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Eco-labelling under International Oligopoly*

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1. Introduction

In recent years, great concern for environment has been growing. Many countries have been taking various kinds of measures to protect environment. Eco-labelling program is one of those measures. Since Germany introduced the ¯rst eco-label called \Blue Angel" in 1977, similar programs have been introduced in more than 26 countries/regions.[1]

It is usually di±cult for consumers to know how environmentally friendly what they consume are. Eco-labelling provides consumers with more information about the environmental e®ects of goods they consume. Thus, eco-labelling programs could a®ect consumer behaviors. In particular, those who are sensitive to environment strongly prefer labeled products to non-labeled products in the same category. This change in consumer behavior helps to raise environmental standards in production. When goods with eco-labels are sold better, producers have incentives to obtain an eco-label, that is, an incentives to produce environmentally friendly products and/or adopt environmentally friendly technologies.

However, it has been pointed out that eco-labelling is voluntary and open to any producers, but it gives domestic producers competitive advantage over foreign producers; that is, eco-labelling is a trade barrier (e.g. see Vossenaar (1997)). This is mainly because the development and implementation of an eco-labelling system is likely to be a®ected by domestic producers alone. As a result, discrimination against foreign producers could arise. For example, a scheme may require foreign producers to meet the same criteria that may be unimportant and/or inappropriate in their home countries.

Although a number of countries/regions adopt eco-labelling programs, the criteria are in fact di®erent across countries/regions. Thus, the issue of trade and eco-labelling has been argued in GATT/WTO and ISO (e.g. see Chakarian (1997); Henry (1997)).[2] In particular, eco-labelling may cover processes and production methods (PPMs). However, trade restrictions based on PPMs are prohibited under GATT/WTO.

[1] The Japanese \Eco-Mark" and the United States \Green Seal" were introduced in 1989.

[2] Global Eco-labelling Network(GEN) was established among twelve countries in 1994 in order to exchange information and enhance cooperation regarding eco-labelling.

Although eco-labelling (in particular, the issue of generically modi¯ed products) has recently been a hot issue, there are only few studies that investigate eco-labelling, particularly the relationship between eco-labelling and international trade.[3] The purpose of this paper is to analyze the following aspects of eco-labelling in the framework of an international oligopoly.

First, we compare di®erent types of eco-labelling. It is known that there are three types of eco-labelling (e.g. see Environment Canada (1997)). Type I is criteria-based, third-party certi¯cation programs. This type includes German \Blue Angels" and Japanese \Eco-Mark". Type II is information self-declaration programs. An example is the Canadian Environmental Choice Programme launched in 1988. Type III is quali¯ed product information label programs, using preset indices. So far, there has been no consensus of usage of these three types. Our analysis sheds some lights on this issue.

Second, we consider a possibility of eco-labelling being a trade barrier in our model. We also compare eco-labelling with another environmentally friendly measure, emission standards. A signi¯cant di®erence between eco-labelling and emission standards is that the former is voluntary and open to both domestic and foreign producers, but the latter is compulsory for those who supply to the domestic market.

Third, we examine how a foreign eco-labelling program a®ects the domestic one. Although the number of countries that introduce eco-labelling is increasing, yet the harmonization among programs is far from completion. Thus, it is important to analyze this question.

The rest of paper is organized as follows. Section 2 describes the basic framework. We analyze eco-labelling under perfect information in Section 3 and under imperfect information in Section 4. Section 5 examines how a foreign eco-labelling program a®ects the domestic one. Section 6 compares eco-labelling with emission standards. Section 7 concludes the paper.

[3] Zarrilli et al. (1997) is a collection of papers that analyze eco-labelling and international trade.

2. Eco-labelling and Demand for Goods

There are two countries (home and foreign) and three goods (X, Y, and Z). Goods X and Y are differentiated goods, and are imperfect substitutes. Good X is produced by a single firm in the home country (firm x), while good Y is produced by a single foreign firm (firm y). These firms compete in the home market. The production of goods X and Y emits pollution which is proportional to the output to and damages environment.[4] However, both firms can abate the emission. Good Z is produced in each country by a competitive industry and serves as a numeraire.

We assume that the cost structures are identical between the home and foreign firms. The marginal production cost is assumed to be zero for simplicity and the marginal abatement cost is given by $c(e_i)$, where e_i is the pollution emission per unit of firm i $(i = x; y)$. $c(e_i)$ is decreasing and convex in e_i and $c(e_0) = 0$, where e_0 is the emission level without any abatement. There are no fixed costs for production and abatement.

There are L identical consumers in the home country. The k-th consumer's utility is given by a simple quadratic utility function:[5]

$$U_k = \alpha x_k - \frac{\beta}{2} x_k^2 + \alpha y_k - \frac{\beta}{2} y_k^2 - \gamma x_k y_k + z_k - \theta(e_x x + e_y y); \qquad (2.1)$$

where $x_k; y_k$ and z_k are the k-th consumer's consumption of goods X, Y, and Z, respectively; and x and y are the total supply of goods X and Y, respectively. In addition, α, β, γ and θ are positive constants with $\beta > \gamma$. θ measures the marginal disutility from pollution.[6] Each consumer views the total pollution $(e_x x + e_y y)$ as exogenous.

The budget constraint of the k-th consumer is

$$p_x x_k + p_y y_k + z_k = I_k;$$

where p_x and p_y are the prices of goods X and Y; and I_k is the income of the k-th consumer. The price of good Z is set equal to one.

[4] One may think that pollution is emitted during consumption instead of production.

[5] For example, Markusen et al. (1993) uses the same utility function to examine the relationship between environmental policy and plant location.

[6] The consumers evaluate home and foreign pollution equivalently. This may be because pollution is transboundary.

Taking the environmental damage, each consumer maximizes her utility subject to the budget constraint. Noticing that $x = \sum_{k=1}^{L} x_k$, $y = \sum_{k=1}^{L} y_k$, and $z = \sum_{k=1}^{L} z_k$, we have the following first order conditions for $k = 1, 2, \ldots, L$:

$$\alpha - \beta x_k - \gamma y_k - \theta e_x - p_x = 0;$$

$$\alpha - \beta y_k - \gamma x_k - \theta e_y - p_y = 0.$$

From these conditions, we can derive the demand functions for goods X and Y as follows:

$$x = x(p_x, p_y, e_x, e_y) = \frac{\alpha L}{\beta + \gamma} - \frac{\beta L(p_x + \theta e_x)}{\beta^2 - \gamma^2} + \frac{\gamma L(p_y + \theta e_y)}{\beta^2 - \gamma^2}; \qquad (2.2)$$

$$y = y(p_x, p_y, e_x, e_y) = \frac{\alpha L}{\beta + \gamma} - \frac{\beta L(p_y + \theta e_y)}{\beta^2 - \gamma^2} + \frac{\gamma L(p_x + \theta e_x)}{\beta^2 - \gamma^2}. \qquad (2.3)$$

Firms X and Y can show the environmental quality of their goods through eco-labels. Here we assume that the emission level represents the environmental quality of the good. Since the demand for the differentiated goods depends on the quality of those goods as is shown in (2) and (3), firms x and y may try to take advantage of eco-labels to increase the demand for their products.

The effects of the eco-labels depend on their types. If the eco-labels reveal the actual quantified environmental information of the products, the firms can alter the demand for their products by using the eco-labels. Such types of eco-labels include what is called Type II or Type III eco-labelling. Type II or III labels reveal quantified information of products, but its verification may be conducted independently.

However, if the eco-labels only reveal the environmental criteria of the products, the consumers cannot know the actual environmental information of the products. If such eco-labels are on the products, the consumers know at least that the products satisfy the required criteria. However, the products may be more environmentally friendly. Then, the firms cannot fully alter the demand for their products through the eco-labels. This type of eco-labels includes Type I eco-labelling. Type I eco-label indicates the overall environmental quality of a product, and governments or third parties give a certificate after verification of the product.

3. Perfect Information and Eco-labelling

In this section, we consider a case with perfect information on the environmental quality, that is, a case where consumers can observe the actual emission levels. In the following, thus, we consider the following stage game. First, the home and foreign firms simultaneously choose the abatement technologies, i.e., the emission levels. Observing the abatement technologies, each consumer determines her demand. Then, the two firms simultaneously choose prices of their goods. Using the Nash equilibrium concept, we solve this game backward.

The profit functions for firms x and y are written as

$$\pi_x = \{p_x - c(e_x)\}x(p_x; p_y; e_x; e_y); \tag{3.1}$$

$$\pi_y = \{p_y - c(e_x)\}y(p_x; p_y; e_x; e_y): \tag{3.2}$$

With given e_x and e_y, the first order conditions for profit maximization are

$$\frac{\partial \pi_x}{\partial p_x} = \left\{ \frac{\alpha}{\beta + \gamma} - \frac{\beta(p_x + \theta e_x)}{\beta^2 - \gamma^2} + \frac{\gamma(p_y + \theta e_y)}{\beta^2 - \gamma^2} - (p_x - c(e_x)) \left(\frac{\beta}{\beta^2 - \gamma^2} \right) \right\} L = 0; \tag{3.3}$$

$$\frac{\partial \pi_y}{\partial p_y} = \left\{ \frac{\alpha}{\beta + \gamma} - \frac{\beta(p_y + \theta e_y)}{\beta^2 - \gamma^2} + \frac{\gamma(p_x + \theta e_x)}{\beta^2 - \gamma^2} - (p_y - c(e_y)) \left(\frac{\beta}{\beta^2 - \gamma^2} \right) \right\} L = 0: \tag{3.4}$$

We denote the solution functions as $p_x(e_x; e_y)$ and $p_y(e_x; e_y)$:

Using this, we can find the level of e_i chosen by each firm. For this, we first derive the effects of a change in the emission level on the commodity prices. Total differentiation of (6) and (7) yields

$$\frac{\partial p_i(e_x; e_y)}{\partial e_i} = \frac{-2\beta^2(\theta - c'(e_i)) + \gamma^2\theta}{4\beta^2 - \gamma^2}; \tag{3.5}$$

$$\frac{\partial p_j(e_x; e_y)}{\partial e_i} = \frac{\beta\gamma(\theta + c'(e_i))}{4\beta^2 - \gamma^2}; \tag{3.6}$$

for $i = x; y$, and $i \neq j$. Then the effects of a change in the emission level on the outputs of the firms are

$$\frac{dx}{de_x} = \frac{\partial x}{\partial p_x}\frac{\partial p_x}{\partial e_x} + \frac{\partial x}{\partial p_y}\frac{\partial p_y}{\partial e_x} + \frac{\partial x}{\partial e_x} = \frac{\beta L(2\beta^2 - \gamma^2)(\theta + c'(e_x))}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)}; \tag{3.7}$$

$$\frac{dy}{de_x} = \frac{\partial y}{\partial p_x}\frac{\partial p_x}{\partial e_x} + \frac{\partial y}{\partial p_y}\frac{\partial p_y}{\partial e_x} + \frac{\partial y}{\partial e_x} = \frac{\beta^2 \gamma L(\theta + c'(e_x))}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)}. \tag{3.8}$$

The effects of e_y is similarly derived. The effect of the emission of the home firm on the foreign profits is given by

$$\frac{d\pi_y}{de_x} = \frac{\partial \pi_y}{\partial p_x}\frac{\partial p_x}{\partial e_x} + \frac{\partial \pi_y}{\partial p_y}\frac{\partial p_y}{\partial e_x} + \frac{\partial \pi_y}{\partial e_x} = \frac{2\beta^2 \gamma L(p_y - c(e_y))(\theta + c'(e_x))}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)}. \tag{3.9}$$

Substituting $p_x(e_x; e_y)$ and $p_y(e_x; e_y)$ into (4) and (5) and using (8)-(12), we can derive the first order conditions:

$$\frac{\partial \pi_x}{\partial e_x} = -\frac{2\beta(p_x - c(e_x))(2\beta^2 - \gamma^2)(\theta + c'(e_x))}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} = 0; \tag{3.10}$$

$$\frac{\partial \pi_y}{\partial e_y} = -\frac{2\beta(p_y - c(e_y))(2\beta^2 - \gamma^2)(\theta + c'(e_y))}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} = 0. \tag{3.11}$$

Since $p_i > c(e_i)$ $(i = x, y)$ holds from (6) and (7), we must have

$$c'(e_x) = c'(e_y) = -\theta. \tag{3.12}$$

The emission levels of both firms must be the same at the equilibrium. We denote the emission level satisfying (15) as e_1; that is, $c'(e_1) = -\theta$.

Next we compare e_1 with the optimal emission levels from a point of view of domestic welfare. Domestic welfare is the sum of consumer surplus, profits, the disutility of pollution, and labor income:

$$W^H = \frac{\beta(x^2 + y^2)}{2L} + \frac{\gamma xy}{L} + \pi_x - \theta L(e_x x + e_y y) + L. \tag{3.13}$$

Note that a change in the emission level has no effects on the output level of the products when (15) is satisfied. Thus, as long as (15) is satisfied, we have

$$\frac{\partial W^H}{\partial e_x}\Big|_{e=e_1} = -\theta L x < 0; \tag{3.14}$$

$$\frac{\partial W^H}{\partial e_y}\Big|_{e=e_1} = -\theta L y < 0; \tag{3.15}$$

These inequalities imply the following proposition:

Proposition 1. The optimal level of the emission per unit in terms of domestic welfare is less than the equilibrium emission level under perfect information.

The following should be noted. First, the perfect information case above could arise under Type II or III eco-labelling that indicates the quantified information of the products, e.g., the actual emission level. That is, the above analysis can be applied to the case where both home and foreign firms actually obtain Type II or III eco-labels.

Second, Proposition 1 implies that the home government has an incentive to reduce the emission levels of both firms by means of trade or environmental measures. The government may have a temptation to employ such measures so that the home firm can take an advantage. The following proposition will support the statement.

Proposition 2. The optimal level of the foreign emission per unit from a point of view of domestic welfare is less than that of the home emission per unit.

[*The proof will be supplied.]

4. Imperfect Information and Eco-labelling

This section considers a case where consumers cannot observe the actual emission levels and the home government introduces Type I eco-labelling program. We assume that the home government selects the criterion of the products. The criterion is set on the emission level of the products. We denote that level by $\hat{e}$: If the emission level of a firm is less than $\hat{e}$, the product of the firm is given a certification and the firm can put the eco-label on its product. But it does not show the actual quantified information of the products. The actual level of the emission may be less than the criterion of the eco-labelling program. Thus, the consumers cannot know the actual emission level of the product, although they know that the maximum emission level is given by the criterion. When they cannot observe the actual level of emission, the firms cannot alter the demand for their products by changing the actual emission levels.

We first show that the emission levels chosen by firms are equal to $\hat{e}$ with a Nash equilibrium. Given the emission levels of the firms as e_x and e_y; the consumer demands for goods

X and Y are $x(p_x; p_y; \tilde{e}_x; \tilde{e}_y)$ and $y(p_x; p_y; \tilde{e}_x; \tilde{e}_y)$. Then firms' profit functions are written as

$$\pi_x = \{p_x - c(e_x)\}x(p_x; p_y; \tilde{e}_x; \tilde{e}_y); \tag{4.1}$$

$$\pi_y = \{p_y - c(e_x)\}y(p_x; p_y; \tilde{e}_x; \tilde{e}_y): \tag{4.2}$$

Note that e_i and $\tilde{e}_i$ may take different values here. The first order conditions for profit maximization with respect to the prices are

$$\frac{\partial \pi_x}{\partial p_x} = \left\{ \frac{\alpha}{\beta + \gamma} - \frac{\beta(p_x + \theta\tilde{e}_x)}{\beta^2 - \gamma^2} + \frac{\gamma(p_y + \theta\tilde{e}_y)}{\beta^2 - \gamma^2} - (p_x - c(e_x)) \left(\frac{\beta}{\beta^2 - \gamma^2} \right) \right\} L = 0; \tag{4.3}$$

$$\frac{\partial \pi_y}{\partial p_y} = \left\{ \frac{\alpha}{\beta + \gamma} - \frac{\beta(p_y + \theta\tilde{e}_y)}{\beta^2 - \gamma^2} + \frac{\gamma(p_x + \theta\tilde{e}_x)}{\beta^2 - \gamma^2} - (p_y - c(e_y)) \left(\frac{\beta}{\beta^2 - \gamma^2} \right) \right\} L = 0: \tag{4.4}$$

From (22) and (23), the prices turn out to depend on e_x, e_y, $\tilde{e}_x$, and $\tilde{e}_y$: We denote the solution functions for p_x and p_y as $p_x(e_x; e_y; \tilde{e}_x; \tilde{e}_y)$ and $p_y(e_x; e_y; \tilde{e}_x; \tilde{e}_y)$:

The effects of a change in the emission level of the firms on the prices are given by

$$\frac{\partial p_i(e_x; e_y; \tilde{e}_x; \tilde{e}_y)}{\partial e_i} = \frac{2\beta^2 c'(e_i)}{4\beta^2 - \gamma^2} < 0; \tag{4.5}$$

$$\frac{\partial p_j(e_x; e_y; \tilde{e}_x; \tilde{e}_y)}{\partial e_i} = \frac{\beta\gamma c'(e_i)}{4\beta^2 - \gamma^2} < 0; \tag{4.6}$$

for $i = x; y$, and $i \neq j$. The emission levels also change the total supply of the firms.

$$\frac{dx}{de_x} = \frac{\partial x}{\partial p_x}\frac{\partial p_x}{\partial e_x} + \frac{\partial x}{\partial p_y}\frac{\partial p_y}{\partial e_x} + \frac{\partial x}{\partial e_x} = \frac{\beta L(2\beta^2 - \gamma^2)c'(e_x)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} < 0 \tag{4.7}$$

$$\frac{dy}{de_x} = \frac{\partial y}{\partial p_x}\frac{\partial p_x}{\partial e_x} + \frac{\partial y}{\partial p_y}\frac{\partial p_y}{\partial e_x} + \frac{\partial y}{\partial e_x} = \frac{\beta^2\gamma L c'(e_x)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} < 0: \tag{4.8}$$

The effects of e_y is similarly derived.

Substituting $p_x(e_x; e_y; \tilde{e}_x; \tilde{e}_y)$ and $p_y(e_x; e_y; \tilde{e}_x; \tilde{e}_y)$ into (19) and (20) using (23)-(26), we obtain the following inequalities.

$$\frac{\partial \pi_x}{\partial e_x} = -\frac{2\beta(p_x - c(e_x))(2\beta^2 - \gamma^2)c'(e_x)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} > 0; \tag{4.9}$$

$$\frac{\partial \pi_y}{\partial e_y} = -\frac{2\beta(p_y - c(e_y))(2\beta^2 - \gamma^2)c'(e_y)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} > 0: \tag{4.10}$$

Thus, both firms emit as much as possible. That is, the equilibrium emission levels are given by $\bar{e} = e_x = e_y = \tilde{e}_x = \tilde{e}_y$. We should note that this is the case even with $\hat{e} = e_0$. Thus, if there is no eco-labelling system under imperfect information, the emission levels of both firms are equal to e_0.

The above analysis establishes the following proposition.

Proposition 1. Under Type I eco-labelling program, the actual level of the emission is identical to the criterion level $\hat{e}$.

We consider the effects of a change in the criterion of the eco-labelling. Notice that a change in $\bar{e}$ alters e_x, e_y, $\tilde{e}_x$, and $\tilde{e}_y$ simultaneously. We have the following results.

$$\frac{dp_x}{d\bar{e}} = \frac{dp_y}{d\bar{e}} = \frac{-(\beta - \gamma)\theta + \beta c'(\bar{e})}{2\beta - \gamma} < 0, \tag{4.11}$$

$$\frac{dx}{d\bar{e}} = \frac{dy}{d\bar{e}} = \frac{\beta(\theta + c'(\bar{e}))L}{(\beta - \gamma)(2\beta - \gamma)}, \tag{4.12}$$

$$\frac{d\pi_x}{d\bar{e}} = \frac{2\beta\gamma L(p_x - c(\bar{e}))(\theta + c'(\bar{e}))}{(\beta + \gamma)(\beta - \gamma)(2\beta - \gamma)}. \tag{4.13}$$

Now we consider how the criterion on the emission per unit changes the total emission in the economy. The total emission is given by $E = \bar{e}(x + y)$. Then, we have

$$\frac{dE}{d\bar{e}} = (x + y) + \frac{2\beta(\theta + c'(\bar{e}))\bar{e}L}{(\beta - \gamma)(2\beta - \gamma)} \tag{4.14}$$

If $\hat{e} > e_1$, we have $\theta + c'(\bar{e}) > 0$. Therefore, we obtain $dE/d\bar{e} > 0$. That is, the more restrictive the criterion becomes, the less the total emission is. However, if the criterion is less than e_1, we may have $dE/d\bar{e} < 0$. Even if the government intends to reduce the total emission by means of Type I eco-label, the government may fail to do that.

Proposition 2. When $\hat{e} > e_1$, a reduction of the emission criterion of Type I eco-labelling may lead to more emission.

Next, let us consider the optimal emission criterion of Type I eco-labeling. As long as (15) is satisfied, the following holds from (30):

$$\frac{\partial W^H}{\partial \bar{e}}\Big|_{\hat{e}=e_1} = -\theta L(x + y) < 0. \tag{4.15}$$

This implies the following proposition.

Proposition 3. The optimal emission criterion of Type I eco-labelling in terms of domestic welfare is more sever than the equilibrium emission level under perfect information, i.e., Type II or III eco-labelling.

5. Foreign Eco-labelling and Domestic Eco-labelling

*** To be supplied ***

6. Eco-label and Emission Standards

In this section, we will compare the e®ects of eco-label and that of emission standards. In the case of eco-label, the ¯rms have a choice not to obtain the eco-label and satisfy the criteria. In the case of standards, however, the ¯rms must satisfy the level of standards. Otherwise, they cannot sell their products in the market.

*** To be supplied ***

7. Concluding Remarks

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