Study on the Supervising Mechanism of Ecological Products Market under Asymmetric Information

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Abstract Considering a really bad situation of the ecological market, such as untruth prices, some manufacturers' shoddy and using ordinary products instead of ecological products and so on, we focused on the government supervision. Firstly, we analyzed quantitatively the difficulties and obstacles of government supervising on the ecological product market under asymmetric information. Further, considering the government as decision-maker, we constructed the adverse selection model of government supervision to maximize the total social welfare and proposed the contract menu about transfer payment, production quantity, and price limit. In the last, we deeply analyzed the efficiency of the supervising mechanism and its effect on the ecological product market. The research results show that in the early stage of the market, the supervising mechanism can avoid the high ecological level manufacturers from obtaining the information rents, thus effectively restrain the overpriced phenomenon in the ecological product market. The results of this paper provide better theoretical support and decision-making reference for the government to supervise the market of ecological products so as to promote the benign and sustainable development of ecological products market.

1. Introduction

With the worsening of ecological environment and frequent outbreaks of environment, health and food safety accidents, in order to meet the needs of the people's health and life, ecological products [1] get more and more attention of consumers, ecological product market has been gradually establishing and developing, from ordinary daily necessities such as ecological eggs, rice, ecological clothing to some life's durable goods such as ecological air-conditioner, automobile, etc. Ecological product market, as a new kind of market with strong public welfare and premium price, lack of standard market operating systems and rules and shows some shortcomings and inefficiencies, such as untruth prices, some manufacturers' shoddy and using ordinary products instead of ecological products [2], thus some complaints of consumers have arisen. Should the government regulate the eco-products market? How can they regulate? It has become a dilemma choice for the government. On the one hand, the bad market behavior will not only harm the interests of consumers but also lead to unreasonable allocation of resources, which will damage the whole social welfare. On the other hand, improper government regulation can cause problems such as loss of efficiency of manufacturers and disturb the market process. In order to promote the benign and sustainable development of ecological products market, the answers to the following questions are very

important, such as how to motivate and lead the market efficiently? How to regulate the premium price at a reasonable range while giving full play to the ecological public welfare?

At present in the research areas about government's guidance and regulation of ecological products, the topics mainly involved the ecological (low carbon, green) production mode, ecological consumption, and ecological product quality, and the main research issues focused on the importance and significance of the ecological regulation[3-4], supervising policy [5-6] and impact on business decisions [7-8], etc. The vast majority of the above research is qualitative and empirical research. The minority has been done by using the mathematical model, but mainly considered the enterprise as the decision-maker, government parameters as exogenous variables or constraints into the decision-making model, and focused on the influence of government fines, subsidies on strategy of enterprises. Aiming at the characteristics of public welfare and premium price of the ecological product, considering the asymmetric market information, we build the adverse selection model of government regulation to maximize the total social welfare and propose the contract menu about transfer payment, production quantity, and price limitation. The paper quantitatively analyzes the government's supervising dilemma under asymmetric information and the efficiency and influence of government supervising on ecological products market. The research results can provide theoretical support and decision-making reference to help the government to make a reasonable guide policy in the ecological product market.

2. Supervising models under symmetric information

2.1. Basic model description

Ecological products are beneficial to improving the environment and human life, keeping health and so on. They can simultaneously satisfy consumer's dual requirements of usage value and ecological value. So, they have a premium price. To model this problem, we assume that the governments transfer payment to the unit's ecological product is S. To avoid the high ecological level manufacturers who obtained the government subsidy further increase the selling price and limit the sales volume to obtain the excess profits, we supposed the quantity supplied by the eco-manufacturer should not be lower than Q, and the payment limit of the consumer to the eco-manufacturer is T. Assuming the social cost that the government take 1 unit of money is $(1 + g)$, of which $g > 0$. To simplify the solution of the model, assume the fixed cost of the manufacturer is zero. The manufacturer's production cost is $C(Q) = (c + e)Q$, and $(c + e)$ is the marginal cost of production for ecological products. $e(e \geq 0)$ is the additional production cost for ecological value, such as the cost of energy conservation and emissions reduction, acquisition of green materials et al, in other words, it is the ecological cost of the product. Without loss of generality, considering that e is positively related to the ecological level of products. The larger e is, the higher the ecological level of products is. When $e = 0$, it means the product is a traditional product.. Assume that the utility function of a consumer is $U(Q)$. The government makes decisions according to T, S, Q. To let the manufacturers and consumers participate in the trade, and maximize the social welfare, the government's problems can be modeled as:

$$\max_{(T,S,Q)} \left\{ \left[U(Q) - TQ \right] + \left[TQ + SQ - (c+e)Q \right] - (1+g)SQ \right\}$$

$$s.t. \quad TQ + SQ - (c + e)Q \geq 0$$

$$U(Q) - TQ \geq 0$$

2.2. The efficiency and dilemma of government regulation

To solve the above basic model through the first-order approach, we can get proposition 1:

Proposition 1: $U'(Q) = T + S = e + c$

As can be seen from Proposition 1, the expected return of the eco-manufacturer (the willingness of consumers to pay) is equal to the limit payment (T) plus the transfer payment (S). That is $U'(Q) = T + S$. If the government transfer payments S=0, then $U'(Q) = T$. Proposition 1 shows that government bears the burden of consumption ecological product. In reality, government subsidy can be shown as a direct subsidy to eco-manufacturers or indirectly to consumers.

Proposition 1 demonstrates that under complete information situation, the supervising mechanism (T,S,Q) can realize the marginal revenue of the ecological manufacturer equal to the marginal cost, that is $U'(Q) = e + c$. Proposition 1 shows that the supervising mechanism is efficient and it can make the market of ecological products comply with the Ramsey pricing law (the marginal utility of an agent is equal to its marginal cost). However, in order to achieve the above regulation, the necessary condition is that the government must master the relevant information. It means that the government needs to know the exact marginal production cost of the eco-manufacturer $(c + e)$ and the consumer demand for the eco-products in the market.

In reality, the government can understand the production cost information of non-ecological part (c) through the ordinary manufacturers; however, it is difficult to grasp the ecological cost information(e), which is the private information of eco-manufacturers. The higher the ecological cost (e) is, the higher the consumer willing to pay. The bigger (T+S) the vendor gets.

Therefore, out of self-interest, the manufacturer prefers hiding the ecological cost information, and even disguises the traditional product as the high ecological level products. So, the government needs to solve the problem of adverse selection under asymmetric information.

3. The regulation model under asymmetric information

According to The Principal-Agent Theory, the ecological product information is asymmetry, and producers have the tendency to show high-cost type (high level of ecological) signal. In order to protect consumers' rights and interests, the government should provide different $\mathbf{T, S, Q}$ to different eco-level manufactures based on the manufacturer's prior probability. So, we design a set of supervising contracts menu to reveal the vendor's real types.

Suppose there are two possible vendor types, one of which is the high ecological level, its cost is e^H, the other is low ecological level, it's cost is e^L, $e^H > e^L$. To enable manufacturers to choose their preferred contracts, the government offers a menu of contracts that is $\{(T^H, S^H, Q^H), (T^L, S^L, Q^L)\}$.

The contract must satisfy two conditions: participation conditions and incentive compatibility conditions [1,8]. Participation conditions require that both types of manufacturers and consumers accept the contract. The incentive compatibility condition requires that the best interest can be obtained only when the manufacturer selects a supervising contract that is designed for its own type. Under both previously described condition, in order to maximize the social welfare, the government makes decisions based on the prior probability θ(when $e = e^H$) and $(1 - \theta)$ (when $e = e^L$) of the manufacturer's ecological level. Thus, the following government regulation model can be established:

$$\max_{\{((T^H, S^H, Q^H), (T^L, S^L, Q^L))\}} \begin{cases} \theta[U(Q^H) - T^H Q^H] + (1 - \theta)[U(Q^L) - T^L Q^L] + \\ \theta[T^H Q^H + S^H Q^H - (c + e^H)Q^H] \\ +(1 - \theta)[T^L Q^L + S^L Q^L - (c + e^L)Q^L] \\ -[\theta(1 + g)S^H Q^H + (1 - \theta)(1 + g)S^L Q^L] \end{cases} \tag{1}$$

$$\text{s.t.} \quad T^H Q^H + S^H Q^H - (c + e^H)Q^H \geq 0 \tag{2}$$

$$T^L Q^L + S^L Q^L - (c + e^L)Q^L \geq 0 \tag{3}$$

$$U(Q^H) - T^H Q^H \geq 0 \tag{4}$$

$$U(Q^L) - T^L Q^L \geq 0 \tag{5}$$

$$T^H Q^H + S^H Q^H - (c + e^H)Q^H \geq T^L Q^L + S^L Q^L - (c + e^H)Q^L \tag{6}$$

$$T^L Q^L + S^L Q^L - (c + e^L)Q^L \geq T^H Q^H + S^H Q^H - (c + e^L)Q^H \tag{7}$$

Formula (1) is the objective function of government regulation, namely maximization of social welfare; Formula (2) and (3) are the participation constraints of manufacturers in the case of high ecological level and low ecological level; Formula (4) and (5) are the participation constraints of consumers; Formula (6) and (7) are incentive compatible constraints, that is, to ensure that manufacturers are only interested in the regulation contracts designed for themselves, and are unwilling to pass themselves off as other types. Easy to know formula (3) is implicit in formula (2) and formula (7), which are non-tight constraints.

Applying the Lagrange multiplier of formula (2), (4), (5), (6) and (7) is respectively as $\alpha, \beta, \gamma, \xi, \kappa,$ Lagrangian first order conditions for solving $T^H, S^H, T^L, S^L, Q^H, Q^L$, then solve the first order condition of Lagrange, we have the following equations:

$$\alpha = g, \beta = \theta g, \kappa = (1 - \theta)g + \xi, \gamma = \kappa - \xi; U'(Q^H) = (c + e^H) + \kappa(e^H - e^L)/[\theta(1 + g)];$$

$$U'(Q^L) = (c + e^L) - \xi(e^H - e^L)/(1 - \theta + \gamma)$$

4. Analysis on market characteristics and supervising efficiency under asymmetric information

4.1. Market characteristics

Proposition 2: $\xi = 0$, the high ecological level manufacturer is unwilling to disguise as a low ecological level manufacturer.

Proof: because $\kappa = (1 - \theta)g + \xi > 0$, according to the K-T condition:

$$T^L Q^L + S^L Q^L - (c + e^L)Q^L - [T^H Q^H + S^H Q^H - (c + e^L)Q^H] = 0 \tag{14}$$

If $\xi > 0$, According to the K-T condition:

$$T^H Q^H + S^H Q^H - (c + e^H)Q^H - [T^L Q^L + S^L Q^L - (c + e^H)Q^L = 0 \tag{15}$$

By the equations (14) and (15), we can get: $(C^L - e^H)Q^H = (C^L - e^H)Q^L)$, it means $Q^H = Q^L$.

But, because $U'(Q^H) = (c + e^H) + \frac{g(1-\theta)(e^H - e^L)}{[\theta(1+g)]}$, then $U'(Q^H) - (c + e^H) > 0$;

If $Q^H = Q^L$, then $U'(Q^H) = U'(Q^L)$, it means $U'(Q^L) - (c + e^H) > 0$, so $U'(Q^L) - (c + e^L) > 0$, it contrary with $U'(Q^L) - (c + e^L) = -\xi(e^H - e^L)/(1 - \theta + \gamma) < 0$. so $\xi > 0$ is false, so $\xi = 0$.

That is, as for incentive compatible conditions (6), the left side is greater than the right forever. It means that the utility of the high eco-manufacturer is greater than that of the low eco-manufacturer. Therefore, the high eco-manufacturers in the market will not disguise themselves as low ecological manufacturers.

Because $\xi = 0$, then $= (1 - \theta)g, \gamma = \kappa$, so lagrangian multipliers are $\alpha, \beta, \kappa, \gamma > 0$, according to the K-T condition, we can get the following equations:

$$T^H Q^H + S^H Q^H - (c + e^H)Q^H = 0 \tag{16}$$

$$U(Q^H) - T^H Q^H = 0 \tag{17}$$

$$U(Q^L) - T^L Q^L = 0 \tag{18}$$

$$T^L Q^L + S^L Q^L - (c + e^L)Q^L - T^H Q^H - S^H Q^H + (c + e^L)Q^H = 0 \tag{19}$$

Proposition 3: $Q^H < Q^L$, it means that quantity of high ecological products on the market is smaller than that of low ecological products.

Proof: by equation (19) , it can be obtained that: $Q^L[T^L + S^L - (c + e^L)] = Q^H[T^H + S^H - (c + e^L)]$, because $T^L + S^L < T^H + S^H$, then $T^L + S^L - (c + e^L) < T^H + S^H - (c + e^L)$, so $Q^H < Q^L$.

Proposition 3 shows that the quantity of high ecological product will be strictly less than that of low ecological products. Generally, high-level ecological vendors often decrease the market sales to win super profits.

Proposition 4: $U'(Q^H) = (c + e^H) + g(1 - \theta)(e^H - e^L)/[\theta(1 + g)]$; $U'(Q^L) = (c + e^L)$.

From Proposition 4, it can be seen that, under adverse selection, consumers' willingness to pay for high ecological products is greater than their marginal cost, and high eco-manufacturers obtain information rent ($g(1 - \theta)(e^H - e^L)/[\theta(1 + g)]$) due to the asymmetry of ecological cost information; The willingness of consumers to pay for low ecological products is equal to their marginal cost. Proposition 4 shows high ecological products can get high premium price in the market, mainly due to the asymmetry information of product's ecological level. Consumers will pay prices through expectations of a gap ($e^H - e^L$) in the ecological level of high ecological products and low ecological products.

$$\text{Make } \omega = U'(Q^H) - (c + e^H), \Delta = e^H - e^L, \text{ then } \omega = g(1 - \theta)\Delta/[\theta(1 + g)]$$

Lemma 1 $\partial\omega/\partial\Delta > 0, \partial\omega/\partial\theta < 0$.

From Lemma 1, we know that the larger the value of ecological products is, the higher the information rent eco-manufacturers can get. This can explain the fact that the higher the ecological level of the product is, the more obvious is the premium phenomenon. Due to the asymmetry of ecological cost information, consumers' payment of ecological products mainly depends on their expectation of ecological value (Δ). According to lemma 1, as the probability (θ) of high ecological manufacturers increases in the market, the information rent of eco-manufacturers will decrease. When eco-manufacturers in the market all have the high ecological level, it means $\theta=1$, the information rent is zero. On the contrary, when there are fewer high eco-manufacturers in the market, more information rent is available.

4.2. The efficiency of government regulation under asymmetric information

Proposition 5: $T^H + S^H = c + e^H$; $c + e^L < T^L + S^L < c + e^H$

Solve combined equations (16) and (19), we can get proposition 5.

According to Proposition 5, under asymmetric information, government regulation can realize the marginal revenue of high ecological manufacturer equals to its marginal cost. Proposition 5 shows that, under the asymmetric information, the government can avoid low ecological companies disguising as high ecological manufacturers by distorting low ecological vendor contracts and relaxing price limit of low ecological products.

From Proposition 4 and Proposition 5, we can get lemma 2.

Lemma 2 $T^H + S^H = U'(Q^H) - g(1 - \theta)(e^H - e^L)/[\theta(1 + g)]$; $U'(Q^L) < T^L + S^L < c + e^H$

Lemma 2 shows that the regulation mechanism can avoid the high eco-manufacturer obtaining information rent ($g(1 - \theta)(e^H - e^L)/[\theta(1 + g)]$). This can effectively restrain the high premium price of high ecological products in the market.

The government can also increase transfer payments (S^H) to reduce consumers' pay limit (T^H) for high ecological products. Thus can improve consumer's purchasing power to high ecological products; By Lemma 2 we know that the marginal utility of consumers' consumption of low ecological products is lower than their price (T^L) plus transfer payments (S^L), and it means that the value of consuming high ecological products is higher than that of consuming low ecological products.

Proposition 5 and lemma 2 show that the regulation mechanism has a positive effect. It can avoid high ecological vendors obtaining information rent, and achieve the marginal profit of high ecological manufacturer equals to its marginal cost, so as to optimize the market allocation of resources. The smaller θ is, it means when the majority of manufacturers are low eco-level manufacturers in the market, the fewer the amount of high eco-manufacturers is, the more effective government regulation is.

5. Conclusions

For the ultra-premium problems of ecological products, and considering the characteristics of public welfare of ecological products, we analyze quantitatively the difficulties and obstacles of government supervising on the ecological product market under asymmetric information. Further, standing in the government's perspective, we construct the adverse selection model of government regulation to maximize the total social welfare and propose the contract menu about transfer payment, production quantity, and price limit.

The research results show that the asymmetric information of ecological product leads to low allocation efficiency of resource in the ecological product market. For example, high ecological manufacturers access to information rent and win the excess profit, and low ecological manufacturers conceal their true ecological level, even pretending to be a high ecological manufacturer. However, through a set of separate regulation contract menu ($\{(T^H, S^H, Q^H), (T^L, S^L, Q^L)\}$), it is possible to effectively restrain the ultra-premium of high ecological products, improve the allocation efficiency of resource in the ecological product market.

The results show that in the early stage of the market, high eco-level manufacturers are less (θ smaller) and government regulation is of great significance to the benign and sustainable development of the market. It can avoid the impact of the information asymmetry on the market. However, the implementation of government regulation depends on the balance between the regulation costs and outcome. It has tended to over-rely on the empirical data of the ecological product market, such as ecological cost information (e), the prior probability (θ) of the eco-manufacturers in the market, and so on.

Acknowledgments

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