

Research on Supply Chain Decision-making Considering Fairness Concerns and Green Technology Innovation

Yalou Chen

School of Economics and Management, Chongqing University of Posts and Telecommunications, Chongqing 400065, China

Abstract: A supply chain consisting of a manufacturer and a retailer is constructed. On this basis, the Stackelberg game between the upper and lower levels of the supply chain is adopted, Consider the balance between manufacturers and retailers in the development of green technology innovation under the concern of fairness. The research shows that green technology innovation has a significant positive impact on the whole supply chain system. Retailers' fair concern behavior will have a certain negative impact on the whole supply chain system and increase the potential conflict among the members of the supply chain. Enterprises need to actively incorporate environmental protection into supply chain management and partner selection decisions, and should not ignore the negative impact of fairness concerns on team cooperation.

Keywords: Green supply chain, Fairness preference, Stackelberg game.

1. Introduction

The goal of green technology innovation is to produce high-quality and innovative products to reduce the impact on the environment. Due to the increasing environmental challenges, the importance of green technology innovation has been widely recognized. For example, the European Commission's Sustainable Development Sector Initiative supports small and medium-sized enterprises in green technology innovation. In the process of green transformation of the supply chain, the innovation of green technology is also a hot topic of current research. Green technology innovation is not only one of the important contents of green supply chain management, but also an important issue of sustainable development research. Green technology innovation is generally the general term of management innovation and technology innovation, and its goal is to coordinate the relationship between human and environment. At the same time, enterprises' green technological innovation can also ensure the stability of social welfare.

At present, domestic and foreign scholars have conducted extensive and in-depth research on green technology innovation and green supply chain. Habiba [1] and others have studied the impact of financial development, green technology innovation and renewable energy use on carbon emissions. The results show that green technology innovation and renewable energy use will be the main factors leading to the reduction of carbon emissions. Wang [2] et al. found that green process innovation and green product innovation can effectively improve the economic benefits of enterprises by building the economic performance transmission model of green technology innovation and upgrading. The research results deepen the understanding of the green technology innovation process and have implications for optimizing the design of green development policies. Deng [3] et al. used game theory and optimization theory to analyze the optimal green technology innovation strategy of enterprises under the two scenarios of whether there is political competition or not. Wen Huwei [4] and others used the multiple difference method to investigate the heterogeneity effect of

environmental tax policy intervention based on the environmental tax collection standard, and discussed the impact of environmental protection tax reform on green technology innovation of enterprises. Roh [5] et al. studied the impact of internal green activities such as green management innovation and green marketing innovation on promoting enterprises to achieve environmental performance. Li [6] et al. conducted a tripartite evolutionary game analysis between two types of enterprises and banks with different R&D capabilities, and obtained the impact relationship between market-oriented environmental regulatory policies and the implementation of green technology innovation of enterprises.

In recent years, the supply chain considering fairness concerns has become a hot research topic. Traditional economics often assumes that the decision-maker is completely rational, that is, all members of the supply chain take profit as the only goal. Behavioral economics, based on irrational assumptions, incorporates psychology and sociology into the utility function and modifies the assumption of "self-interested" economic man. FHer [7] et al. gave the utility function to evaluate fairness for the first time and proposed the FS model. Based on this model, many scholars have analyzed the impact of fairness behavior among supply chain members, and Du Shaofu [8] and others have studied the impact of fairness concerns on the contract and coordination of supply chain. Liu Yunzhi [9] and others studied VMI supply chain coordination under supplier's unfair aversion. Du Jianguo [10] and other researchers have shown that when risk-averse retailers have a fair preference, the retailer's fair preference negatively affects the product price, wholesale price, supplier's green input level and supplier's utility. Liu Jing [11] et al. studied that compared with the optimal decision when fairness is neutral and risk is neutral, retailers' fairness concern behavior and risk aversion behavior will affect the optimal decision of green supply chain. However, the existing research has not taken into account the fairness concern behavior under the supply chain of green technology innovation.

To sum up, technology innovation and income distribution in green supply chain have received extensive attention.

However, few literatures consider the fairness concerns of decision makers and the impact of green technology innovation on the supply chain at the same time. In view of this, this paper proposes a supply chain consisting of a manufacturer and a retailer, taking into account the concerns of green technology innovation's supply chain members about fairness. Through the green technology innovation efforts provided by the manufacturer and its pricing strategy, the optimal decision is obtained. For this reason, this paper considers the Stack-elberg game between manufacturers and retailers to maximize their profits and utility, and considers the issue of fairness concerns, and obtains reasonable management significance.

2. Model Notation and Assumptions

Consider a supply chain consisting of a manufacturer and a retailer. Manufacturers sell their products to retailers at a certain wholesale price, and retailers sell these products to the market at a certain sales price. Manufacturers are committed to contributing to the development of green technology innovation. Products with green technology innovation will attract more consumers with different preferences. To facilitate the analysis of this paper, the following research assumptions are proposed:

Hypothesis 1: The demand function is affected by the sales price provided by suppliers and manufacturers and the green technology innovation work. The market demand function is:

$$D = \alpha - ip + k\beta \quad (1)$$

Among them, α It is a constant parameter of the market and is not affected by price or green technology innovation. i is the sensitivity coefficient of sales price, p is the retail price of goods, $\alpha > ip$. k is the coefficient of green technological innovation efforts provided by manufacturers. β Represent the efforts of green technology innovation provided by manufacturers.

Hypothesis 2: introduce equity concern coefficient λ , Policymakers will pursue their own fair utility while paying attention to their actual profits. The decision-making goal of manufacturers and retailers is to maximize their own utility. Based on this, we assume that the utility functions of retailers with fairness concerns are:

$$U_R = \pi_R - \lambda(\pi_M - \pi_R) \quad (2)$$

3. Model Construction and Solution

In the supply chain model, the manufacturer is the leader, the retailer considering fair utility is the follower, and the upper and lower members of the supply chain play a Stack-elberg game. The optimal pricing decision of retailer's fair utility function is given. When only retailers are concerned about fairness, the relevant profit function and utility function are:

$$\pi_M = (w - c)(\alpha - ip + k\beta) \quad (3)$$

$$\pi_R = (p - c)(\alpha - ip + k\beta) \quad (4)$$

Calculate the first partial derivative of p from equation (2) to obtain:

$$\frac{\partial U_R}{\partial p} = (\alpha + k\beta)(1 + \lambda) + i(w - c\lambda + 2w\lambda - 2p(1 + \lambda))$$

$$\pi_M = - \frac{(c - w)((\alpha + k\beta)[1 + \lambda] - i(w - c\lambda + 2w\lambda))}{2(1 + \lambda)}$$

$$\frac{\partial \pi_M}{\partial w} = \frac{c + 3c\lambda + (\alpha + k\beta)(1 + \lambda) - 2w(1 + 2\lambda)}{2(1 + \lambda)}$$

Let it be 0 and solve it:

$$w^* = \frac{(\alpha + k\beta)(1 + \lambda) + c(i + 3i\lambda)}{2(i + 2i\lambda)}$$

Substitute w^* into p to get:

$$p^* = \frac{ci + 3\alpha + 3k\beta}{4i}$$

$$\pi_M^* = \frac{(-ci + \alpha + k\beta)^2(1 + \lambda)}{8(i + 2i\lambda)}$$

$$\pi_R^* = \frac{(-ci + \alpha + k\beta)^2(1 + 4\lambda)}{16(i + 2i\lambda)}$$

Ratiocination:

With the increase of retailers' equity concerns, the wholesale prices of products and the profits of manufacturers have decreased correspondingly, while the profits of retailers have increased. However, the strength of retailers' equity concerns does not affect the retail prices of products. As manufacturers' efforts to promote green technology innovation have increased, the wholesale price, sales price, manufacturer's profit and retailer's profit of products have increased accordingly.

4. Numerical Analysis

In order to verify the correctness of the established model and further analyze the impact of retailers' equity concerns and green technology innovation on the green supply chain, this paper compares the effects of different subsidy strategies and the impact of retailers' equity preference behavior on government subsidies through numerical simulation. hypothesis $\alpha = 100, c = 10, i = 5, k = 3$. Retailer equity concern coefficient λ Value in the range of 0~1 and the level of green technology innovation efforts $\beta =$ At 0.5, the changes of various indicators in the green supply chain are shown in Figure 1-4.

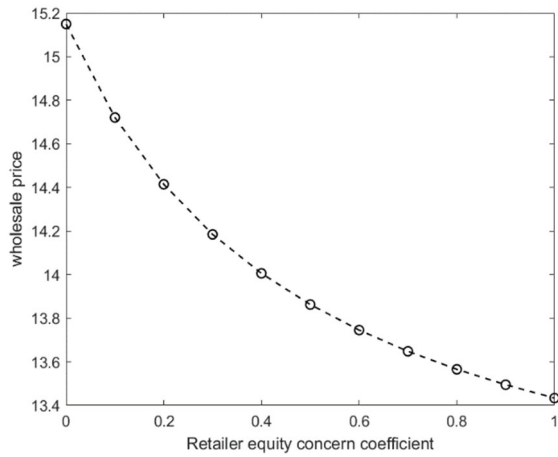


Figure 1. Wholesale price

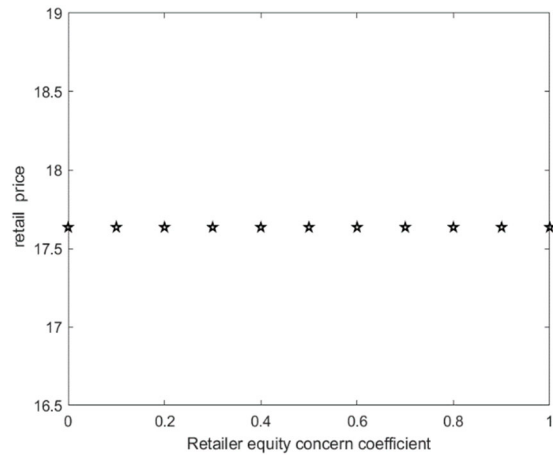


Figure 2. Retailer price

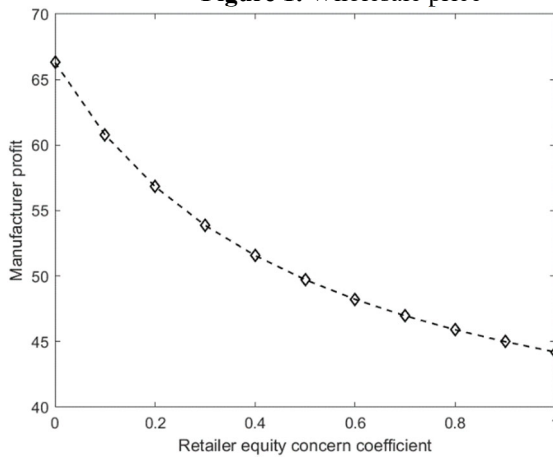


Figure 3. Manufacturer's profit

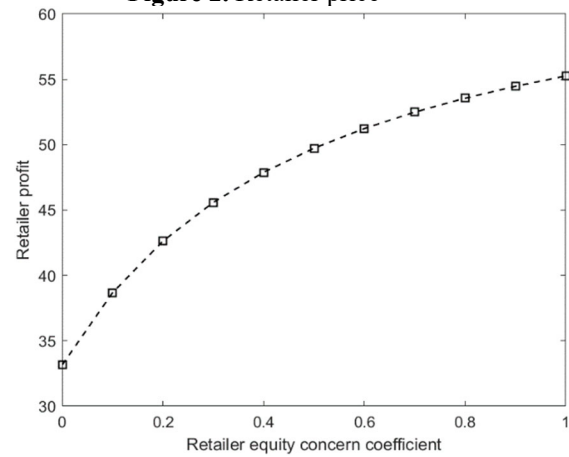


Figure 4. Retailer's profit

According to the data in Figure 1 - Figure 4, it can be seen that the wholesale price and profit of manufacturers decrease with the increase of the retailer's equity concern coefficient, which means that the higher the retailer's equity concern, the lower the manufacturer's wholesale price and profit. It is difficult for manufacturers to gain any benefits in the supply chain system. While the retail price has nothing to do with the

retailer's equity concern coefficient, the retailer's profit increases with the increase of the retailer's equity concern coefficient. When the level of green technology innovation efforts β Value in the range of 0~1 and retailers' equity concern coefficient $\lambda=$ At 0.5, the changes of various indicators in the green supply chain are shown in Table 1:

Table 1. The impact of retailers' equity concerns on supply chain members

β	0.2	0.4	0.6	0.8	1
w	13.795	13.84	13.89	13.97	14.06
p	17.59	17.68	17.77	17.86	17.95
π_M	48.1	49.2	50.4	51.5	52.7
π_R	44.7	45.8	46.5	47.8	48.4

5. Conclusions

The innovation and development of green technology is one of the important contents of green supply chain management, which is of great significance to the realization of the goal of "no waste in the world, negative carbon ecology". This paper develops a quantitative model to study the supply chain system composed of a supplier and a manufacturer, taking into account the fairness concerns and the impact of green technology innovation efforts on all members of the supply chain. The following research results are obtained. First, manufacturers are motivated to participate in the development of green innovative technologies. Green technology innovation has a significant positive impact on the whole supply chain system. Secondly, retailers' equity concerns will have a certain negative impact on the whole supply chain

system and increase the potential conflicts among members of the supply chain. Finally, enterprises need to actively incorporate environmental protection into supply chain management and partner selection decisions, and should not ignore the negative impact of fairness concerns on team cooperation. And for enterprises with better green integration at present, it is advisable to support other enterprises in the upstream and downstream cooperation of the supply chain to improve the green degree of the entire supply chain, which is also an important way to achieve supply chain cooperation.

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