A CAVEAT: ARE NON-PRODUCT-RELATED PRODUCT AND PROCESS METHODS (PPMS) IN ECO-LABELLING CRITERIA EFFICIENT?

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ABSTRACT

Eco-labelling can be said to be the practice of informing consumers about the environmental characteristics of a commodity. Although eco-labelling is a good environmental policy tool from both domestic and international perspectives it has raised considerable concern in relation to international trade, particularly, between developing and developed countries. These concerns arise mainly from the inclusion of non-product-related process and production methods (PPMs) in eco-labelling criteria. Using a game theoretical model, this article compares different alternatives including, and excluding, non-product-related PPMs in eco-labelling criteria when an emission tax is imposed on the production phase. Through this comparison it is possible to deduce much in terms of policy implications as well as the possible direction of future research in this area.

KEYWORDS

Eco-labelling Criteria, Non-product-related PPMs, Emission Tax, Policy Mix

1. Introduction

Eco-labelling has been receiving growing attention in modern environmental policies. Since Germany introduced "Blue Angel" program in 1977, many other countries haveintroduced their own eco-labelling programs. The objective of these programs is to promote their domestic environmental improvement. Therefore, they are set up on a national specific situation in favor of their economic, environmental, and technology infrastructure (Salzman 1997). It is noted that such schemes may raise significant concerns with regard to their possible trade effects. Trade concerns arise mainly from two sources. One is the transparency of the schemes and the other is the non-product-related process and production methods (PPMs) in eco-labelling criteria. This research examines the latter which is more structural and influential. Among the various types of eco-labelling, this research focuses on eco-labels awarded by a third party for products which meet the preset environmental criteria, called "type I" in the terminology used by ISO.

Negative impacts of PPMs can be of two sorts. A process or production method can affect the characteristics of a product so that the product itself may pollute or degrade the environment when it is used or disposed (product-related PPMs). Alternatively, a process or production method itself can have a negative impact on the environment through, for example, the release of pollutants into the air or the water during the production phase (non-product-related PPMs) (OECD 1997b). It may be justifiable to impose product-related PPMs requirements on imported products to prevent domestic environmental degradation in the use or the disposal phase. The Agreement on Technical Barriers to Trade (TBT), in article 2.2, also allows making product-related PPMs requirements in order to avoid consumption externalities. It, however, is a very complex and controversial issue whether or not to include non-product-related PPMs in eco-labelling criteria.

It can be said that the non-product-related PPMs criteria result from the use of Life Cycle Assessment (LCA) (WTO/CTE 1999). "Cradle-to-grave" product LCA, which includes the analysis of raw materials and other inputs, PPMs characteristics, distribution, end use and final disposal characteristics, can be a potentially valuable environmental assessment tool. In practice, however, LCA is not easy to conduct. Although International Organization for Standard (ISO) has worked on standardizing LCA methodology in ISO 14040 series, LCA is a methodology still in the process of development, requiring additional research and systematic data collection. Furthermore, if an importing country uses eco-labelling criteria based on LCA, the exporting countries will feel that there is no reason for the importing country to make requirements on their local water and air pollution standards when these do not affect consumers in the importing country. The importing country can be suspicious of using the eco-label as a *de facto* non-tariff barrier. This concern may be serious especially to developing countries adopting export-oriented policies which focus on their major export markets in developed countries.

In spite of these problems, a growing number of eco-labelling schemes are based on LCA procedures (OECD 1997a, Neitzel 1997). The main reason is that it helps to avoid the transfer of environmental impacts across media (emission parameters) or phases of the product life cycle. Besides eco-labelling schemes most developed countries have several regulatory instruments, such as command-and-control (CAC), emission tax, and permit system, which can internalize the externalities in the production phase. Hence, such instruments can prevent pollutant transfer from other phases to the production phase, even if we exclude non-product-related PPMs from the eco-labelling criteria. If the non-product-related PPMs criteria shall give firms additional incentives to reduce emission in the production, in addition to the incentives of other economic instruments, firms would invest too much on the non-product-related PPMs relative to product-related PPMs. This can generate inefficiency in allocating emission reduction cost among the phases. Consequently, the purpose of this research is to investigate if it is efficient to include non-product-related PPMs in eco-labelling criteria.

To address the question, in Section 2, a simple game theoretic model has been constructed to compare the alternatives including and excluding non-product-related PPMs from environmental performance point of view when emission tax is imposed on the production phase. Section 3 deals with equilibrium analysis of the model. Finally, Section 4 narrates the conclusions of this paper.

2. Model

The life cycle of a product mainly consists of the five phases of supply, production, distribution, use, and disposal. In each phase some environmental pollutants such as air emissions, water emissions, and solid wastes are generated. For better understanding of the main idea, assume that the amounts of pollutants from the supply phase and the distribution phase are fixed, and the use and the disposal phase together are integrated as the consumption phase. Furthermore, assume that the emission taxes t_N, t_G are imposed on the unit emission in the production phase of non-green products and green products, respectively. With these conditions a comparison of the environmental performances of the two eco-labelling schemes will be made: i) alternative 1 (A1) which includes emissions from both the production phase and the consumption phase in the eco-labelling criteria, ii) alternative 2 (A2) which includes emissions only in the consumption phase in the eco-labelling criteria.

Structure of the game

Suppose that there are two identical firms $i = 1,2$ selling a product that is identical in all aspects except environmental characteristic. Consider the following two stage non-cooperative game under complete information.

Stage 1: Each firm selects the emission levels of its product in the production and consumption phase considering emission reduction cost and market benefits being granted eco-label to maximize its own profit. According to the labelling criteria, the more environmentally friendly product of the two firm's products is granted the G (green) label. The other product is recognized as N (non-green). Because each firm produces one type of products, they can be identified with its product label.

Stage 2: Taking as given, either G or N, firms choose the prices of their products to maximize their profits.

Consumers

There are n consumers. Each Consumer has unit demand; i.e., each consumes one or zero unit of the specific good. Of the total of n consumers, there is a fraction $1-r$ of non-green, while r is a fraction of green consumers. Assume that non-green consumers purchase only non-green products called N product, but green consumers purchase only green products labelled G. This means that market is clearly separated into non-green market and green market.[1] Each non-green consumer has a willingness to pay s for a non-green product and each green consumer is willing to pay $s+\alpha$ for a green product. Then, the demand q_N for non-green product and the demand q_G for green product can be denoted as follows.

$$q_N = q_N(p_N) = \begin{cases} n(1-r), & \text{if } 0 \le p_N \le s \\ 0, & \text{if } p_N > s \end{cases}$$

$$q_G = q_G(p_G) = \begin{cases} nr, & \text{if } 0 \le p_G \le s+\alpha \\ 0, & \text{if } p_G > s+\alpha \end{cases}.$$

Firms

The cost function of each firm $i = 1,2$ is characterized as follows:

$$C(x_{iP}, x_{iC}) = C_P(x_{iP}) + C_C(x_{iC})$$

$C_P(x_{iP}) = \frac{1}{2}(\bar{x}_P - x_{iP})^2$: The cost of investment for production technology (non-product-related PPMs) to limit the emission level per product at x_{iP} in the production phase

$C_C(x_{iC}) = \frac{1}{2}k(\bar{x}_C - x_{iC})^2$: The cost of product design (product-related PPMs) to limit the emission level per product at x_{iC} in the consumption phase

$$(C_P', C_C' < 0,\quad C_p'', C_C'' > 0,\ C_P(\bar{x}_P) = 0, C_C(\bar{x}_C) = 0,\ 0 < x_{iP} \le \bar{x}_P,\ 0 < x_{iC} \le \bar{x}_C)$$

where x_{iP}, x_{iC} are the emissions per product from the production phase and from the consumption phase of firm i, respectively. The cost function is dependent only on the environmental aspect of the product. The other cost is normalized to 0. It is assumed that the production technology and the production design affect the emissions of their single respective phase only. The cost function, therefore, can be separable into two sub-cost functions: the cost of investment for production technology; the cost for product design. Then, the two sub-cost functions are decreasing and convex in x_{iP} and x_{iC}, respectively. Meanwhile, the terms of $\bar{x}_P$, $\bar{x}_C$ are the emissions per product from the production phase and the consumption phase, respectively, at which firms do not make any effort to diminish the emissions of each phase. The pollutants from the production phase and the consumption phase are assumed to be identical and have the same environmental effects.[2]

If the eco-labelling criteria include the production phase, the total environmental effect of labelled product will be less than that of the other in the production phase and the consumption phase. The less total environmental effect, the less amount of total emissions, because the pollutant from the production phase and the consumption phase is identical and has the same environmental effect. This labelling condition, therefore, can be described as follows.

If $x_{iP} + x_{iC} < x_{jP} + x_{jC}$, then $i = G$ (green), $j = N$ (non-green), $(i, j = 1, 2,\quad i \ne j)$.[3]

If production phase is not included in the eco-labelling criteria, the labelling condition is:

If $x_{iC} < x_{jC}$, then $i = G$ (green), $j = N$ (non-green), $(i, j = 1, 2,\quad i \ne j)$.

If the emission taxes t_N, t_G are imposed on the unit emission in the production phase of non-green products and

[1] This assumption is not critical to the main result, but somewhat unrealistic. The assumption is to be refined through modifing the model of Kuhn (1998).

[2] The model can be easily extended to the case of the various pollutants and non-identical effects.

[3] Since the labelling criteria are preset in practice, the eco-labelling schemes appear to take an absolute evaluation. However, the eco-labelling bodies set the level of criteria such that about 15~20% products of the product category can meet. Therefore, the schemes can be said to take a relative evaluation in terms that there are always some winner products and the other loser products. Therefore, the labelling condition of this model may capture the relevant aspect of the practice.

green products, the profits of the firms are

$$\Pi_N^R(p_N, x_{NP}, x_{NC}) = p_N q_N(p_N) - \frac{1}{2}(\bar{x}_P - x_{NP})^2 - \frac{1}{2}k(\bar{x}_P - x_{NC})^2 - t_N q_N(p_N) x_{NP} \quad (1)$$

$$\Pi_G^R(p_G, x_{GP}, x_{GC}) = p_G q_G(p_G) - \frac{1}{2}(\bar{x}_P - x_{GP})^2 - \frac{1}{2}k(\bar{x}_P - x_{GC})^2 - t_G q_G(p_G) x_{GP} \quad (2)$$

3. Analysis

In the following an analysis of the above model focusing on A1 case first, and then on A2 is given.

A1 Case

Since the model is a two-stage game, backward induction has been adopted to find an equilibrium. In the second stage, given the emissions in each phase of firm N and G, $\{(x_{NP}, x_{NC}), (x_{GP}, x_{GC})\}$ which belong to the decision of the first stage, each firm decides the price of its product. Because non-green consumers only buy non-green products while green consumers green products, each firm (N or G) is a monopolist in its market. Firm N and firm G, therefore, set their price to maximize their own profits as follows.

$$p_G{}^* = s + \alpha, \quad p_N{}^* = s$$

Substitute these in equation (1) and (2) to get

$$\Pi_N^R(s, x_{NP}, x_{NC}) = n(1-r)s - \frac{1}{2}(\bar{x}_P - x_{NP})^2 - \frac{1}{2}k(\bar{x}_P - x_{NC})^2 - t_N n(1-r) x_{NP} \quad (3)$$

$$\Pi_G^R(s+\alpha, x_{GP}, x_{GC}) = nr(s+\alpha) - \frac{1}{2}(\bar{x}_P - x_{GP})^2 - \frac{1}{2}k(\bar{x}_P - x_{GC})^2 - t_G nr x_{GP} \quad (4)$$

If green market is less attractive than non-green market in terms of profit, an eco-labelling scheme has no effect and the analysis becomes trivial. An additional assumption has been put to prevent that situation. Assume that $nr(s+\alpha) - t_G nr x_{GP}{}^* > n(1-r)s - t_N n(1-r) x_{NP}{}^*$, where the superscript * means the equilibrium under A1 case. In the first stage each firm sets the optimal emission levels in the production and consumption phases, considering emission reduction cost and market benefits from the eco-label to maximize its own profit. Without loss of generality, assume $i = N, j = G$ at the subgame perfect equilibrium ($i, j = 1, 2, \quad i \neq j$). A Nash equilibrium in the first stage is an emission profile, $\{(x_{NP}^N, x_{NC}^N), (x_{GP}^N, x_{GC}^N)\}$[4], such that for a given (x_{NP}^N, x_{NC}^N), firm G choose (x_{GP}^N, x_{GC}^N) to maximize Π_G^R; and for a given (x_{GP}^N, x_{GC}^N), firm N chooses (x_{NP}^N, x_{NC}^N) to maximize Π_N^R. However, there is no Nash equilibrium in the first stage.

Lemma 1 There is no Nash equilibrium for emissions in the first stage of the game.
Proof. Abbreviation due to page limit.

Since there is no Nash equilibrium for emissions in the first stage, there is a need to introduce another equilibrium concept. An undercutproof equilibrium will be employed. In an undercutproof equilibrium, each firm chooses the emission levels to maximize its profit, subject to the constraint that the emission levels are sufficiently low so that the rival firm would not find it profitable to set sufficiently lower emission levels in order to take the position of the competitor.[5]
Because the green market is more attractive than the non-green market in terms of profit, firm G has no incentive to hold the position of firm N instead of its own. Therefore, firm N solves the following problem with no constraint:

$$\max_{x_{NP}, x_{NC}} \Pi_N^R(s, x_{NP}, x_{NC})$$

Solving the problem, the optimal emissions of firm N, $(x_{NP}{}^*, x_{NC}{}^*)$, is:

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[4] The superscript N means a Nash equilibrium.
[5] For a more rigorous definition, see Shy(1995).

$$x_{NP}^* = \bar{x}_P - n(1-r)t_N \quad (5)$$
$$x_{NC}^* = \bar{x}_C \quad (6)$$

The second-order condition is satisfied.
The behavior of firm G, however, is different from that of firm N. Since the green market is more attractive, if there is any chance for firm N to be labelled G increasing its own profit, firm N would undercut the emission levels and capture the green market. The profit of firm G, therefore, should not be more than that of firm N under the undercutproof equilibrium concept. If firm G makes less profit than firm N, firm G would try to increase profit by raising the emission level to the degree in which firm N has no incentive to undercut. Hence, in the undercutproof equilibrium the profits of two firms must be equal. Even if both the profits are equal, by not choosing the efficient combination of the emission levels, firm G would lose its position. Firm G solves the following problem:

$$\min_{x_{GP}, x_{GC}} x_{GP} + x_{GC} \quad \text{(P-1)}$$
$$\text{subject to } \Pi_G^R(s+\alpha, x_{GP}, x_{GC}) - \Pi_N^R(s, x_{NP}^*, \bar{x}_C) = 0$$

To solve this problem, Lagrangian has been used:

$$L_1(x_{GP}, x_{GC}, \lambda) = x_{GP} + x_{GC} + \lambda(\Pi_G^R - \Pi_N^R)$$

Solving the problem, the following emissions have been obtained:

$$x_{GP}^* = \bar{x}_P - nrt_G - \frac{\sqrt{k}\sqrt{n}}{\sqrt{k+1}}\sqrt{2r\alpha + (4r-2)s + nr^2(t_G - \frac{\bar{x}_P}{nr})^2 - n(1-r)^2(t_N - \frac{\bar{x}_P}{n(1-r)})^2} \quad (7)$$

$$x_{GC}^* = \bar{x}_C - \frac{\sqrt{n}}{\sqrt{k}\sqrt{k+1}}\sqrt{2r\alpha + (4r-2)s + nr^2(t_G - \frac{\bar{x}_P}{nr})^2 - n(1-r)^2(t_N - \frac{\bar{x}_P}{n(1-r)})^2} \quad (8)$$

<u>A2 Case</u>

If we exclude the production phase from the eco-labelling criteria, the only thing to change is the behavior of firm G. Hence, the optimal prices in the second stage are $p_G^* = s+\alpha$, $p_N^* = s$ in case A1 and the optimal emission levels of firm N, $(x_{NP}^{**}, x_{NC}^{**})$, is

$$x_{NP}^{**} = \bar{x}_P - n(1-r)t_N \quad (9)$$
$$x_{NC}^{**} = \bar{x}_C \quad (10)$$

where the superscript ** indicates the equilibrium in the case A2.
Under the A2 scheme, instead of minimizing the aggregation of the emissions in the production phase and the consumption phase, firm G would try to minimize the emissions only in the consumption phase keeping its own profit as much as that of firm N. Firm G solves the following problem:

$$\min_{x_{GP}, x_{GC}} x_{GC} \quad \text{(P-2)}$$
$$\text{subject to } \Pi_G^R(s+\alpha, x_{GP}, x_{GC}) - \Pi_N^R(s, x_{NP}^*, \bar{x}_C) = 0$$

Solving this problem in the same way as problem (P-1), the following conditions have been obtained:

$$x_{GP}^{**} = \bar{x}_P - nrt_G \quad (11)$$

$$x_{GC}** = \bar{x}_C - \frac{\sqrt{n}}{\sqrt{k}}\sqrt{2r\alpha + (4r-2)s + nr^2(t_G - \frac{\bar{x}_P}{nr})^2 - n(1-r)^2(t_N - \frac{\bar{x}_P}{n(1-r)})^2} \quad (12)$$

<u>Comparison</u>

The difference between the total emissions of firm G in the two schemes is

$$\begin{aligned}\Delta &= (x_{GP}** + x_{GC}**) - (x_{GP}* + x_{GC}*) \\ &= \sqrt{n}\left(\frac{\sqrt{k+1}}{\sqrt{k}} - \frac{1}{\sqrt{k}}\right)\sqrt{2r\alpha + (4r-2)s + nr^2(t_G - \frac{\bar{x}_P}{nr})^2 - n(1-r)^2(t_N - \frac{\bar{x}_P}{n(1-r)})^2}\end{aligned}$$

For every $k > 0$, the difference between the sums of the emissions is positive. It means that, given the conditions, the case A1 is superior to the case A2 from an environmental performance point of view.
However, it is notable that the emission reduction cost is less in case A2 than in case A1. Let

$$A = \sqrt{2r\alpha + (4r-2)s + nr^2(t_G - \frac{\bar{x}_P}{nr})^2 - n(1-r)^2(t_N - \frac{\bar{x}_P}{n(1-r)})^2}$$

then, the emission reduction cost of firm G in each case be

$$C_P(x_{GP}*) + C_C(x_{GC}*) = \frac{1}{2}(nrt_G)^2 + nrt_G\frac{\sqrt{k}\sqrt{n}}{\sqrt{k+1}}A + \frac{1}{2}nA^2 \quad (13)$$

$$C_P(x_{GP}**) + C_C(x_{GC}**) = \frac{1}{2}(nrt_G)^2 + \frac{1}{2}nA^2 \quad (14)$$

The total costs of firm G in two cases, which consist of emission reduction cost and tax payment, are equal. While the emission reduction cost of firm G is less in case A2, firm G pays more taxes in case A2 than in case A1. It is because firm G emits more pollutants in the production phase of case A2 than of case A1, as shown in equations (7) and (11). For firms, the tax is a cost, while it is not a cost in a social perspective. What matters to policy makers is the social cost. Equation (13) and (14) show those are the social costs for environmental improvement in two cases.
A comparison between two cases can be made through defining and using a social welfare function. However, for better understanding of the properties in the two cases, a comparison of two cases focuses only on the environmental performance. For this purpose, the comparison needs to be based on the same social cost for environmental improvement. It is not clear which case is superior if the social costs are different. Hence, one more condition has been added that, in case A2, the government returns a part of tax revenues equal to the difference between equation (13) and (14) with lump sum base to firm G through public procurement. Firm G in A2 with tax return case spends the additional total incentive in reducing the emissions in the consumption phase, because the profit of firm G must be equal to that of firm N on the undercutproof equilibrium. Hence, The emissions of firm G in A2 case with tax return, ($x_{GP}***, x_{GC}***$), are as follows.

$$x_{GP}*** = \bar{x}_P - nrt_G = x_{GP}**$$

$$x_{GC}*** = \bar{x}_C - \sqrt{2nrt_G\frac{\sqrt{n}}{\sqrt{k}\sqrt{k+1}}A + \frac{n}{k}A^2}$$

It is difficult to compare directly these emission levels with ($x_{GP}*, x_{GC}*$). Therefore a different approach has been taken up. Given the fixed cost for environmental improvement, the first best solution, (x^F_{GP}, x^F_{GC}), satisfies the condition that the marginal reduction cost in each phase is equal, i.e.,

$$-C_P'(x^F_{GP}) = -C_C'(x^F_{GC}) \quad (15)$$

where (x^F_{GP}, x^F_{GC}) satisfy

$$C_P(x^F_{GP}) + C_C(x^F_{GC}) = \frac{1}{2}(nrt_G)^2 + nrt_G \frac{\sqrt{k}\sqrt{n}}{\sqrt{k+1}} A + \frac{1}{2} n A^2$$

Of the two emission combinations, ($x_{GP}*, x_{GC}*$) and ($x_{GP}***, x_{GC}***$), the combination closer to condition (15) is less in the total emissions. The marginal reduction costs of these combinations have the following forms:

$$-C_P'(x_{GP}*) = nrt_G - C_C'(x_{GC}*) \quad (16)$$

$$-C_P'(x_{GP}***) = nrt_G \quad (17)$$

If comparison is made between equation (16) and (17), it also becomes clear that the marginal reducing cost in the production phase is higher in case A1 than in case A2 with tax return. Therefore, if $nrt_G \geq -C_C'(x^F_{GC})$, condition (17) is closer to condition (15) than condition (16) regardless of other coefficients. In other words, case A2 with tax return is superior to case A1 in environmental performance regardless of other coefficients. It is because firm G in case A1 has double incentives to reduce the emissions in the production phase. The double incentives are the tax payment reduction and market benefit from eco-label. As a result, firm G may choose less efficient combinations of emissions in case A1 than in case A2 with tax return. This can be arranged into Proposition 1.

Proposition 1. If $nrt_G \geq -C_C'(x^F_{GC})$, case A2 with tax return is superior to case A1 in terms of environmental performance.

4. Conclusions

The main purpose of this research is to investigate whether non-product-related PPMs in eco-labelling criteria is indispensable and efficient in order to promote environmental improvement. In this article, interim results for a game theoretic model have been presented. The game theoretic model showed that excluding non-product-related PPMs from eco-labelling criteria was better than including it if tax was higher than a certain level. Based on this result, later the applicability of the policy mix will be checked that eco-labelling schemes should be used for internalizing externalities generated from the use and the disposal phase, while the direct regulation or the economic instruments, such as emission tax and permit system, should be used for internalizing externalities generated from the production phase. Without non-product related PPMs in eco-labelling criteria, this policy mix can cover the whole life cycle of products.

If the game theoretic model is refined and more rigorously analyzed, it is expected that the model will be able to be extended easily to the cases in which the regulatory measure in the production phase could be either emission quantity regulation or permit system instead of the emission tax. Another interesting subject on eco-labelling criteria is under which condition consumers are more willing to buy eco-labelled products when non-product-related PPMs are included or when they are excluded. Will consumers feel responsible for the pollution in the production phase of products, is the question here.

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