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Eco-labels, Production Related Externalities and Trade

Abstract:
We analyze the trade and welfare effects of eco-labels in a domestic market with one domestic firm and one foreign firm. Pollution is production related, and the government can choose between including the product category in an eco-label scheme and setting an environmental standard. The environmental standard will only apply to the domestic firm, while both firms can adopt the eco-label.

Given that the environmental damage is not too large, we find that it is optimal for the government to introduce an eco-label scheme. An eco-label scheme is optimal even though the domestic firm may loose profit and the foreign firm may gain. Hence, the eco-label scheme is not introduced for protectionist purposes. Further, if the government for some reason were prevented from using eco-labels, global, domestic and foreign welfare would be hampered.

Keywords: Eco-labels, strategie environmental, policy, trade

JEL classification: H7, Q2, R3

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1 Introduction

All industrialized countries except Australia have an eco-label scheme in place, while no country in Africa and only Brazil in Latin-America has got an eco-label scheme [5]. Eco-labels has received considerable attention in the WTO, and is one of the more controversial aspects of the trade-environment debate. The criteria for obtaining an eco-label are often based on non-product-related process and production methods, and the labels are therefore criticized for imposing the environmental concerns of importing countries on the production methods of their trading partners. However, to our knowledge, the trade and welfare effects of voluntary eco-label schemes which include prescriptions for process- and production methods is never analyzed before in a formal model.

A typical eco-label scheme lists a set of environmentally related criteria for each product category, and awards the eco-label to the products that fulfill the criteria. The same eco-label is often used for a wide range of different product categories. Firms decide themselves whether they will adjust their products and/or methods of production, and can continue to market their products even though the products do not have the eco-label.

Most eco-label schemes are put in place on an initiative from a governmental body, examples are the EU eco-label, the U.S. EPA Energy Star and the Nordic Swan. For the time being they are also dependent of governmental funding - the Nordic Swan receiving about half of its budget from the Nordic governments[12]. Thus, eco-label schemes must be regarded as a part of a government's environmental policy.

It is evident that eco-label schemes frequently include prescriptions regarding process- and production methods. One example is the EU eco-label criteria for copying paper which includes only prescriptions related to the production of the paper, that is, demand for sustainable forest management, chlorine free bleaching and maximum limits for polluting discharges per ton paper produced [6].

With respect to national firms or EU firms the same environmental targets could be reached by introducing environmental minimum standards. Hence, we ask why countries include production related environmental standards in voluntary eco-label schemes instead of regulating their firms directly. Among others the WTO seems to have the view that eco-labels partly serve protectionist purposes, and that environmental minimum standards which only affect the local producers should be the preferred instrument. Thus, we also question whether eco-labels based on production and/or process related criteria are likely to hurt exporting countries and to reduce global welfare.

The paper provides a theoretical analysis of these questions. In a simple model with international trade we compare eco-labels with environmental minimum standards. We find that eco-labels only have a rationale as long as consumers prefer to buy eco-labeled products regardless of the product being produced at home or abroad. Eco-labels may then be preferable to environmental standards because they provide governments with an opportunity to regulate pollution outside their jurisdiction.

Further, we find that eco-labels may, under some circumstances, increase both the welfare of the importing country and the welfare of the exporting country. The reason is that eco-labels makes it possible for the exporting firm to commit to more stringent environmental regulation whenever this is profitable. Hence, in the case treated in the paper the product category is not included in the eco-label scheme of protectionist purposes, but to satisfy the demand in the importing country for global environmental quality.

The analysis also contains some other potentially interesting insights. It is argued in the so called Porter-hypothesis that more stringent environmental regulation will enhance the competitiveness of firms [13]. This paper suggests that this can happen if consumers demand green products, but have no means to check whether a product is really produced in an environmentally friendly way. The environmental quality of a product is a sort of *credence good*, that is, a good for which the quality can neither be observed before purchase nor experienced by use. Hence, if consumers do not trust firms to incur extra costs in order to produce in an environmentally friendly way, firms may be unable to supply green products when left to themselves.

In our model there are just two countries and two firms: One *foreign firm* which exports to a *domestic market,* and competes with one *domestic firm*. Production of the products implies emissions to the local environment in both countries, but only the domestic consumers have preferences for a better environment[1]. Further, they are willing to pay more for less polluting products. However, according to the GATT rules, the domestic government can not tax or deny imports of foreign products that are produced in a way which does not follow the national, environmental minimum standard. An environmental standard will therefore only apply to the domestic firm.

In order to compare the welfare effects of eco-labels and environmental standards, we need a model where firms initially make positive profit, that is, before any environmental policy is introduced. Our point

[1] An example of such preferences could be the preferences of American consumers for the well being of dolphins both inside and outside the economic zone of the U.S. See Teisl, Roe & Hicks (2001) on the tuna-safe labeling in the U.S.

of departure is therefore that the domestic market is historically differentiated along some horizontal, taste dimension. Although consumers are willing to pay more for less polluting products, they likely differ in how much more they are willing to pay. Hence, the environmental performance of products can be used to differentiate products along a vertical, quality dimension. This implies that the market may be differentiated along both one horizontal dimension and one vertical dimension as in the model of Neven and Thisse [11].

Oligopoly models with vertical differentiation, see for example the one introduced by Shaked and Sutton [15], have been used frequently to analyze markets with demand for green products. Arora and Gangopadhyay[2] study over-compliance with respect to minimum environmental standards in a vertical differentiation model. Further, Cremer and Thisse[4] use a similar vertical differentiation model to analyze how an environmental subsidy interacts with firms environmental quality decisions. In both papers it is assumed that consumers know the environmental records of firms, and there is no analysis of eco-labels.

Motta and Thisse[10] use the vertical differentiation model to look at trade effects when there is demand for green products. However, unlike this paper, they focus on *product related* pollution externalities, and they do not include eco-labels. Eco-labels have no role to play in their model since it is assumed, as in Arora and Gangopadhyay[2] and in Cremer and Thisse[4], that consumers know the environmental performance of different products.

The model with differentiation in two dimensions differs from the pure vertical differentiation model of Motta and Thisse[10], Arora and Gangopadhyay[2] and Cremer and Thisse [4] in many ways. They all typically find that firms will supply different levels of environmental quality in equilibrium. On the contrary, with differentiation in two dimensions, the equilibrium may be that both firms supply high environmental quality. Further, unlike the pure vertical differentiation model, firms make positive profit initially, and when they supply the same level of environmental quality.

Clearly, getting information about and verifying the environmental performance of products can be difficult. This is even more likely to be the case if pollution are related to the production of the product, and production takes place far away from consumption. In the paper we assume that only the domestic government can inform the domestic consumers about the environmental performance of products. Thus, firms are not willing to supply "greener products" when left to themselves.

A similar case is also treated in Rege[14]. In her model consumers are willing to pay more for "greener products", however, they do not know whether firms cheat, that is, claims to produce with a clean technology while actually producing with a dirty technology. This leads to a too low adoption of the clean technology - possibly no adoption at all. Further, by setting an environmental standard, or offering an eco-label, the government can help firms committing to cleaner production.

Since the purchase of one single consumer virtually has no effect on the state of the environment, the consumer motivation behind green demand also needs to be explained. The type of consumer behavior in question is a sort of voluntary contribution to a public good, that is, the global environment. According to Andreoni[1] voluntary contributions to a public good can be explained by what he coins *impure altruism*. In this case the consumer gets utility from both giving (referred to as *warm glow* by Andreoni[1]) and from the public good in question. The act of choosing a green product can give the consumer a quiet conscience, is a simple way to express a political opinion, may help building an identity as a responsible citizen, and all this may well yield extra satisfaction independent of the resulting effect on the environment.

2 The model

The model consists of a three-stage game of perfect information among the domestic government and two firms, one domestic and one foreign. At Stage 1, the domestic government chooses whether it will regulate pollution with a national environmental standard or include the product category in an eco-label scheme. Further, it decides the level of environmental regulation, that is, either the strength of the environmental standard, $\bar{r}_s$, or the strength of the eco-label criterium for the new product category, $\bar{r}_c$. At Stage 2, firms decide whether to adopt the eco-label if an eco-label is offered. Lastly, in Stage 3, firms compete in prices on the domestic country market.

2.1 Consumers

Consumers are uniformly distributed over a unit square. The domestic firm is located at $(0,0)$, whereas the foreign firm is located at $(1,0)$, that is, at each end of the bottom line in the unit square. Let $x \in [0,1]$. Then x is the number of consumers in the interval $[0,x]$.

Each consumer wants only one unit of the good, and would in general like the product to be produced in an "environmentally friendly" way. However, by assumption, she can only be sure that environmentally friendly production takes place if the producer is regulated by an environmental standard set by the domestic government, or if she can observe an eco-label issued by the domestic government.

The utility of consumer x from consuming one unit of the domestic product at $(0,0)$ is:

$$U_x^0 = \begin{cases} s - tx^2 + \lambda_x m(\bar{r}_s) & \text{if environmental standard} \\ s - tx^2 + \lambda_x m(\bar{r}_c) & \text{if adoption of eco-label} \\ s - tx^2 & \text{if no regulation} \end{cases}, \tag{1}$$

and respectively, from the foreign product at $(1,0)$:

$$U_x^1 = \begin{cases} s - t\left[1-x\right]^2 & \text{if environmental standard} \\ s - t\left[1-x\right]^2 + \lambda_x m(\bar{r}_c) & \text{if adoption of eco-label} \\ s - t\left[1-x\right]^2 & \text{if no regulation} \end{cases} \tag{2}$$

(where s is the exogenously given gross utility)

The parameter t expresses the strength of personal tastes, often coined the *transportation cost* parameter, while x, alternatively $[1-x]$, measures how far the consumer is from her ideal product in the horizontal dimension, that is, along the bottom line of the unit square. The t parameter can be normalized to 1 without loss of generality.

The term, $\lambda_x m(\bar{r}_j)$, $j = s, c$, is the consumer's personal benefit of contributing to the environment, also called the *warm glow* effect. In particular, we assume that m is continuously differentiable, and $m(0) = 0$, $m' \geq 0$, $m'' < 0$, that is, the higher the level of environmental regulation, the higher the warm glow effect. The parameter λ_x reflects consumer heterogeneity, and is uniformly distributed on $[0,1]$.

Demand will also depend on the relative strength of the two differentiation dimensions, or as Neven and Thisse coin it, whether demand is *horizontally* or *vertically* dominated. Horizontal domination implies that the taste parameter is relatively more important for the consumer than the environmental performance of the product, and obtains when $m(\bar{r}_c) \leq \frac{2}{t}$. While vertical domination can be interpreted as the opposite case, that is, environmental quality is relatively more important than taste, which obtains when $m(\bar{r}_c) > \frac{2}{t}$ (Neven and Thisse [11]).

2.2 Firms

Emissions, e_i, $i = d, f$, are assumed to be proportional to output, q_i, $i = d, f$ (domestic/foreign), and can be abated at a cost. Further, let $(1 - r_i)$, $r_i \in [0,1]$, $i = d, f$, denote the emission/output ratio chosen by the domestic and foreign firm, respectively. Global emissions can then be written:

$$\begin{aligned} e &= e_d + e_f \\ &= \left[1 - r_d\right] q_d + \left[1 - r_f\right] q_f. \end{aligned} \tag{3}$$

We assume that abatement of emissions increases both total and marginal cost of production, that is, the more the firm produce, the more must be abated both totally and at the margin. Hence, for the firms' cost function we have;

$$\varsigma(q_i, r_i) = [c_0 + c(r_i)]\, q_i, i = d, f \tag{4}$$

where the function,c, is continuously differentiable, and $c(0) = 0$, $c' > 0$ and $c'' > 0$. We also assume $m'(0) > c'(0)$ in order to ensure an interior solution.

Finally, the profit of the firms are given by:

$$\pi_i(p_d, p_f) = [p_i - c_0 - c(r_i)]\, q_i(p_d, p_f),\ \ i = d, f,$$

where p_i is the price of product i, $i = d, f$, and $q_i(p_d, p_f)$ is domestic demand for product i, $i = d, f$.

Assuming an interior solution to the market game in which the whole market is covered, we have for the levels of output, $q_d + q_f = 1$.

2.3 The domestic government

The domestic government maximizes domestic welfare which consists of domestic consumer surplus, CS, domestic profit and the global level of environmental damage:

$$w = CS + \pi_d - \delta e \tag{5}$$

The level of environmental damage is given from an environmental damage function, δe, which reflects that the domestic consumers care for both the domestic and foreign level of pollution. The individual consumer can not directly influence the environmental cost because she is only one of many consumers, and hence, her choice will only have a marginal effect on total environmental cost. Note also that, when $r_d = r_f = 0$, we have $\delta e = \delta$. Hence, the parameter, δ, directly reflects the seriousness of the environmental problem.

Consumer surplus is the total gross utility from buying plus the aggregated warm glow effect; WG, less the transfer of wealth from consumers to firms and the aggregated transport cost; TC:

$$CS = s + WG - p_d q_d - p_f q_f - TC. \tag{6}$$

The transport cost can be thought of as the disutility incurred by each consumer having to consume one of the two products placed at either end of the bottom line of the unit square, instead of somewhere closer to the consumer. Further, due to the assumption of *impure altruism*, the benefit of environmental regulation consists of both the warm glow effect and the reduced environmental cost.

Inserting (6) into (5), we get the following expression for domestic welfare:

$$w = s + WG - p_d q_d - p_f q_f - TC + \pi_d - \delta e, \tag{7}$$

Note that all terms in (7), apart from the total gross utility from buying, s, will depend on the policy of the government.

3 Environmental standard

Let $m(r) \leq 2, \forall r \in [0,1]$ implying that demand is horizontally dominated. Consider now the case in which the domestic government sets an environmental standard, $\bar{r}_s$. For the domestic and foreign firm's emission/output ratio this implies that $(1-r_d) = (1-\bar{r}_s)$, while $(1-r_f) = 1$, respectively (see Appendix).

3.1 The market game

The marginal consumer, x^*, who is just indifferent between buying from firm d and f, is found by solving the following equation for λ_x^*:

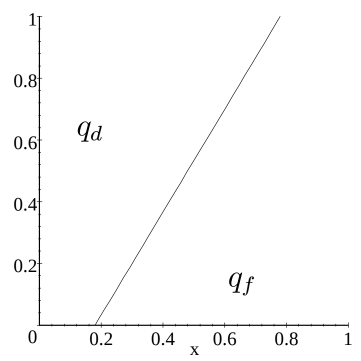
$$s + \lambda_x^* m(\bar{r}_s) - [x^*]^2 - p_d = s - [1 - x^*]^2 - p_f$$

$$\Leftrightarrow$$

$$\lambda_x^* = \frac{2}{m(\bar{r}_s)} \left[x^* + \frac{p_d - p_f - 1}{2} \right], \bar{r}_s > 0. \tag{8}$$

Consumers are uniformly distributed over a unit square, and equation (8) describes a straight line with steepness $\frac{2}{m(\bar{r}_s)}$ which divides the unit square into the market shares of Firm d and Firm f, respectively. Figure 1 shows an example:

Figure 1



Consumers putting much weight on the environment, that is, having a high λ, will tend to buy from the domestic producer placed at 0 even though they are closer on the line to the product placed at 1.

Whenever the products are differentiated along *both* environmental performance and taste, demand functions; $q_i(p_d, p_f), i = d, f$, are composed of three segments. It can be shown that at each kink demand is continuous. Given the domain of the functions, $m(r)$ and $c(r)$, $r \in [0, 1]$, see Figure 2 below and the Appendix, the unique Bertrand-Nash equilibrium can be found on the intermediate segment of the demand function. From the Bertrand-Nash equilibrium we can derive the equilibrium outputs and profits:

$$\pi_d = 2\left[q_d\right]^2 = 2\left[\frac{6 - 2c(\bar{r}_s) + m(\bar{r}_s)}{12}\right]^2 \tag{9}$$

and:

$$\pi_f = 2\left[q_f\right]^2 = 2\left[\frac{6 + 2c(\bar{r}_s) - m(\bar{r}_s)}{12}\right]^2 \tag{10}$$

where we have used the fact that $r_d = \bar{r}_s$, and $r_f = 0$. Note that output and profit when $\bar{r}_s = 0$ is equal to, $\frac{1}{2}$, for both firms.

From the Bertrand-Nash equilibrium, we can also find the reduced form expressions for the aggregated transport cost and the aggregated warm glow effect:

$$TC_s^{hd} = \frac{1 + \left[m(\bar{r}_s)\right]^2 + \left[c(\bar{r}_s)\right]^2 - m(\bar{r}_s)c(\bar{r}_s)}{12} \tag{11}$$

$$WG_s^{hd} = \frac{m(\bar{r}_s)}{4}\left[1 + \frac{m(\bar{r}_s) - c(\bar{r}_s)}{3}\right] \tag{12}$$

Note that transport costs are minimized when $\bar{r}_s = 0$. The intuition is that consumers placed close to the foreign product with respect to their tastes may buy the domestic product for environmental reasons when $\bar{r}_s > 0$, see Figure 1 above.

Further, note that the aggregated warm glow effect is decreasing in c. The intuition is that a higher c, implies a lower market share for the domestic firm, and hence, a lower aggregated warm glow effect.[2]

3.2 Optimal policy

The domestic government maximizes welfare with respect to $\bar{r}_s$. The domestic government has three kinds of strategic incentives: 1) keep

[2]The complete derivation of the demand functions, the Nash-price equilibrium, the equilibrium outputs and profits, the transport cost and the warm glow effect are shown in the Appendix.

products similar in the vertical dimension to reduce *transport costs*, 2) keep foreign output and price down to minimize the *wealth shift* from domestic consumers to the foreign firm and 3) shift production to the domestic producer which is regulated, in order to increase the *warm glow effect* and to reduce the global level of environmental damage.

Define the constant, $\bar{s} = s - c_0 - \delta - \frac{7}{12}$. Inserting into the welfare expression (7), from the emission function (3) when $r_d = \bar{r}_s$ and $r_f = 0$, and further, inserting from (9), (10), (11), and (12), we get

$$w_s(\bar{r}_s) = \bar{s} - \frac{[m(\bar{r}_s)]^2 + [c(\bar{r}_s)]^2 - m(\bar{r}_s)c(\bar{r}_s)}{36} \tag{13}$$

$$+\frac{5}{6}\left[\frac{m(\bar{r}_s)}{2} - c(\bar{r}_s)\right] + \delta\bar{r}_s q_d(\bar{r}_s).$$

Denote the environmental standard which maximizes (13), $\bar{r}_s^*$. Assume that the second-order condition for a welfare maximum holds i.e. $\frac{\partial^2 w_s(\bar{r}_s)}{(\partial\bar{r}_s)^2}$. Further, assume that $\frac{\partial\bar{r}_s^*}{\partial\delta} > 0$, that is the stringency of the environmental standard is increasing in the seriousness of the environmental damage.

We then make the following observation (see Proof in the Appendix):

$$\text{If } \delta = 0, \text{ then } \frac{m(\bar{r}_s^*)}{2} > c(\bar{r}_s^*).$$

Hence, there must exist an interval: $\left[0, \bar{\delta}\right]$, such that for $\delta \in \left[0, \bar{\delta}\right]$, we have $\frac{m(\bar{r}_s^*)}{2} \geq c(\bar{r}_s^*)$. We then have the following corollary:

Corollary 1 *If $\delta \in \left[0, \bar{\delta}\right]$, domestic profit will increase from the environmental standard.*

Proof. The result can be seen directly from (9) and (10). ■

The intuition is straight-forward. If the warm glow effect is large relative to the cost of abatement, the average willingness to pay for "green products" will be sufficient to cover the optimal level of the per unit abatement cost. By setting an environmental standard, and making the standard known, the government makes the consumer value of the domestic product increase.

4 Eco-label scheme

Instead of setting an environmental standard, the government may include the product category in an eco-label scheme and set a criterium, $\bar{r}_c$. This allows the foreign firm to voluntarily choose to be regulated by the eco-label scheme criterium, $\bar{r}_c$, which will imply: $r_f = \bar{r}_c$.

4.1 The market game

In case only the domestic firm has adopted the eco-label, the profit of the two firms is described by (9) and (10), that is, an eco-label scheme is identical to an environmental standard. This holds also for the case in which only the foreign firm has adopted the eco-label; however, it is then *as if* the foreign firm were regulated by an environmental standard, and not the domestic firm.

In case both firms have adopted the eco-label, the model "collapses" to the Hotelling model with only horizontal differentiation. This implies that both firms charge a constant mark-up on their marginal cost, and earn profit, $\pi_d = \pi_f = \frac{1}{2}$, independent of the size of the marginal cost (see Appendix).

4.2 Adopting the eco-label

Our tie-breaking rule is that in order for a firm to adopt the eco-label, its profit should not decrease. We then look for Nash-equilibria in the second stage of the game when the firms must choose between the pure strategies "adopt" or "not adopt". There is a unique equilibrium in this stage of the game. Depending on the values on the functions $m(\bar{r}_c)$ and $c(\bar{r}_c)$, the equilibrium is either that both firms adopt the eco-label, or that none of the firms adopt the eco-label.

This can be seen directly from the profit expressions (9) and (10). Given that the foreign firm does not adopt the eco-label, the domestic firm adopts the eco-label if

$$\frac{1}{2}\left[\frac{6 - 2c(\bar{r}_c) + m(\bar{r}_c)}{6}\right]^2 \geq \frac{1}{2}, \tag{14}$$

and given that the foreign firm adopts the eco-label, the domestic firm also adopts the eco-label if:

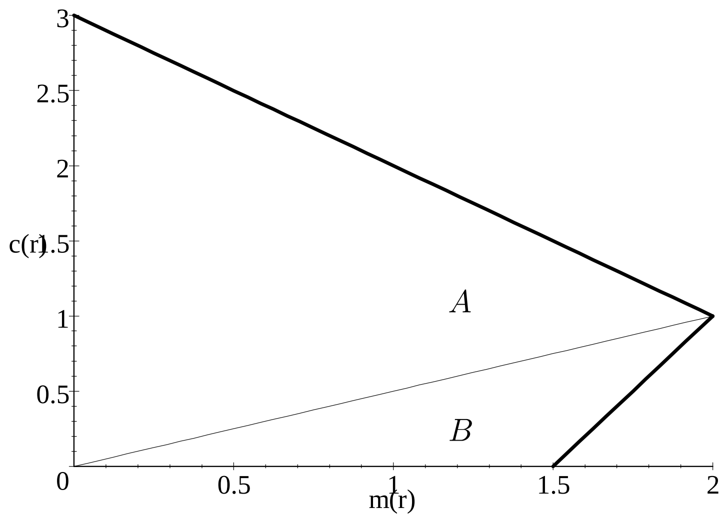
$$\frac{1}{2}\left[\frac{6 + 2c(\bar{r}_c) - m(\bar{r}_c)}{6}\right]^2 \leq \frac{1}{2}, \tag{15}$$

Note that both condition (15) and condition (14) can be reduced to; $\frac{m(\bar{r}_c)}{2} \geq c(\bar{r}_c)$. Hence, as long as $\frac{m(\bar{r}_c)}{2} \geq c(\bar{r}_c)$ the strategy "adopt" strictly dominates the strategy "not adopt" for the domestic firm. Since firms are symmetric, this must hold also for the foreign firm.

When $\frac{m(\bar{r}_c)}{2} < c(\bar{r}_c)$, "not adopt" strictly dominates "adopt" for both firms. Thus, in order to get adoption of the eco-label *the average willingness to pay for the eco-label* has to be equal to or greater than the *per unit abatement cost.*

Figure 2 shows the relevant ranges for $m(r)$ and $c(r)$:

Figure 2



Area $A + B$ constitute the domain of the model in the case of horizontal domination. That is, we restrict attention to types of functions, $m(r)$ and $c(r)$, $r \in [0, 1]$, which map into the set which consists of Area A and Area B. The unique Bertrand-Nash equilibrium will then be on the intermediate segment of the demand function. Further, in Area B both firms will adopt the eco-label, while in Area A no firm will adopt the eco-label.

4.3 Optimal policy

In case both firms adopt the eco-label, we have for the aggregated transport cost and the aggregated warm glow effect:

$$TC_c = \frac{1}{12}, \tag{16}$$

$$WG_c = \frac{m(\bar{r}_c)}{2}. \tag{17}$$

(see Appendix)

Clearly, it is of no point to the domestic government to include the product category into an eco-label scheme, if no firm is going to the adopt the eco-label. Hence, for

$$\frac{m(\bar{r}_c)}{2} \geq c(\bar{r}_c),$$

welfare in the eco-label scheme case is given by:

$$w_c(\bar{r}_c) = \bar{s} + \frac{m(\bar{r}_c)}{2} - c(\bar{r}_c) + \delta\bar{r}_c, \tag{18}$$

where $\bar{s} = s - \delta - c_0 - \frac{7}{12}$ as before. And where we have inserted, $\pi_d = \pi_f = \frac{1}{2}$, the emission function (3) when $r_d = r_f = \bar{r}_c$, further, (16) and (17) into the welfare function (7).

Denote the eco-label scheme criteria which maximizes (18), $\bar{r}_c^*$. Note that $\frac{m(\bar{r}_c^*)}{2} \geq c(\bar{r}_c^*)$ must hold.

5 The full game

Comparing the welfare in the two cases analyzed above, we obtain:

Proposition 2 *If $\delta \in [0, \bar{\delta}]$, the sub-game perfect equilibrium in the game must have the following properties:*

- *The government chooses to introduce an eco-label, and set the criterium; $\bar{r}_c = \bar{r}_c^*$.*
- *Both firms adopt the eco-label.*

Proof. As long as $\frac{m(\bar{r}_s^*)}{2} \geq c(\bar{r}_s^*)$, the government can set $\bar{r}_c = \bar{r}_s^*$, and get both firms to adopt the eco-label. Then by comparing (13) with (18) when $\bar{r}_c = \bar{r}_s = \bar{r}_s^*$, we see from the welfare-expressions that welfare in the eco-label case is higher than welfare in the environmental standard case (remember that $q_d(\bar{r}_s) < 1$). ■

Domestic welfare is maximized with an eco-label. This holds even though domestic profit would be higher with a corresponding environmental standard. The intuition is that the environmental benefit increases discontinuously when the foreign firm adopts the eco-label. Further, we also have a positive effect on welfare from the reduced transport cost.

We may also have situations in which the level of environmental damage is large, but in which it is still optimal to introduce an eco-label. For this second characterization of the sub-game perfect equilibrium we have:

Proposition 3 *In case $\delta > \bar{\delta}$, there may still exist a sub-game perfect equilibrium with the following properties:*

- *The government chooses to introduce an eco-label, and set the criteria; $\bar{r}_c = \bar{r}_c^* < \bar{r}_s^*$.*

- *Both firms adopt the eco-label.*

Proof. See Appendix. ■

All though regulation is less stringent, the government may increase the environmental benefit of regulation by introducing an eco-label since both firms get "regulated". In addition an eco-label also reduces the transport cost.

As long as $\delta \in \left[0, \bar{\delta}\right]$, global welfare is maximized with an eco-label. This conjecture follows directly from the fact that the eco-label maximizes domestic welfare, and that poor country profit would be lower with an environmental standard than with an eco-label. The eco-label makes it possible for the foreign firm to commit to a cleaner production process from which both the firm and the domestic consumers benefit.

6 Pure egoism

In order to explain that consumers are willing to pay more for green products in spite of the fact that their individual choices do not influence the over all state of the environment, we have used the notion of *impure altruism* taken from Andreoni[1]. However, some may reject the assumption that consumers care for the foreign environment, especially if the environmental problem is not transboundary. This can be captured by the notion *pure egoism,* also taken from Andreoni[1]. If consumers get utility from buying green in itself, but do not derive any utility from the actual state of the foreign environment, we would have *pure egoism* with respect to the foreign environment.

We then have that the foreign level of environmental damage, δe_f, should not be included in the welfare function. Since $\delta e = \delta e_d + \delta e_f$, we can rewrite the welfare functions in the two relevant cases.

For the environmental standard case we have:

$$w(\bar{r}_s) = \bar{s} - \frac{\left[m(\bar{r}_s)\right]^2 + \left[c(\bar{r}_s)\right]^2 - m(\bar{r}_s)c(\bar{r}_s)}{36} + \frac{5}{6}\left[\frac{m(\bar{r}_s)}{2} - c(\bar{r}_s)\right]$$

$$+\delta\bar{r}_s q_d(\bar{r}_s) + \delta q_f(\bar{r}_s),$$

and for an eco-label, given that $\frac{m(\bar{r}_c)}{2} \geq c(\bar{r}_c)$,

$$w(\bar{r}_c) = \bar{s} + \frac{m(\bar{r}_c)}{2} - c(\bar{r}_c) + \delta\bar{r}_c + \frac{\delta\left[1 - \bar{r}_c\right]}{2}.$$

We have added the correct expressions for, δe_f, for each case. The new term reflects the fact that there is an environmental benefit of shifting production abroad as long as the domestic consumers do not derive utility from the actual state of the foreign environment.

On the other hand, the warm glow term, $\frac{m(\bar{r}_c)}{2}$, still influences demand and thereby consumer surplus, and profits.

Denote the optimal environmental standard in case of pure egoism, $\bar{r}^*_{pe}$, and denote the optimal eco-label criteria in this case, $\bar{r}^{**}_{pe}$.

By comparing the welfare expressions for the two policy choices, we get the following proposition:

Proposition 4 *In case of pure egoism, if* $\frac{m(\bar{r}^*_{pe})}{2} \geq c(\bar{r}^*_{pe})$*, it is optimal for the government to introduce an eco-label and set the criterium,* $\bar{r}^{**}_{pe}$.

Proof. In order to prove the proposition, it is sufficient to show that:

$$\delta\bar{r}_s + \frac{\delta\left[1 - \bar{r}_c\right]}{2} \geq \delta\bar{r}_s q_d(\bar{r}_s) + \delta q_f(\bar{r}_s)$$

$$\Leftrightarrow$$

$$\bar{r}_s + 1 \geq 2\bar{r}_s q_d(\bar{r}_s) + 2q_f(\bar{r}_s)$$

$$\Leftrightarrow$$

$$\bar{r}_s\left[2q_f(\bar{r}_s) - 1\right] \geq 2q_f(\bar{r}_s) - 1$$

Since $\frac{m(\bar{r}^*_{pe})}{2} \geq c(\bar{r}^*_{pe})$, we have $2q_f(\bar{r}_s) - 1 < 0$. Then, since $\bar{r}_s \leq 1$, the proposition must hold. ■

As long as $\frac{m(\bar{r}^*_{pe})}{2} \geq c(\bar{r}^*_{pe})$, an eco-label with criterium, $\bar{r}^{**}_{pe}$, actually shifts some production, and hence pollution, to the foreign country.

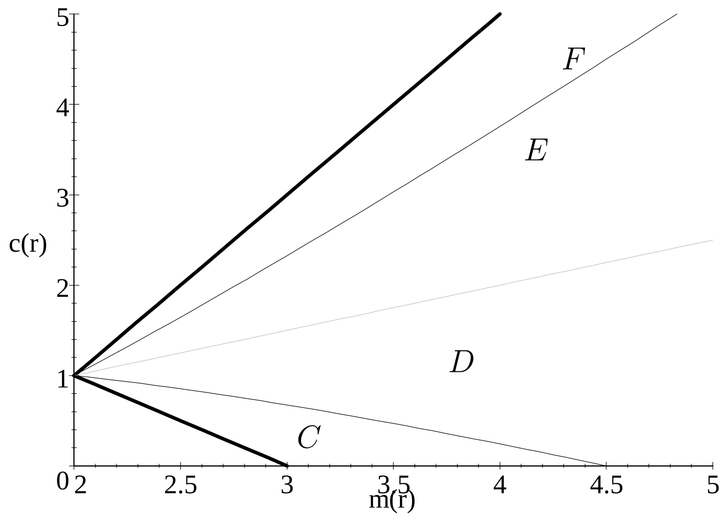
Lastly, if the consumers neither get warm glow from consuming the foreign product when the product has an eco-label, nor have any concern for the foreign environment, the whole rationale behind eco-labels based on production related criteria disappears. Firstly, it would not be possible to get the foreign firm to adopt the eco-label since the eco-label will not trigger a higher willingness to pay for the foreign product. Secondly, the government could do as well with an environmental standard because when only the domestic firm adopts the eco-label, welfare is independent of the policy instrument.

7 Vertical domination.

Our model can also be applied to situations in which products are poorly differentiated from the beginning. As already mentioned, Neven and Thisse [11] refer to this situation as *vertical domination*. In our model *vertical domination* obtains when $m(r) > 2$.

With *vertical domination* we may have two Nash equilibria in pure strategies in the second stage of the game. All the relevant ranges for $m(r)$ and $c(r)$ are shown in the figure below:

Figure 3



The area $C+D+E+F$ constitute the domain of the model in case of vertical domination.

In the area $D+E$ only one of the firms will adopt the eco-label. Hence, there are two Nash-equilibria; one in which the domestic firm adopts the eco-label, and the foreign firm does not, and one in which the foreign firm adopts the eco-label, and the domestic firm does not. However, due to the introduction of the eco-label, both firms will increase their profit in both equilibria. Hence, foreign country welfare will increase even if the foreign firm does not adopt the eco-label.

Note also that, in area D, the firm that adopts the eco-label will earn more than the firm that does not adopt, while in area E, the firm that adopts the eco-label will earn less than the firm that does not adopt! Hence, it can happen that only the domestic firm adopts the eco-label, but all the same, the foreign firm earn more than before and more than the domestic firm.

We may also have combinations of $m(r)$ and $c(r)$ in which there is an unique equilibrium in this stage of the game. That is, in Area C both firms adopt the eco-label, while in Area F no firm adopts the eco-label.

When the domain of the functions, $m(r)$ and $c(r)$, fall into the area $D+E$, and the Nash equilibrium implies that only one firm adopts the eco-label, the government will in most cases do as well with an environmental standard. If instead it had introduced an eco-label, it would have run the risk of the foreign firm being the only firm to adopt the eco-label.

However, if $m(r)$ and $c(r)$ also fall into Area C, we may still have that it is optimal for the domestic government to introduce an eco-label. In this case the analysis follows the case for horizontal domination.

8 Discussion

Clearly, eco-labels only have a role as long as consumers are willing to pay more for "greener products". There exists empirical evidence directly suggesting that this, at least sometimes, is the case. Nearly all tuna fish sold in the U.S. now have a "dolphin safe" label. In order to obtain the label the number of dolphins killed accidentally during a tuna fish catch has to be below a certain limit set by the U.S. government. In an empirical study Teisl, Roe & Hicks[16] find that the label has lead to a significant increase in total tuna fish sales.

There is also a study from Denmark on actual shop purchases data by Bjørner et al [3]. They find that the Nordic Swan label significantly increases the marginal willingness to pay for two types of products, namely detergent and toilet paper. They find no significant effect on paper towels, but according to the authors this could be due to the green consumer rather choosing a reusable alternative to paper towels as dishcloth.

The paper further argues that eco-labels only have a role as long as consumers have preferences for the global environment in one way or the other. Thus, the critique that eco-labels are hidden protectionist measures may be overstated. On the other hand, one could question whether consumers really have preferences for the environment in other countries. Many environmental bads are of course global of nature. This not only goes for bads like global warming and decreasing biodiversity, but also for industrial emissions of dangerous chemicals like dioxins etc. which may accumulate in the food chain and turn up as a problem far from the original source. However, the paper is also meant to cover typically local environmental problems like emissions of organic waste into lakes etc. Consumers may have a willingness to pay for environmental improvements outside the territory of their nation. They could be directly affected in connection with for example holidays, and/or they may express option- and existence values towards the environment far from their home.

We have assumed throughout the paper that only the domestic government can inform the domestic consumers about the environmental performance of products. Hence, firms do not have any incentive to do abatement when left to themselves. As mentioned, one rational for this assumption can be found in Rege [14]. There may also be other explanations for the relatively widespread use of eco-labels. Howarth et al.[7] discusses the informational aspect of eco-labels. As long as the eco-label is known to consumers, it serves as a simple sign of environmental superiority. In the EU and in the Nordic countries the same eco-label is used across many different product categories. Hence, the use of eco-labels likely have scale advantages, compared to the situation in which each firm privately advertises the environmental performance of its products.

Another question is whether an environmental standard can trigger an extra willingness to pay for a "greener product" in the same way as eco-labels. In principle there is nothing that precludes the domestic government from publishing information regarding the environmental regulation of its domestic firms. In Tietenberg [17] there is a discussion of various kinds of disclosure strategies, among others the U.S. toxic release inventory (TRI) where U.S based firms must report their emissions. We can also think of other types of schemes, for example, a label stating that *"this product is produced by a U.S. factory that is controlled and found environmentally sound by the U.S. EPA"*.

As it turns out, equilibria where consumers do not believe producers to be regulated unless they see an eco-label, may not conflict with the more basic assumption that consumers are rational, and should expect that domestic firms are regulated as long as they in fact are regulated. Suppose consumers do not believe producers to be regulated unless they see an eco-label. An environmental standard will then not trigger an extra willingness to pay for the products of the regulated firm. This implies that domestic output and profit will be strictly decreasing in the environmental standard, while foreign output and profit will be strictly increasing.

For small values on the environmental damage parameter; δ, we may then have that optimal policy is not to introduce an environmental standard. In this case consumer beliefs turn out to be self-fulfilling. At the same time a positive criterium for an eco-label may still increase domestic welfare. The main reason is the warm glow effect which increases the benefit of regulation. In addition domestic profit is not hampered as is the case for an environmental standard. Thus, with such beliefs, including the product category in an eco-label scheme may be the only environmental policy instrument available.

In the paper eco-labels are not used for protectionists purposes. Some empirical evidence suggest that the reverse is happening. Körber [9] discusses the U.S. dolphin safe policy and the embargo of the Mexican tuna fishing fleet. According to Körber the criteria for the dolphin safe label has been set with protectionist purposes in mind. Among others the criteria have been made increasingly stringent as the Mexican tuna fishing fleet has improved their dolphin records.

Further, regarding protectionism, Proposition 3 can be given an alternative interpretation. Assume that the foreign firm has a technology which only permits the firm to abate up to a certain level, apart from that the firms are still symmetrical. In this case the government may be able to reserve the eco-label for the domestic firm by setting the criteria sufficiently stringent. However, Proposition 3 tells us that this might not be optimal. It could well be better for the domestic government to set a less stringent criterium in order to get both firms to adopt the eco-label.

Hence, this paper does not generally support a policy where the criteria is purposely chosen so that only a limited number of firms obtain the eco-label. The environmental benefit of a scheme will be higher the more widespread the eco-label is among the products in a category. Further, consumers may incur a disutility from not buying their most preferred product with respect to their other tastes because they want a product with an eco-label. Clearly, a high adoption of eco-labels inside a product category reduces this disutility.

Lastly, the paper suggests that none of the firms will loose compared to the situation without any environmental policy when they both adopt the eco-label. Thus, the domestic consumers pay for the abatement costs of both firms. Here, the assumption about full coverage of the market is crucial. When all consumers buy one unit independent of prices, the price game allows both producers to raise their price with exactly the same as the increase in marginal cost.

There are reasons to believe that the price increase for simple environmental improvements will be modest, see for example Jaffe *et al* [8] which suggests that abatement cost are in the range of 1% of product prices. The assumption about full coverage of the market may then not be too far from reality. In fact, if consumers with a high valuation of the environment have stayed out of the market, we could have that market size *increased* with eco-labels.

The paper also asserts that firms could gain even if they do not adopt the eco-label. This is the case when products are poorly differentiated from the beginning, and the willingness to pay for an eco-label is significant. Hence, eco-labels may not be particularly threatening to the welfare of exporting countries.

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A Demand in the two dimensional differentiation case

We start by looking at the case in which only the domestic firm is regulated by an environmental standard. This case also corresponds to the case in which only the domestic firm adopts the eco-label, given the same stringency of regulation i.e. $\bar{r}_s = \bar{r}_c$.

A.1 Horizontal domination

The straight line,

$$\lambda_x^* = \frac{2}{m(\bar{r}_s)}y + \frac{p_d - p_f - 1}{m(\bar{r}_s)}, \bar{r}_s > 0, \tag{19}$$

divides the unit square into the market shares of firm d and f.

The demand function consists of three line segments. The first line segment covers the case in which p_d is so high that the line, (19), which divides the unit square, do not cross the $x$axes, that is, it only cuts of the upper, left corner of the unit square. Demand is then given by the following integral:

$$q_d(p_d, p_f) = 1 - \int_0^{\frac{m(\bar{r}_s)-p_d+p_f+1}{2}} \left[\frac{2}{m(\bar{r}_s)}y + \frac{p_d - p_f - 1}{m(\bar{r}_s)}\right] dy$$

$$-(1 - \frac{m(\bar{r}_s) - p_d + p_f + 1}{2}),$$

$$\text{for } p_d - p_f - 1 \geq 0 \text{ and } \frac{m(\bar{r}_s) - p_d + p_f + 1}{2} \geq 0,$$

that is, all consumers to the right of, $\frac{m(\bar{r}_s)-p_d+p_f+1}{2}$, on the line, buy from firm f irrespectively of their λ, while consumers between, 0, and, $\frac{m(\bar{r}_s)-p_d+p_f+1}{2}$, may buy from either of the firms depending on their λ.

The second segment is the case shown in Figure 1. The line, (19), then cuts of the unit square from the $x$axes, but because: $\frac{m(\bar{r}_s)-p_d+p_f+1}{2} < 1$, all consumers to the right of, $\frac{m(\bar{r}_s)-p_d+p_f+1}{2}$, on the line, still buy from firm f irrespectively of their λ. For this intermediate case, demand is given by the following integral:

$$q_d(p_d, p_f) = 1 - \int_{\frac{p_f - p_d + 1}{2}}^{\frac{m(\bar{r}_s) - p_d + p_f + 1}{2t}} \left[\frac{2}{m(\bar{r}_s)} y + \frac{p_d - p_f - 1}{m(\bar{r}_s)} \right] dy$$

$$-(1 - \frac{m(\bar{r}_s) - p_d + p_f + 1}{2}),$$

$$\text{for } p_d - p_f - 1 < 0 \text{ and } \frac{m(\bar{r}_s) - p_d + p_f + 1}{2} < 1$$

The last segment of the demand consists of those cases in which the line, (19), cuts of the unit square from the $x$axes, but only leaves the bottom, right corner to firm f:

$$q_d(p_d, p_f) = 1 - \int_{\frac{p_f - p_d + 1}{2}}^{1} \left[\frac{2}{m(\bar{r}_s)} y + \frac{p_d - p_f - 1}{m(\bar{r}_s)} \right] dy,$$

$$\text{for } \frac{p_f - p_d + 1}{2} \leq 1 \text{ and } \frac{m(\bar{r}_s) - p_d + p_f + 1}{2} \geq 1$$

The three integrals can be solved, and we obtain the demand meeting firm d:

$$q_d(p_d, p_f) = \begin{cases} \frac{(m(\bar{r}_s) - p_d + p_f + 1)^2}{4m(\bar{r}_s)} & \text{for } p_f + 1 \leq p_d \leq m(\bar{r}_s) + p_f + 1 \\ \frac{m(\bar{r}_s) - 2(p_d - p_f - 1)}{4} & \text{for } m(\bar{r}_s) + p_f - 1 < p_d < p_f + 1 \\ \frac{4m(\bar{r}_s) - (p_f - p_d - 1)^2}{4m(\bar{r}_s)} & \text{for } p_f - 1 \leq p_d \leq m(\bar{r}_s) + p_f - 1 \end{cases} \tag{20}$$

It is easy to check that the three expressions yield a continuous demand function.

A.2 Vertical domination

In order to derive the demand functions in the vertical domination case we also have to set up three integrals. However, it is only the intermediate case which differs from the horizontal domination case. For the intermediate case the line, (19), now divides the unit square from the λaxes to the vertical line, $x = 1$.

This intermediate integral in the vertical domination case can be written:

$$q_d^v(p_d, p_f) = 1 - \int_0^1 \left[\frac{2}{m(\bar{r}_s)} y + \frac{p_d - p_f - 1}{m(\bar{r}_s)} \right] dy,$$

$$\text{for } p_f + 1 \leq p_d \leq m(\bar{r}_s) + p_f - 1.$$

The integral can be solved to yield the demand meeting firm 1 in the vertical domination case. We can then write the demand function as above:

$$q_d^v(p_d, p_f) = \begin{cases} \frac{(m(\bar{r}_s) - p_d + p_f + 1)^2}{4m(\bar{r}_s)} & \text{for } m(\bar{r}_s) + p_f - 1 \leq p_d \leq p_f + m(\bar{r}_s) + 1 \\ \frac{m(\bar{r}_s) - p_d + p_f}{m(\bar{r}_s)} & \text{for } p_f + 1 < p_d < m(\bar{r}_s) + p_f - 1 \\ \frac{4m(\bar{r}_s) - (p_f - p_d - 1)^2}{4m(\bar{r}_s)} & \text{for } p_f - 1 \leq p_d \leq p_f + 1 \end{cases} \tag{21}$$

It is easy to check that the three expressions give a continuous demand function.

A.3 Both firms adopt the eco-label/no regulation

When either both firms adopt the eco-label, or none of the firms are regulated, there is no vertical differentiation, and demand can be written:

$$q_d(p_d, p_f) = \frac{1 - p_d + p_f}{2} \tag{22}$$

B Deriving the Nash-price equilibrium

B.1 Horizontal domination, environmental standard

As shown above, the demand function facing firm d is composed of three segments of which we have chosen to focus on the intermediate, linear segment where the following condition must be satisfied:

$$m(\bar{r}_s) + p_f - 1 < p_d < p_f + 1. \tag{23}$$

The domestic firm then solves the following problem:

$$\max_{p_d, r_d} \pi_d = [p_d - c_0 - c(r_d)] \frac{2(p_f - p_d + 1) + m(\bar{r}_s)}{4}, \tag{24}$$

s.t.

$$r_d \geq \bar{r}_s.$$

Since $\frac{\partial \pi_d}{\partial r_d} < 0$, we have that the domestic firm sets $r_d = \bar{r}_s$.

For foreign profit we have:

$$\max_{p_f, r_f} \pi_f = [p_f - c_0 - c(r_f)] \frac{2(p_d - p_f + 1) - m(\bar{r}_s)}{4}, \tag{25}$$

s.t.

$$r_f \geq 0.$$

Since $\frac{\partial \pi_f}{\partial r_f} < 0$, we have that the foreign firm sets $r_f = 0$.

From (24) and (25) we obtain two first order conditions which can be solved to yield the Nash-equilibrium prices:

$$p_d = c_0 + \frac{6 + 4c(\bar{r}_s) + m(\bar{r}_s)}{6}, \tag{26}$$

$$p_f = c_0 + \frac{6 + 2c(\bar{r}_s) - m(\bar{r}_s)}{6}. \tag{27}$$

Since the demand functions are composed of three segments, we must check if the Nash-price equilibrium candidate is consistent with the segment of demand that was used to derive the Nash-price equilibrium in the first place. By inserting into (23) we get that the prices (26) and (27) constitutes a Nash-equilibrium as long as:

$$m(\bar{r}_s) \leq \min \left\{ 3 - c(\bar{r}_s), \frac{3 + c(\bar{r}_s)}{2} \right\} \tag{28}$$

It is not difficult to find functional forms for m and c that satisfies (28).[3] As long as the Nash-equilibrium prices are consistent, we know that the Nash price-equilibrium is unique (see Neven & Thisse [11]).

For the equilibrium output we have:

$$q_d = \frac{6 - 2c(\bar{r}_s) + m(\bar{r}_s)}{12} \tag{29}$$

$$q_f = \frac{6 + 2c(\bar{r}_s) - m(\bar{r}_s)}{12} \tag{30}$$

It is then easy to obtain the reduced form profit functions:

$$\pi_d = \frac{1}{2} \left[\frac{6 - 2c(\bar{r}_s) + m(\bar{r}_s)}{6} \right]^2 \tag{31}$$

and:

$$\pi_f = \frac{1}{2} \left[\frac{6 + 2c(\bar{r}_s) - m(\bar{r}_s)}{6} \right]^2 \tag{32}$$

Lastly, we obtain the profit and output of both firms when both or none of the firms adopt the eco-label by setting $c(\bar{r}_s) = 0$ and $m(\bar{r}_s) = 0$ in the expressions (29), (30, (31) and (32).

[3] We have for example: $m(r) = \sqrt{r}$, $c(r) = r^2, r \in [0, 1]$.

B.2 Vertical domination, environmental standard

In order to have vertical domination we must have, $m(\bar{r}_s) > 2$. As long as the following condition is fulfilled:

$$p_f + 1 < p_d < m(\bar{r}_s) + p_f - 1, \tag{33}$$

we have that the domestic firm solves:

$$\max_{p_d, r_d} \pi_d = [p_d - c_0 - c(r_d)] \frac{m(\bar{r}_s) - p_d + p_f}{m(\bar{r}_s)}. \tag{34}$$

s.t.

$$r_d \geq \bar{r}_s.$$

Since $\frac{\partial \pi_d}{\partial r_d} < 0$, we have that the domestic firm sets $r_d = \bar{r}_s$.

For the foreign profit we have:

$$\max_{p_f, r_f} \pi_f \pi_f = [p_f - c_0 - c(r_f)] \frac{p_d - p_f}{m(\bar{r}_s)}. \tag{35}$$

s.t.

$$r_f \geq 0.$$

Since $\frac{\partial \pi_f}{\partial r_f} < 0$, we have that the foreign firm sets $r_f = 0$.

From (34) and (35) we obtain two first order conditions which can be solved to yield the Nash-equilibrium prices:

$$p_d = c_0 + \frac{2}{3} \left[m(\bar{r}_s) + c(\bar{r}_s) \right], \tag{36}$$

$$p_f = c_0 + \frac{1}{3} \left[m(\bar{r}_s) + c(\bar{r}_s) \right]. \tag{37}$$

By inserting (36) and (37) into (33), we see that the set of prices constitutes a Nash equilibrium as long as:

$$m(\bar{r}_s) > \max \left\{ 3 - c(\bar{r}_s), \frac{3 + c(\bar{r}_s)}{2} \right\} \tag{38}$$

The conditions in (38) is then used to construct the domain of the model. Note the similarity between the conditions in (38) and the conditions in (28).

We have for the outputs:

$$q_d = \frac{2m(\bar{r}_s) - c(\bar{r}_s)}{3m(\bar{r}_s)},$$

$$q_f = \frac{m(\bar{r}_s) + c(\bar{r}_s)}{3m(\bar{r}_s)},$$

from which we easily obtain the reduced form profit functions:

$$\pi_d = \frac{[2m(\bar{r}_s) - c(\bar{r}_s)]^2}{9m(\bar{r}_s)}, \tag{39}$$

and:

$$\pi_f = \frac{[m(\bar{r}_s) + c(\bar{r}_s)]^2}{9m(\bar{r}_s)}. \tag{40}$$

which are used to deduce the different equilibrium possibilities in the second stage of the game.

For the case, $\bar{r}_s = 0$, or for the case, $r_d = r_f = \bar{r}_s > 0$, there is no vertical differentiation, and we have that: $\pi_d = \pi_f = \frac{1}{2}$, as above.

C Deriving the "transport cost"

C.1 Horizontal domination, environmental standard

When the price equilibrium is on the intermediate segments of demand, we have that transport cost can be written:

$$TC_s^{hd} = \int\limits_0^{\frac{p_f - p_d + 1}{2}} y^2 dy + \int\limits_{\frac{p_f - p_d + 1}{2}}^{\frac{m(\bar{r}_s) + p_f - p_d + 1}{2}} y^2 \left[1 - \frac{2}{m(\bar{r}_s)} y - \frac{p_d - p_f - 1}{m(\bar{r}_s)}\right] dy$$

$$+ \int\limits_{\frac{p_f - p_d + 1}{2}}^{\frac{m(\bar{r}_s) + p_f - p_d + 1}{2}} [1-y]^2 \left[\frac{2}{m(\bar{r}_s)} y + \frac{p_d - p_f - 1}{m(\bar{r}_s)}\right] dy + \int\limits_{\frac{m(\bar{r}_s) + p_f - p_d + 1}{2}}^{1} [1-y]^2 dy$$

The second and the third integral is weighted with the fraction of consumer situated at $x^* \in \left[\frac{p_f - p_d + 1}{2}, \frac{m(\bar{r}_s) + p_f - p_d + 1}{2}\right]$ buying from firm d and firm f respectively. All consumers left of, $\frac{p_f - p_d + 1}{2}$, buy from firm d independent of their λ, and all consumers right of, $\frac{m(\bar{r}_s) + p_f - p_d + 1}{2}$, buy from firm f independent of their λ.

The integral can be solved to yield:

$$TC_s^{hd} = \frac{1}{3} - \frac{1 - [p_f - p_d]^2}{4} - \frac{3m(\bar{r}_s)[p_d - p_f] - [m(\bar{r}_s)]^2}{12},$$

which by inserting for p_f and p_d yields:

$$TC_s^{hd} = \frac{1 + [m(\bar{r}_s)]^2 + [c(\bar{r}_s)]^2 - m(\bar{r}_s)c(\bar{r}_s)}{12}.$$

Hence, we have:

$$TC_s^{hd} \geq \frac{1}{12} \text{ for } \forall m(\bar{r}_s), c(\bar{r}_s) \in [0,2]$$

We obtain the transport cost in the pure horizontal differentiation case with identical costs by setting $m(\bar{r}_s), c(\bar{r}_s) = 0$.

Note that transport costs are minimized and equal to: $\frac{1}{12}$, when there is no vertical differentiation, that is, either both firms have adopted the eco-label or there is no regulation.

C.2 Vertical domination, environmental standard

When the price equilibrium is on the intermediate segments of demand, we have that the transport cost can be written:

$$TC_s^{vd} = \int_0^1 y^2 \left[1 - \frac{2}{m(\bar{r}_s)}y - \frac{p_d - p_f - 1}{m(\bar{r}_s)}\right] dy$$

$$+ \int_0^1 [1-y]^2 \left[\frac{2}{m(\bar{r}_s)}y + \frac{p_d - p_f - 1}{m(\bar{r}_s)}\right] dy.$$

The unit square is now divided so that even a consumer situated at 1 may buy from firm d if her λ is high enough, and vice versa, a consumer situated at 0 may buy from firm f if her λ is low enough.

By inserting for p_f and p_d, the integral can be solved to yield:

$$TC_s^{vd} = \frac{m(\bar{r}_s) - 1}{3m(\bar{r}_s)}.$$

And its derivative:

$$\frac{dTC_s^{vd}}{d\bar{r}_s} = \frac{3m'}{9m^2} > 0$$

i.e. the higher the, $\bar{r}_s$, the higher the transport cost because more buy from firm d even if they are situated closer to firm f on the line.

D Deriving the "warm glow"

D.1 Horizontal domination, environmental standard

When the price equilibrium is on the intermediate segment of the demand function, we have that the "warm glow" can be written:

$$WG_s^{hd} = \int_0^{\frac{p_f - p_d + 1}{2}} \int_0^1 \left[\lambda m(\bar{r}_s)\right] d\lambda dy + \int_{\frac{p_f - p_d + 1}{2}}^{\frac{m(\bar{r}_s) + p_f - p_d + 1}{2}} \int_{\frac{2y + p_d - p_f - 1}{m(\bar{r}_s)}}^{1} \left[\lambda m(\bar{r}_s)\right] d\lambda dy$$

With respect to the first integral, we have that all consumers left of, $\frac{p_f - p_d + 1}{2}$, buy from firm d independent of their λ. While for the second integral, only consumers with a $\lambda \in \left[\frac{2y + p_d - p_f - 1}{m(\bar{r}_s)}, 1\right]$ buy from firm d. Lastly, no consumer to the right of, $\frac{m(\bar{r}_s) + p_f - p_d + 1}{2}$, buy from firm d.

The integral can be solved to yield:

$$WG_s^{hd} == \left[\frac{p_f - p_d + 1}{2}\right] \frac{m(\bar{r}_s)}{2} + \frac{(m(\bar{r}_s))^2}{6},$$

which by inserting for p_f and p_d yields:

$$WG_s^{hd} = \frac{m(\bar{r}_s)}{4} \left[1 + \frac{(m(\bar{r}_s) - c(\bar{r}_s))}{3}\right].$$

D.2 Vertical domination, environmental standard

When the price equilibrium is on the intermediate segments of demand, we have that the "warm glow" can be written:

$$WG_s^{vd} = \int_0^1 \int_{\frac{2y + p_d - p_f - 1}{m(\bar{r}_s)}}^{1} \left[\lambda m(\bar{r}_s)\right] d\lambda dy$$

The unit square is now divided so that even a consumer situated at 1 may buy from firm d if her λ is high enough, and vice versa, a consumer situated at 0 may buy from firm f if her λ is low enough.

The integral can be solved to yield:

$$WG_s^{vd} = \frac{m(\bar{r}_s)}{2} - \frac{1}{12m(\bar{r}_s)} \left[1 + p_d - p_f\right]^3 + \frac{1}{12m(\bar{r}_s)} \left[p_d - p_f - 1\right]^3.$$

which by inserting for p_f and p_d yields:

$$WG_s^{vd} = \frac{m(\bar{r}_s)}{2} - \frac{1}{12m(\bar{r}_s)} \left[\left(1 + \frac{m(\bar{r}_s) + c(\bar{r}_s)}{3}\right)^3 - \left(\frac{m(\bar{r}_s) + c(\bar{r}_s)}{3} - 1\right)^3\right]$$

D.3 Both firms adopt the eco-label

In this case all consumers buy eco-labeled products, that is, we have:

$$WG_c = \int_0^1 \int_0^1 [\lambda m(\bar{r}_s)]\, d\lambda dy = \frac{m(\bar{r}_s)}{2}.$$

E Proof of Observation in Section 3

The expression for welfare in case, $\delta = 0$, is:

$$w_s(\bar{r}_s) = \bar{s} - \frac{[m(\bar{r}_s)]^2 + [c(\bar{r}_s)]^2 - m(\bar{r}_s)c(\bar{r}_s)}{36} + \frac{5}{6}\left[\frac{m(\bar{r}_s)}{2} - c(\bar{r}_s)\right]$$

We assume an interior solution i.e. $\bar{r}_s^* > 0$, hence, the second term above must be negative. Thus, we see that in order for $\bar{r}_s^* > 0$ to be optimal, we have to have $\frac{m(\bar{r}_s^*)}{2} > c(\bar{r}_s^*)$.

F Proof of Proposition 4

In order to prove the Proposition it is enough to show that it holds for at least one example.

Assume that:

$$\bar{s} = s - c_0 - \delta - \frac{7}{12} = 2 - \frac{7}{12} \text{ for } \delta = 3$$

Let further $m(r)$ and $c(r)$ be given:

$$m(r) = \sqrt{r}, c(r) = r^2 \text{ for } r \in [0,1]$$

Domestic welfare in case of an environmental standard can then be expressed:

$$w = 2 - \frac{7}{12} - \frac{r + r^4 - r^{\frac{5}{2}}}{36} + \frac{5}{6}\left[\frac{\sqrt{r}}{2} - r^2\right] + 3r\left[\frac{6 - 2r^2 + \sqrt{r}}{12}\right],$$

where $r = \bar{r}_s$.

And in case of an eco-label:

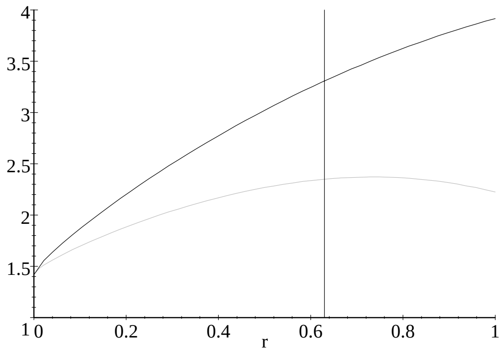
$$w = 2 - \frac{7}{12} + \left[3r + \frac{\sqrt{r}}{2} - r^2\right].$$

For the adoption constraint we have:

$$\frac{\sqrt{r}}{2} \geq r^2 \Leftrightarrow r \leq \sqrt[3]{\frac{1}{4}} \ (\approx 0,63).$$

We can then plot the welfare expressions:

Figure 4.



The vertical, dotted line is the adoption constraint. The black line is welfare in case of an eco-label, while the grey line is welfare in case of an environmental standard. The internal welfare optimum in the latter case obtains when $\bar{r}_s \approx 0,7$, and hence, $\delta > \bar{\delta}$. However, we see that welfare with an eco-label is higher even though the optimal criteria is $\bar{r}_c \approx 0,63$, that is, the welfare maximization for an eco-label is constrained.

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