Analyses of Green Products in Duopoly Market on the Base of Environment Quality Model

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Abstract—Since 21st Century, "green wave" has been quickly coming into our real life which has influenced every single part of our lives. Green product has become hot topic from then on. With the development of green products as well as its building-up market, our government meets new challenges from making environmental protection policies. In this paper, an environmental quality model is set up in the duopoly market. Through analysis, it can be drawn that government policies, especially strict regulations will sometimes have negative impact on the environment. Therefore only a comprehensive policy of government policies and financial subsidies can truly protect the environment.

Index Terms—Green products, environmental quality, duopoly market, government policies

I. INTRODUCTION

Green products, we define them as having a positive impact in that they reduce the environmental impact of other products (Dangelico 2010). As the pace of the globalization and economic development has ever fastened than before, the need of sustainable development is stronger around the world. “Green wave” is not a fashion but necessary today.

For a market, green attributes must be taken into account when designing and developing the new products. But not all of them can have the final green attributes. Hence customers, manufacturers, government property are all concerned about the green product. The demand of green products comes from customers’ awareness of environmental values and needs (Simon 1992). Customers should be segmented into two parts by their environmental awareness and attitudes (Simmons Market Research Bureau 1992). Customers with positive environmental attitude are more willing to pay the environmental premium (Eriksson 2004). A report from survey conducted by the Gallup International Institute (1992) shows that 65% of Americans, 59% of Germans, and 31% of Japanese will pay a green premium for an eco-safe product.

Governments around the world have set many environmental standards and subsidies for green products. Many countries do have some related regulations. Most of them are useful, while the rest do not work well, or even counterproductively.

II. LITERATURE REVIEW

Lancaste pointed out that product is a combination of different attributes and customers may have heterogeneous preferences over these attributes (1966). According to the U.S. EPA (1991), when “green” customers choose products, the environmental attributes is the most important criterion. “Green” consumers appear to take individual responsibility for the provision of public goods. The propensity to take such responsibility may depend on the beliefs about others’ behavior, even for consumers motivated by internalized moral norms, not by social sanctions (Nyborg 2006). And “green” consumers’ willingness to pay the environmental premium may be uniformly or non-uniformly distributed (Eriksson 2004). L. Bird, show that, in the electricity market, more than 10% customers prefer to choose green power, with a premium will be paid (2002). For the green product manufactory, high environmental performance is signaled through high prices for less polluted products are more costly to produce (Mahenc 2006). Many firms are attempting to make their products less environmentally harmful. However, marketers and others within the firms often limit the environmental expertise (Polonsky 1998). For manufacturers, the cost of green products is too high, and high cost will inevitably bring a high price. Since the customers who have special preferences for green products do not care much about the price. So manufactory will offer both green and traditional products (Rlibago 1998).

III. FRAMEWORK

We assume that in a duopoly market, there are two manufacturers of similar size, manufacturers i and j. They can provide the market with two durable homogeneous products: traditional products and green products. All of these products contain just two competing attributes: the traditional attributes and environmental attributes. In this paper, we make qualities represent attributes. So the traditional attributes and environmental attributes change into traditional qualities and environmental qualities (denoted by Q_t and Q_e). Because of the competing nature of the two qualities, the sum of Q_t and Q_e is a constant and scaled to 1 (Chen 2001). There are more Q_e in green product than traditional product.

On the demand side, the market is divided into two parts, the ordinary and green segments (denoted by segments o and g). The unit of products will be given a positive value (denoted by V) by customer. In the ordinary market, there is only demand for the traditional qualities, so for a product formed by Q_t and Q_e, they just value it as V × Q_t. However, in the green market, traditional qualities and environmental qualities are all needed by customer, so they value the

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product as \( v_t q_t + v_e q_e \, (v_e > v_t > 0) \).

On the supply side, we assume that all products produced by the manufacturers can be digested by the market. The cost of a unit quality is \( C \). We assume \( C \) is the Variable cost of the product, \( C = c_q q + c_e q_e \, (c_e > c_q > 0) \). There is no fixed cost, which does not affect the result of this paper.

The market follows the Cournot-model. The output of two manufacturers are \( Q_i \) and \( Q_j \), so the total quantity is \( Q = Q_i + Q_j \), the market-clearing price is

\[
p = \begin{cases} \alpha - \beta Q & \alpha > \beta Q \\ 0 & \alpha \leq \beta Q \end{cases}
\]

Without cooperation, the profit function of manufacturer \( i \) is

\[
\pi = Q_i (p - C) = Q_i (\alpha - \beta (Q_i + Q_j) - C) = -\beta Q_i^2 + (\alpha - C)Q_i - \beta Q_i Q_j
\]

For the customer, every product will provide consumer's surplus, we defined it as \( S (v_q, q) \). Customers determine how much to buy based on the consumer's surplus provided by the manufacturer and its competitor. And because of products from two manufacturers are homogeneous, customers give them the same value, \( S_i = S_j \), we can get that

\[
Q_i^c = Q_j^c = a - bS + dS_i = a + (d - b)S
\]

IV. MARKET-SEGMENTATION AND NON-MARKET SEGMENTATION STRATEGIES

For manufacturers in the duopoly market, they can take two different strategies, market segment (provide ordinary segment with traditional products, green segment with green products) and non-market segment (provide two segments with traditional products) strategies. So there will be three cases in the market. Firstly, all the manufacturers adopt the non-market segment strategy. Second, they all adopt market segment strategy. The last one, one of them adopt market segment strategy, another one adopt non-market segment strategy. For the third case, in the rational market, the manufacturers are \( Q_i \) and \( Q_j \), so the total quantity is \( Q \, (Q = Q_i + Q_j) \), the market-clearing price is

\[
p = \begin{cases} \alpha - \beta Q & \alpha > \beta Q \\ 0 & \alpha \leq \beta Q \end{cases}
\]

Without cooperation, the profit function of manufacturer \( i \) is

\[
\pi = Q_i (p - C) = Q_i (\alpha - \beta (Q_i + Q_j) - C) = -\beta Q_i^2 + (\alpha - C)Q_i - \beta Q_i Q_j
\]

For \( j \),

\[
\pi = Q_j (p - C) = Q_j (\alpha - \beta (Q_i + Q_j) - C) = -\beta Q_j^2 + (\alpha - C)Q_j - \beta Q_i Q_j
\]

manufacturer who adopts the non-market segment will lose green customer, it is not responsible for the profit. So this case will not happen.

A. Traditional Products on the Market Only

There are no green products on the market, so the green customers will join the ordinary segment. In this way, all customers in the market value a unit of \( q \) as \( v_q q_t \).

So, the one of the manufacturer’s output is

\[
Q_j = Q_i = a + (b - d)(p - v_q q_t)
\]

When the profit gets the maximization, the price of the product is

\[
p = \frac{\alpha - 2a \beta + 2b(b - d) v_q q_t}{1 + 2b(b - d)}
\]

And the quality of product is

\[
q_t^* = \frac{(\alpha + 2c_e)(1 + 2b(b - d)) + 6a \beta - 3a}{6b(b - d) v_t + 2(c_e - c_c)(1 + 2b(b - d))}
\]

These are the qualities for the traditional products when the Maximum benefit is arrived.

B. Market Segmentation Strategy

When the second case happens, for maximize the who market’s profit, manufacturers will consider two segments together, so there are

\[
\max \pi_1 = Q_i (p_o - C_o) + Q_j (p_g - C_g)
\]

\[
\max \pi_j = Q_i (p_o - C_o) + Q_j (p_g - C_g)
\]

We can get that,

\[
Q_o = Q_j = \frac{\alpha - C_o}{3 \beta_o}
\]
\[ Q_{i\alpha} = Q_{e\alpha} = \frac{\alpha_{i} - c_{i} - (c_{e} - c_{i})q_{e\alpha}}{\beta_{i}} \]
\[ \max_{\pi_{i}} = \max_{\pi_{j}} = \frac{(\alpha_{i} - c_{i})^{2}}{9\beta_{i}} + \frac{(\alpha_{e} - c_{e})^{2}}{9\beta_{e}} \]

In the traditional segment, customers value \( q \) as \( v_{c}q_{ct} \) and in the green segment, it will be \( v_{c}q_{ct} + v_{e}q_{e} \)

V. EFFECTS OF GOVERNMENT’S POLITICAL STANDARDS ON ENVIRONMENT

To protect the environment, government usually sets minimum environmental standards. Once lower than the standards, there would be a serious punishment, which is the case no manufacturer is willing to see. We assume the minimum environmental standard in duopoly market is \( r \), and \( q_{e}^{e*} < r < q_{e}^{e*} \). What if \( r \leq q_{e}^{e*} \), any product will be up to this standard, there is useless for protecting the environment. However, if \( r > q_{e}^{e*} \), none products can satisfy it which is beyond reality. And the environmental quality in all products including green products and ordinary products must be more than \( r \).

Firstly, we focus profits. There are two cases,

\[ q_{e}^{e*} < r \leq q_{e}^{e} \quad \text{and} \quad q_{e}^{e*} < r \leq q_{e}^{e} \]

when \( q_{e}^{e*} < r \leq q_{e}^{e} \),
\[ \pi_{1} = \frac{(\alpha_{e} - c_{e} - c_{i})q_{e}^{e}}{9\beta_{e}} \]
\[ \pi_{2} = \frac{(\alpha_{e} - c_{e} - c_{i}r)^{2}}{9\beta_{e}} + \frac{(\alpha_{e} - c_{e} - (c_{e} - c_{i})q_{e}^{e})^{2}}{9\beta_{e}} \]

On the other hand, when \( q_{e}^{e*} < r \leq q_{e}^{e} \),
\[ \pi_{1} = \frac{(\alpha_{e} - c_{e} - c_{i}r)^{2}}{9\beta_{e}} \]
\[ \pi_{2} = \frac{(\alpha_{e} - c_{e} - (c_{e} - c_{i})q_{e}^{e})^{2}}{9\beta_{e}} + \frac{(\alpha_{e} - c_{e} - (c_{e} - c_{i})q_{e}^{e})^{2}}{9\beta_{e}} \]

No matter in which cases, \( \pi_{2} \) will decrease when \( r \) increases, there may be a \( r' \), when \( r > r' \), the \( \pi_{2} \) will be less than \( \pi_{1} \). For more profit, the manufacturer will use non-market segmentation strategy instead of market segmentation strategy.

Secondly, we take the total environmental qualities in the market into account.

When \( q_{e}^{e*} < r \leq q_{e}^{e} \), they have
\[ TG_{1} = Q'q_{e}^{e}, \quad TG_{2} = Q'r + Q_{e}^{e}q_{e}^{e} \]

And when \( q_{e}^{e*} < r \leq q_{e}^{e} \), there are
\[ TG_{1} = Q'r, \quad TG_{2} = Q'r + Q_{e}^{e}q_{e}^{e} \]

No matter in which cases, they all have \( TG_{2} > TG_{e} \). So, when \( r > r' \), the manufacturer will choose non-market segmentation strategy, where there is a side-effect to the environment. That is the case we do not want to see, and the strict environmental policy will play the opposite role.

VI. CONCLUSION

We discuss a market with three parts, customers, manufacturers and governments, which play as demander, supplier and policymaker respectively. Since green products do have positive effect on environment which government wants to protect, government should be responsible for the market as a supervisor. On the demand side, we show how customers can maximum their satisfaction by buying ordinary products and green products. On the supply side, we analyze the green market, and how much green qualities can get when the manufacturers achieve the peak of profit. On the policy side, we suggest that government should give financial subsidies to green products to lower the price and enlarge the market. Strict regulations, sometimes, may have a negative effect on improving the environment. In the future, we hope that the model in this paper can be applied in other kinds of markets, such as perfectly competitive market and imperfectly competitive market.

REFERENCE