m\lambda_s + (B + d(-p + w))\lambda_m(B - \lambda_s)\lambda_s + \lambda_m^2\lambda_s^2))/(2(B + d(c - w))(B + d\lambda_m\lambda_s^2))$, $[B - d(p - w)] > 0$, $e_m^{G^*} - e_m^{N^*} > 0$, $e_m^{G^*} > e_m^{N^*}$.

Proposition 2. When $[B - d(p - w)] > 0, e_s^{G^*} < e_s^{N^*}$, the optimal CSR investment of suppliers in N mode is significantly greater than their optimal CSR investment in G mode.

Proof. $e_s^{G^*} - e_s^{N^*} = [B - d(p - w)](-2d^2(c - p) - B^2(\lambda_m + 2\lambda_s) - 2d(c - w)(2d^2(c - w)(p - w) - (d(p - w) + \lambda_m)\lambda_s))/(2(B - wd))(B - d(p - w) + \lambda_m\lambda_s$, $[B - d(p - w)] > 0, e_s^{G^*} - e_s^{N^*} < 0$，$e_s^{G^*} < e_s^{N^*}$.

5. Numerical Analysis

In previous studies, es reflected the level of supplier CSR investment, while em reflected the manufacturer's CSR audit investment. Firstly, we conduct numerical analysis to further illustrate the impact of decisions made by both parties on their respective profits under different modes. For the values of the parameters, we set w=0.2, p=0.6, c=0.01, B=0.7, d=0.4, e_a=0.3, λ_g=0.02, λ_m=0.01, λ_s=0.1. Keep these parameters unchanged and set e_s=0.3 to change e_m from 0 to 1. The research results strongly validate Proposition 1, that when suppliers make "greenwashing" investments, manufacturers will audit suppliers at a higher level of investment.

Keep other parameters unchanged and set e_m=0.9 to change e_s from 0 to 1. The research results fully demonstrate that when suppliers reduce their investment in greenwashing, they will increase their CSR investment to improve their profit level.

6. Conclusion

This article is based on the CSR investment model of upstream and downstream enterprises in the supply chain, studying the level of supplier CSR investment and manufacturer CSR audit investment, revealing the optimal decisions and profits of all parties under the Stackelberg model led by suppliers. The main conclusion is as follows: (1) When the government's fines exceed the profits under current market demand, manufacturers will invest more funds in auditing when suppliers have a higher degree of greenwashing. Firstly, when society has a low tolerance for "greenwashing" behavior, the government will increase fines on companies that engage in such behavior. In order to cover up their false environmental behavior and ensure their profit level, enterprises have sufficient motivation to spend a lot of energy and financial resources to cover up. When manufacturers perceive that society has a low tolerance for "greenwashing" behavior, they will audit suppliers at a higher level of investment to maintain and improve their profit levels. (2) When suppliers reduce their investment in concealing defaults, they tend to increase their corporate social responsibility investment, resulting in higher profit levels.

Based on the above conclusions, there are the following inspirations: (1) Enterprises should pay attention to their own sustainable development and limit the occurrence of "greenwashing" behavior. (2) Enterprises do not need to conceal defaults, but rather increase CSR investment to promote themselves from "greenwashing" to "true greenwashing". (3) Government departments and regulatory agencies should establish a sound regulatory mechanism, increase the punishment for enterprises' "greenwashing" behavior, and scientifically govern the "greenwashing" behavior of enterprises.

There are still certain limitations and room for future research expansion in this article, mainly reflected in the following two aspects: (1) The model can further explore the sensitivity of consumers to corporate CSR investment and the learning effect of consumers on green products. (2) Both parties in the model make decisions based on maximizing their own interests, without incorporating enterprise value into the decision-making objectives. Therefore, their balanced decisions may not always lead to the optimal overall revenue of the supply chain.

Acknowledgements

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