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Pricing Strategy and Governments Intervention for Green Supply Chain with Strategic Customer Behavior

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Abstract This paper researches the pricing strategy and government intervention mechanism for green supply chain in monopoly market, while considering strategic customer behavior. According to optimization theory, it establishes the target functions of retailer and strategic customers and investigates the interactions between retailer and strategic customers in accordance with Stackelberg's game theory, so as to confirm the optimal discount level for green products. In addition, it discusses the regulatory effect of government intervention, including the guiding price and fiscal subsides, on the sales of green products. The research shows that the retailer can make the profit maximization by adjusting the discount level; the governments can regulate the sales of products by implementing the guiding price and fiscal subsides to the retailer.

Keywords strategic customer behavior; governmental intervention; pricing strategy

1 Introduction

Green supply chain management (GSCM), also known as environmentally conscious supply chain management or environmentally supply chain management, is a modern management mode that takes the impact on environment and the utilization efficiency of resources into consideration. Along with the increasing of environmental problems and the raising of public environmental consciousness, consumer demand for green products is growing. According to a market survey report from TÜV SÜD in 2011, Chinese consumers' demand for green products

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and services has been expanding quickly, with most consumers (about 94%) prefering to pay more (about 45% more) for the certified-green product or service. To improve the environmental problem and satisfy customer demand, GSCM draws high attention to the theory and practice circle.

The successful operation of green supply chain (GSC) needs to achieve the expected sales of green products, so as to ensure the profit space for each participant in the supply chain, in addition, the sales of products are one of the major drivers for improving the environmental performance of Chinese enterprises[1]. Therefore, the decision makers of GSC need to take the influence, caused by customer behavior, on the sales of products into consideration. In practice, retailers tend to dynamically readjust the price in order to inspire more consumers to buy, because of the uncertainty and stochastic volatility of demand[2]. The widely application of revenue management, such as the strategy above, has developed a large number of strategic customers. Strategic customers will estimate the product price in the future[3] and the possibility of acquiring products at lower price in the future[4], so as to choose the optimal opportunity to buy. In addition, strategic customers have been waiting for discounting and requiring retailers to promise the return policy, which causes a great loss to the enterprises' profit[4]. Similar cases have been proved to exist in many enterprise practice: Best-Buy publicly deems the strategic customers as devils, while deeming the nonstrategic customers as angles, thus, they separate these two kinds of customers through effective pricing mechanism so as to reduce the losses caused by customers' waiting[5]. Apart from the above mentioned companies, Best-Buy, Bloomingdale's, AnnTaylor, Gap and Home Depot also optimize the pricing mechainsm to impact customers' behavior for replying customer' waiting. Accordingly, strategic customer behavior greatly influences business profit, so the relevant pricing researches about GSC should take strategic customer behavior into consideration.

Although GSCM is important to improve global environments and industrial ecology, and fulfill customers' green demand, the environmental protection awareness and social responsibility of enterprises is not sufficient for sustaining GSCM. According to the channel power theory, it is indispensable for GSCM that governments acting as mediators can enhance the coordination and relationship in supply chain, though financial intervention[6]. Accordingly, governments are regarded as the main power influencing the operation of GSC, thus, this paper brings the governmental financial interventions, such as guiding price and subsides, into the scope of discussion.

This paper researches the influence of strategic customer behavior on the product sales of green perishable products and probe retailers' optimal pricing strategy, in addition, it researches retailers' optimal pricing strategy under government intervention with guiding price and subsides. Specifically, this paper attempts to answer the research questions as follows:

1. How does strategic customer behavior impact the demanding distribution of green perishable products?

2. For strategic customer behavior, how does the single retailer make the optimal decision to maximize its profit?

3. Whether the governmental financial interventions with guiding price and subsides affect

the sales of green perishable products and how to design the price mechanism with guiding price and subsides under the government invention?

Previous literatures about GSC were almost under the hypothesis that customers only have short-sight behavior without considering the impact of strategic customer behavior. Besides, the importance of governmental financial interventions for increasing the sales of green products had not been researched wildly. In addition, while considering strategic customer behavior, researchers usually assumed the products are durable and did not take the impact of products' perishability on strategic customer behavior into consideration. Therefore, this paper intends to research the pricing strategy in green perishable products supply chain while considering strategic customer behavior and governmental financial interventions, so as to make up the shortage of previous researches in this field.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literatures in brief. Section 3 describes and hypothesizes the research context. Section 4 discusses the decision process of strategy customer and the impact of strategic customer behavior on demanding of GSC. Section 5 discusses the decision process of retailer and how the decision variables of retailer influence the strategic customer behavior and the demanding distribution, so as to solve the optimal pricing strategy. Section 6 introduces the governmental financial interventions with guiding price and subsides into this work, and solves the pricing strategy and economic incentives under the governmental financial interventions. Section 7 gives the conclusions and the future research.

2 Literature review

The concept of GSC was initially put forward by Michigan State University in 1961, after that, many researchers studied it. Currently, the relevant researches about GSC concentrate on these three aspects as follows: the definition and inscape of GSC[7−8], the operation of GSC[9−12], and the pricing of green products[13−16]. These literatures ignored the influence of strategic customer behavior on the operation of GSC, thus, this paper brings the strategic customer behavior in to the scope of research.

In the aspect of strategic customer behavior, Muth initially put forward the strategic customer behavior and rational expectation equilibrium hypothesis from the perspective of economics[17]. Aviv and Pazgal, based on the dynamic pricing problem of strategic customer behavior and inventory limit, found that the advance approach of price-declaring would add more profit to enterprise than the approach of dynamic optimal price-cutting[18]. Su and Zhang introduced the rational expectation equilibrium hypothesis and strategic customer behavior into the newsvendor model, and analyzed the influence, caused by quantity commitment and price commitment, on the performance of the supply chain, besides, they showed how to use the wholesale price contract and repurchase contract to realize the supply chain coordination[19]. After that, rational expectation equilibrium hypothesis were widely used in the researches with strategic customer behavior as a classic constraint. Levin et al. researched the strategic behaviors of customer and retailer, and established a stochastic dynamic game in which the retailer prices dynamically and the customers decides the optimal purchasing occasion, so they proved the existence of sub-game perfect Nash equilibrium[20]. Cachon and Swinney divided all cus-

tomers into short-sight customers, discount-searching customers and strategic customers, and the findings show that the retailer's profit will decrease when the strategic customers exist[21]. Liu and Huang researched, while facing strategic customer behavior, how the enterprise decides the inventory and price under certain demand and uncertain demand[22]. Yang, Zhou and Song probed the different characteristics of strategic and short-sighted customer behavior and researched the optimal decision of dynamic pricing at the second phase when the market demand is in random distribution[23]. However, most relevant literature in the past almost (all) hypotheses the products are durable directly or indirectly. Accordingly, this paper researches the strategic customer behavior in a perishable supply chain.

In the aspect of governmental interventions, Francisco researched the effects of information disclosure strategy compared with the traditional environmental regulation, such as taxes and subsides, in considering the information disclosure strategy as the approach of environmental policy[24]. Sheu and Chen researched the effects of governmental financial interventions with taxes and subsidies on a number of GSCs[6]. On this basis, the government interventions are considered into this paper for the pricing of green products.

3 Description and assumptions

This paper researches a GSC where only one retailer exists and all the customers have strategic behavior. This GSC manufactures and sells a kind of green product and the green feature of the product is measured by green degree. The green products are perishable because the lifecycle of green products is short, so the valuation which customers place on the products will be decreasing along with the passage of time. There are two sales phases: the first phase is called full price phase that the products are sold at a full price; the second phase is called discount phase where the products are sold at a discounted price, but customers have certain probability of failing to obtain any products and have lower valuation on the products. Besides, there is no replenishment opportunity for retailer.

In the process of selling, we probe the interaction between the retailer and customers on the basis of Stackelberg game in which the retailer is leader and the customers are followers, so the retailer publishes the price policy at first and then the customers respond accordingly. Due to strategic customer behavior, all the customers will compare the utilities obtained by full-price purchasing and discount-price purchasing and no purchasing, so as to choose the optimal purchasing occasion or giving up on buying. The retailer makes the optimal decision by forecasting the customer behavior. Moreover, we assume the retailer and customers are risk neutral and perfectly rational.

To facilitate the discussion, these parameters and hypothesis are given as below:

e: the green degree of unit product;

w: the whole price of unit product;

p: the full price of unit product;

β: the discount level, $\beta \in (0, 1)$;

p_s: the discount price of unit product, $p_s = \beta p$;

k: the payment for unit green degree the customers prefer to pay;

θ: customers' expected green degree, and θ is a stochastic variable distributed on $(0, e)$;

v: the value of green products which the customers expect at full price phase, $v = k\theta$;
α: customers' acceptability for green products at discount phase, $\alpha \in (0, 1)$;
αv: the value of products which the customers expect at discount phase;
δ: the probability for obtaining the products at discounted price phase, $\delta \in (0, 1)$;
l: the retailer's extra losses when the customers give up on purchasing;

In addition, we assume $\alpha > \beta$ so that the discount level is below the customers' acceptability, so as to ensure the attraction of discount price to each customer. Moreover, there are no factors to quantify the strategic customers' behaviors but it is a decision process of the customers and then it describes the strategic behaviors of the customers.

4 The decision process of strategic customers

We assume the customer's utility is $\mu = U(s)$, therein, $U(s) = s$ is customer's utility fuction and s indicates customer's surplus, $\partial U/\partial s > 0$. Besides, customers gain no utility if they give up on purchasing or face shortages. All the customers are strategic and they will compare the utility from three phases. More specific, the utility of purchasing at full price phase is:

$$u_1 = U(v - p) = U(k\theta - p),$$

the utility of purchasing at discount phase is:

$$u_2 = U(\alpha - \beta p)\delta + 0\delta = U(\alpha k\theta - \beta p)\delta,$$

the utility of purchaing nothing is:

$$u_3 = 0.$$

Therein, we discuss the decision process of strategic customers. Because the stratrgic cutomers choose the optimal purchasing occasion or give up on purchasing by comparing the utilitis of the decisions shown above to maximize the utility, the target function of strategic customers is $\max(u_1, u_2, u_3)$. Thus,

(1) the condition for purchasing at full price phase is

$$\begin{cases} u_1 > u_2, \\ u_1 > u_3, \end{cases}$$

so

$$\begin{cases} \theta > \dfrac{(1 - \beta\delta)p}{(1 - \alpha\delta)k}, \\ \theta > \dfrac{p}{k}, \end{cases}$$

which means full price purchasing maximizes the utility of strategic customers;

(2) the condition for purchaing at discount phase is

$$\begin{cases} u_2 > u_1, \\ u_2 > u_3, \end{cases}$$

so

$$\begin{cases} \theta < \dfrac{(1 - \beta\delta)p}{(1 - \alpha\delta)k}, \\ \theta > \dfrac{\beta p}{\alpha k}, \end{cases}$$

which means discount purchasing maximizes the utility of strategic customers;

(3) the condition for giving up on purchasing is

$$\begin{cases} u_3 > u_1, \\ u_3 > u_2, \end{cases}$$

so

$$\begin{cases} \theta < \dfrac{p}{k}, \\ \theta < \dfrac{\beta p}{\alpha k}, \end{cases}$$

which means strategic customers maximize the utility while purchasing nothing.

Due to the hypothsis as before, $\alpha > \beta$ (the discount level is below the customers' acceptability, so as to ensure the attraction of discount price to each strategic customer),

1. the expected green degree of these strategic customers, who choose to purchase at full price phase, is $\theta \in (\frac{(1-\beta\delta)p}{(1-\alpha\delta)k}, e)$, because of the condition of the full price purchasing and $\frac{(1-\beta\delta)p}{(1-\alpha\delta)k} > \frac{p}{k}$;

2. the expected green degree of these customers, who choose to purchase at discount phase, is $\theta \in (\frac{\beta p}{\alpha k}, \frac{(1-\beta\delta)p}{(1-\alpha\delta)k})$, because of the condition of the discount purchaing;

3. the expected green degree of these customers, who give up on purchasing, is $\theta \in (0, \frac{\beta p}{\alpha k})$, because of the condition that it gives up on purchasing and $\frac{\beta p}{\alpha k} < \frac{p}{k}$.

To facilitate the discussion, let $\theta_1 = \frac{(1-\beta\delta)p}{(1-\alpha\delta)k}$ is the first critical value of customers' expected green degree and $\theta_2 = \frac{\beta p}{\alpha k}$ is the second critical value of customers' expected green degree, additionally, we assume market capacity is $N = 1$ and customer's expected green degree θ is evenly distributed on $(0, e)$. Therefore,

$$q_1 = N \int_{\theta_1}^{e} f(\theta) \mathrm{d}\theta$$

is the demand at full price phase as the strategic customers with the expected green degree $\theta \in (\theta_1, e)$ will purchase at full price;

$$q_2 = N \int_{\theta_2}^{\theta_1} f(\theta) \mathrm{d}\theta$$

is the demand at discount phase as the strategic customers with the expected green degree $\theta \in (\theta_2, \theta_1)$ will purchase at discount price;

$$q_3 = N \int_{0}^{\theta_2} f(\theta) \mathrm{d}\theta$$

is the amount of the customers giving up on purchasing as the strategic customers with the expected green degree $\theta \in (0, \theta_2)$ will give up on purchasing;

$$q_1 + q_2 = N \int_{\theta_2}^{e} f(\theta) \mathrm{d}\theta$$

is the sales of green products.

Accordingly, the expected green degree influences the strategic customers' decision for purchasing. When the expected green degree exceeds the first critical value, the strategic customers will purchase at full price phase; when the expected degree is bellow the first critical value but exceeds the second critical value, the strategic customers will purchase at discount phase; while the expected degree is bellow the second critical value, the strategic customers will give up on purchasing.

5 The decision process of retailer

5.1 The influence of retailer's decision

Herein, we discuss the influence of retailer's decision on these three customers' decision above. The retailer can influence customer's behavior through publishing price policy, thereby, the retailer's decision variable is $(\beta,\ \delta)$.

Proposition 1 (1) *If β is constant and δ increases, q_1 will decrese and q_2 will increase and q_3 will be constant;*
(2) *If β is constant and δ decreases, q_1 will increase and q_2 will decreasse and q_3 will be constant;*
(3) *If δ is constant and β increases, q_1 will increase and q_2 will decreasse and q_3 will increase;*
(4) *If δ is constant and β decreases, q_1 will decrease and q_2 will increasse and q_3 will decrease.*

Proof

We take the derivative of δ and β for $\theta_1 = \frac{(1-\beta\delta)p}{(1-\alpha\delta)k}$ and $\theta_2 = \frac{\beta p}{\alpha k}$ so we find

$$\begin{cases} \dfrac{\partial\theta_1}{\partial\delta} = \dfrac{(\alpha-\beta)p}{(1-\alpha\delta)^2 k} > 0, \\ \dfrac{\partial\theta_1}{\partial\beta} = \dfrac{-\delta p}{k(1-\alpha\delta)} < 0, \\ \dfrac{\partial\theta_2}{\partial\delta} = 0, \\ \dfrac{\partial\theta_2}{\partial\beta} = \dfrac{p}{\alpha k} > 0, \end{cases}$$

thus, the proposition 1 is proven to be established.

Therefore, we suggest that the retailer can, by adjusting orders to change the probability for obtaining the products at discounted phase, lead the strategic cutomers to purchase green products at full price phase or discount phase, but cannot increase the real sales of green products; however, the retailer can, by ajusting the discount level, increase the real sales of green products. The details are tabulated in Table 1.

5.2 The optimal decision of retailer

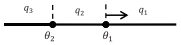
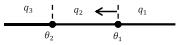
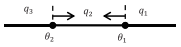
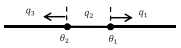
Now we discuss the optimal decision of retailer, according to the hypothesis as before, the retailer's profit function is

$$\Pi(\beta,\ \delta) = pq_1 + \beta pq_2 - lq_3 - cN.$$

More specific, the first two items indicate the sales proceeds at full price phase and discount price and the last two items indicate the shortage cost and manufacturing cost.

The rational retailer will adjust the discount level and the probability for obtaining the products at discounted phase, so as to maximize its own profit. Therefore, the retailer's target

Table 1 The influence of retailer's decision on the demand for green products

Decision Variables of Retailer		Critical Value		Demand Distribution			Market Structure
		θ_1	θ_2	q_1	q_2	q_3	
δ	$\uparrow$	$\uparrow$	–	$\downarrow$	$\uparrow$	–	
	$\downarrow$	$\downarrow$	–	$\uparrow$	$\downarrow$	–	
β	$\uparrow$	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	
	$\downarrow$	$\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$	

function is:

$$\max_{\beta} \Pi(\beta,\, \delta) = pq_1 + \beta pq_2 - lq_3 - cN.$$

Proposition 2 *There is unique optimal discount level* $\beta^* = \frac{\alpha\delta+\alpha}{2}$ *which maxmizes the retailer's profit* $\Pi(\beta,\, \delta)$.

Proof $\frac{\partial\Pi^2(\beta,\,\delta)}{\partial^2\beta} = \frac{-2p^2}{\alpha ke(1-\alpha\delta)} < 0$, so $\Pi(\beta,\, \delta)$ is concave about β and there must be $\beta = \frac{\alpha\delta+\alpha}{2}$ to let $\frac{\partial\Pi(\beta,\,\delta)}{\partial\beta} = \frac{p^2(\alpha\delta+\alpha-2\beta)}{\alpha ke(1-\alpha\delta)} = 0$. Therefore, there must be unique $\beta^* = \frac{\alpha\delta+\alpha}{2}$ establishing this proposition.

Accordingly, the optimal decision of retailer $(\beta^*,\, \delta)$ are in accordace with the linear relationship as below:

$$\beta^* = \frac{\alpha}{2}\delta + \frac{\alpha}{2}.$$

Therefore, the retailer can set the optimal discount level for the green procucts, through forecasting the probability for obtaining the products at discounted phase, so as to maximize the profits of GSC.

6 The pricing strategy under governmental financial interventions

The rational retailer makes the pricing decision aiming at maximizing its own profit, so the decision maker will not mind the impact of the real sales of green products on social welfare. According to the channel power theory, governments acting as mediators are regarded as the main power influencing the operation of GSC. Therefore, governments can implement the governmental financial interventions, such as the guiding price of green products and subsides for green products selling, so as to increase the real sales of green products for increasing the social welfare. Accordingly, the remainder of this paper will discuss the retailer's pricing strategy under the governmental financial interventions with guiding price and subsides.

According to the discussion as before, when the expected green degree θ exceeds the second critical value θ_2, strategic customers choose to purchase green products. Therefore, governments need to adjust θ_2, by intervntion instuments, to increase the real sales of green products. Therein, total demand of green products is Q comprised of the full-price demand q_1 and the discount-price demand q_2, so $Q = q_1 + q_2$. Thus, the sales of green products is:

$$r = \int_{\theta_1}^{e} f(\theta)\mathrm{d}\theta + \int_{\theta_2}^{\theta_1} f(\theta)\mathrm{d}\theta = \int_{\theta_2}^{e} f(\theta)\mathrm{d}\theta = 1 - \frac{\beta p}{\alpha ke}.$$

Then, we discuss how retailer's decision (δ, β) affect the real sales of green products.

Proposition 3 (1) *β is constant, the changes of δ have no effects on θ_2, r and Q;*
(2) *If δ is constant and β increases, θ_2 will increase and r will decrease and Q will decrease;*
(3) *If δ is constant and β decreases, θ_2 will decrease and r will increase and Q will increase.*

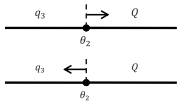
Proof For the equation $r = 1 - \frac{\beta p}{\alpha k e}$, we take the derivative of δ and β then find that

$$\begin{cases} \dfrac{\partial r}{\partial \delta} = 0, \\ \dfrac{\partial r}{\partial \beta} = -\dfrac{p}{\alpha k e} < 0, \end{cases}$$

so the proposition 3 is proven to be established.

Therefore, the probability for obtaining the products at discounted phase has no influence on the real sales of green products as what we have discussed, however, retailer can, by ajusting the discount level, increase the real sales of green products. The details are tabulated in Table 2.

Table 2 The influence of retailer's decision on the real sales of green products

Decision Variables of Retailer		Critical Value θ_2	Real Sales r	Total Demand $Q = q_1 + q_2$	Market Structure
δ	↑	–	–	–	–
	↓	–	–	–	–
β	↑	↑	↓	↓	
	↓	↓	↑	↑	

We regard $\underline{r}$ as the lowest governments' expected sales of green products, that is $s > \underline{s}$, $1 - \frac{\beta p}{\alpha k e} > \underline{s}$, correspondingly, retailer set the discount level $\beta < \frac{\alpha k e(1-\underline{s})}{p}$. Therefore, we suggest the optiamal discount level $\beta^{**} = \frac{\alpha k e(1-\underline{s})}{p}$ under governmental financial interventions is $^{**} = \frac{\alpha k e(1-\underline{s})}{p}$ and $p_G = p\beta^{**} = \alpha k e(1-\underline{s})$ is considered as the guiding price for the discount selling.

To stimulate retailer keeping the desire for selling green products within the constraint of guiding price, governments need to provide some subsides, so as to hold up the profit of retailer. Therefore, the condition of retailer's paticipation is:

$$\Pi(\beta^{**}) + A \geq \Pi(\beta^{*}).$$

Therein, A is the subsides governments provide to the retailer, and $A \geq \Pi(\beta^{*}) - \Pi(\beta^{**})$. After receiving subsides, the retailer prefers to decrease the discount level to increase the real sales of green products, so we also regard A as the social welfare provided by governments. Accordingly, governments can, by setting the guiding price, on the one hand, lead the strategic customers purchasing green products to hold up the sales of green products; and on the other hand, the economic incentives provided by governments, such as subsides, can stimulate retailers and maintain the demand for green products.

7 Conclusions

Along with the increasing of environmental problems and the raising of consumer demand for green products, GSC management draws high attention in theory and practice circle.

This paper has aimed through GSC, on the basis of Stackelberg's game theory, to research the interactions between strategic customer behavior and the retailer's pricing strategy and the government intervention. The results have shown that the retailer can, by adjusting orders to change the probability for obtaining the products at discounted phase, lead the strategic customers to purchase the green products at full price phase or discount phase, but cannot increase the real sales of green products; however, the retailer can, by adjusting the discount level, increase the real sales of green products. In addition, this paper has solved and proved the retailer's optimal pricing strategy and the uniqueness of equilibrium solution, thereby allowing the retailer to set the optimal discount level for the green products, through forecasting the probability for obtaining the products at discounted phase, so as to maximize the profits of GSC. Finally, this paper has discussed the effects of governmental financial interventions, such as guiding price and subsides, on the sales of green products and social welfare, and then solved the retailer's pricing strategy under governmental financial interventions. This paper then has suggested governments can, by setting the guiding price, lead the strategic customers purchasing green products to hold up the sales of green products on the one hand; on the other hand, the economic incentives provided by governments, such as subsides, can stimulate retailer to sell green products.

However, the conclusions above are based on a number of hypothses. On the one hand, the condition of demand certainty is apparent throughout the whole paper, so the pricing strategy under uncertain demand becomes the focus for future research. On the other hand, this paper only researches the retailer's pricing strategy at the end of GSC, but GSC is a multi-echelon system comprised of many stakeholders, accordingly, the pricing strategy and coordination mechanism in two-echelon or multi-echelon GSC as well as the design of contracts are likewise the direction of further research.

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