Competing Environmental Labels*

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Abstract

We study markets in which consumers prefer environmentally friendly products but cannot determine the environmental quality of any given firm's product on their own. A non-governmental organization (NGO) can establish a voluntary standard and label the products of firms whose products comply with the standard. Alternatively, industry can create its own standard and label. We compare the stringency of these two labels, and analyze how they interact.

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1 Introduction

Global environmental issues such as biodiversity and climate change are increasingly important to citizens around the world, but are extremely difficult for governments to address with standard policy tools. The globalization of trade and the need for international coordination on global issues make harmonised world standards for environmental problems unlikely anytime soon. Global trade law also makes it difficult for governments to attempt to regulate attributes of production processes outside their borders, as opposed to inherent product attributes. In the absence of standards for production behavior related to the environment, many groups have put increasing effort into international market mechanisms such as ecolabeling. In some cases, industry takes the lead in developing labels, as in the case of Starkist's move to dolphin-safe tuna (Reinhardt 2000, pp. 31-34) or the pulp and paper industry's "Totally Chlorine Free" label (US EPA 1998, p. B115). In other cases, non-governmental organizations (NGOs) sponsor labels, such as the "Good Environmental Choice" label created by the Swedish Society for the Conservation of Nature (US EPA, p. B99), or the Forest Stewardship Council (FSC) label, which was created by a coalition of groups. In some cases, industry has responded with its own certification standards that employ alternative criteria. The Sustainable Forestry Initiative (SFI) is perhaps the best known of these, and has generated considerable rancor from environmentalists concerned that the weaker SFI standard is undermining the FSC's effectiveness.

There are a number of reports and articles that present case studies on ecolabels. For example, U.S. EPA (1998) offers a thorough review of global use of ecolabels. Sasser et al.

(2006) present an interesting discussion of the competition between FSC and SFI, and which types of firms tend to participate in one labeling scheme as opposed to the other. Yet despite the growing importance of ecolabels, and of competition between them, there has been little formal economic analysis of their effects. Nimon and Beghin (1999) compare competing government standards for a producer in the "North" and one in the "South" to the case with no standards; they find that the South is more interested in harmonising standards than is the North. Heyes and Maxwell (2004) present an insightful model of the potential interaction between a standard adopted by a "World Environmental Organization" (WEO) subject to political pressures, and an ecolabel promulgated by a non-governmental organization (NGO). They find that if the two labels are mutually exclusive, then the creation of the NGO may reduce welfare by undermining the more socially desirable WEO label. If the two labels coexist, however, then the NGO label is a beneficial complement to that of the WEO. Baksi and Bose (2007) compare NGO labels with self-labeling by individual firms, finding that the latter generally dominate the former if the government is willing to engage in costly monitoring of the self-labels.

Our analysis differs from previous work in that we develop a formal model of the rivalry between an NGO label and an industry-sponsored label in a setting with a large number of competing firms. In our analysis government is responsible for neither setting standards nor for monitoring the performance of labels developed by other organizations. We find that if there is only one label, the NGO adopts a more stringent label than does the industry. Furthermore, industry further relaxes its label if the two labels coexist. However, no general

conclusion can be drawn regarding how the NGO label responds to the presence of an industry label; the NGO may tighten or loosen its standards depending upon the distribution of types of firms in the market. Nor is it clear whether environmental damages are higher or lower in the presence of both labels than with the NGO label alone.

The remainder of the paper is organized as follows. Section 2 lays out our basic model, section 3 analyzes the case of a single NGO label and section 4 studies the case of a single industry label. Section 5 compares the two. Section 6 studies the case where the two labels coexist, and section 7 presents simulation results that provide insight into how the NGO label responds to the presence of a competing industry label. Section 8 concludes.

2 Basic Model

The industry consists of a group of n firms that supply a product that sells in a global market. Absent any abatement, each operating firm emits pollutants that impose an external cost on domestic consumers of $Z > 0$. Firms, which are indexed by θ, differ according to their costs of abatement. Each firm chooses its own abatement level s, the cost of which is θs. We assume θ is distributed over $[\underline{\theta}, \overline{\theta}]$ with probability density $f(\theta)$ and cumulative distribution $F(\theta)$. The distribution $F(\theta)$ is common knowledge, but the efficiency of any given firm is not known to other firms or consumers.

There is a large number of consumers, $m > n$, all of whom have "green" preferences. These are captured by assuming that the representative consumer has a willingness-to-pay $p(s)$ with $p'(s) > 0$ and $p''(s) < 0$. For technical reasons that will become apparent below,

we assume that $p'(0) < \underline{\theta}$.

If consumers know that a firm has undertaken abatement level s, and the firm has abatement cost θ, then its profits are

$$\pi(\theta, s) = p(s) - \theta s.$$

However, in the absence of any labels, consumers cannot distinguish the abatement levels of any individual firms, so a firm has no incentive to undertake any abatement and aggregate environmental damages are $ZF(\overline{\theta}) = Z$.

We begin with the situation in which firms have only one labeling option, developed by by institution i with standard s^i. That institution would certify all firms that meet or exceed this level, and allow them to display an ecolabel to consumers. A firm of type θ would mitigate to the level required to obtain certification if $p(s^i) - \theta s^i > p(0)$, or if its costs are lower than the corresponding cutoff level θ^i:

$$\theta < \theta^i \equiv \frac{p(s^i) - p(0)}{s^i}. \tag{1}$$

Thus an interval of low-cost firms would choose to be certified. Note that

$$\frac{\partial \theta^i}{\partial s^i} = \frac{s^i p'(s^i) - (p(s^i) - p(0))}{(s^i)^2} = \frac{s^i p'(s^i) - s^i \theta^i}{(s^i)^2} = \frac{p'(s^i) - \theta^i}{s^i} < 0. \tag{2}$$

The concavity of $p(s)$ ensures that the sign of this expression is negative.[1] In other words, as the standard gets more stringent, fewer firms adopt because the cutoff cost rate falls. Since we assume that $p'(0) < \overline{\theta}$, this holds even as $s \rightarrow 0$. Note that (2) implicitly imposes an upper bound on the standard that can be imposed, namely $\overline{s}$ defined by

$$\frac{p(\overline{s}) - p(0)}{\overline{s}} = \underline{\theta}.$$

There are a number of assumptions in this model that may be worth exploring in subsequent analysis. We assume the willingness to pay for an unlabeled good (or other labeled good) is unaffected by the presence or stringency of another labeled good. We also assume firms are not initially differentiated according to their environmental quality. There is no exit or entry in the model, and no market power.

3 NGO Label

Suppose the NGO is on its own in developing an ecolabel. The NGO is assumed to have as its objective the minimization of environmental damages, so it chooses its standard s^N (and correspondingly θ^N) to minimize

$$D(s^N) = \int_{\underline{\theta}}^{\theta^N} (Z - s^N) f(\theta) d\theta + \int_{\theta^N}^{\overline{\theta}} Z f(\theta) d\theta = Z - s^N F(\theta^N)$$

[1] This can be shown with a Taylor expansion: $p(0) \cong p(s^N) + p'(s^N)(-s^N) + \frac{1}{2} p''(s^N)(-s^N)^2$, so $s^N p'(s^N) - (p(s^N) - p(0)) \cong \frac{1}{2} p''(s^N)(-s^N)^2 < 0$.

The first-order condition is

$$\begin{aligned}\frac{\partial D(s^N)}{\partial s^N} &= -\int_{\underline{\theta}}^{\theta^N} f(\theta)d\theta + \frac{\partial \theta^N}{\partial s^N}(Z - s^N)f(\theta^N) - \frac{\partial \theta^N}{\partial s^N}Zf(\theta^N) \\ &= -F(\theta^N) - \frac{\partial \theta^N}{\partial s^N}s^N f(\theta^N) = 0\end{aligned}$$

which implies

$$p'(s^N) = \theta^N - \frac{F(\theta^N)}{f(\theta^N)}. \tag{3}$$

Checking the second-order conditions,

$$\begin{aligned}\frac{\partial^2 D(s^N)}{\partial (s^N)^2} &= -p''(s^N)f(\theta^N) - (F'(\theta^N) - f(\theta^N) + (p'(s^N) - \theta^N)f'(\theta^N))\frac{\partial \theta^N}{\partial s^N} \\ &= -p''(s^N)f(\theta^N) - (p'(s^N) - \theta^N)^2\frac{f'(\theta^N)}{s^N} \\ &\simeq -p''(s^N)f(\theta^N) > 0\end{aligned}$$

we see an implicit constraint on the distribution to ensure a concave objective function, i.e., that $-p''(s^N)s^N/(p'(s^N)-\theta^N)^2 > f'(\theta^N)/f(\theta^N)$. For example, with the uniform distribution $f'(\theta^N) = 0$, implying $\frac{\partial^2 D(s^N)}{\partial (s^N)^2} = -p''(s^N)f(\theta^N) > 0$.

Industry profits are

$$\Pi(s^N) = \int_{\underline{\theta}}^{\theta^N} (p(s^N) - \theta s^N)f(\theta)d\theta + \int_{\theta^N}^{\overline{\theta}} p(0)f(\theta)d\theta > \int_{\underline{\theta}}^{\overline{\theta}} p(0)f(\theta)d\theta,$$

where the inequality follows from the fact that $p(s^N) - \theta s^N > p(0)$ for all firms that adopt

the ecolabel.

4 Industry Label

Suppose now that there is no NGO label, and the industry sets its own label instead. The industry sets a standard s^I and firms decide whether or not to mitigate to a level that complies with the standard. A firm of type θ will do so if $\theta < \theta^I$, as previously defined.

The industry is assumed to have as its objective the maximization of industry profits, so it chooses s^I to maximize[2]

$$\Pi(s^I) = \int_{\underline{\theta}}^{\theta^I} (p(s^I) - \theta s^I) f(\theta) d\theta + \int_{\theta^I}^{\overline{\theta}} p(0) f(\theta) d\theta.$$

The first-order condition is

$$\frac{\partial \Pi(s^I)}{\partial s^I} = \int_{\underline{\theta}}^{\theta^I} (p'(s^I) - \theta) f(\theta) d\theta + \frac{\partial \theta^I}{\partial s^I} (p(s^I) - \theta^I s^I - p(0)) f(\theta^I) = 0.$$

From the definition of θ^I we know that $p(s^I) - \theta^I s^I = p(0)$, so the above simplifies to

$$\frac{\partial \Pi(s^I)}{\partial s^I} = \int_{\underline{\theta}}^{\theta^I} (p'(s^I) - \theta) f(\theta) d\theta = 0. \tag{4}$$

[2] An important assumption here is that the label does not change demand for the unlabeled product, so that it only affects profits of the labeled products.

We can rearrange terms to get

$$p'(s^I) = \frac{\int_{\underline{\theta}}^{\theta^I} \theta f(\theta) d\theta}{F(\theta^I)}. \tag{5}$$

Integrating by parts yields

$$\int_{\underline{\theta}}^{\theta^I} \theta f(\theta) d\theta = [\theta F(\theta)]_{\underline{\theta}}^{\theta^I} - \int_{\underline{\theta}}^{\theta^I} F(\theta) d\theta = \theta^I F(\theta^I) - \int_{\underline{\theta}}^{\theta^I} F(\theta) d\theta.$$

Thus the industry's FOC can be rewritten as

$$p'(s^I) = \theta^I - \frac{\int_{\underline{\theta}}^{\theta^I} F(\theta) d\theta}{F(\theta^I)}. \tag{6}$$

Industry profits are

$$\Pi(s^I) = \int_{\underline{\theta}}^{\theta^I} (p(s^I) - \theta s^I) f(\theta) d\theta + \int_{\theta^I}^{\overline{\theta}} p(0) f(\theta) d\theta > \int_{\underline{\theta}}^{\overline{\theta}} p(0) f(\theta) d\theta,$$

where the inequality follows from the fact that $p(s^I) - \theta s^I > p(0)$ for all firms that adopt the ecolabel. Clearly, since industry maximizes profits, industry profits are at least as great as when the NGO sets the ecolabel.

5 Comparing Labels

Now we want to compare the degrees of stringency chosen for the two kinds of labels. To do so we impose the relatively weak assumption that the density $f(\theta)$ is log-concave, which

means the natural logarithm of $f(\theta)$ is concave. Bagnoli and Bergstrom (2005) show that this property is satisfied by such familiar distributions as the uniform, the normal, the exponential, and the logistic distributions.

Proposition 1 *If $f(\theta)$ is log-concave, then the NGO always sets a more stringent standard than does the industry.*

Proof. From the two first-order conditions (3) and (6), $s^N > s^I$ if $p'(s^N) < p'(s^I)$, or if for any $\widehat{\theta}$

$$\frac{F(\widehat{\theta})}{f(\widehat{\theta})} > \frac{\int_{\underline{\theta}}^{\widehat{\theta}} F(\theta)d\theta}{F(\widehat{\theta})}. \tag{7}$$

Rearranging terms, this is equivalent to

$$\left[F(\widehat{\theta})\right]^2 > f(\widehat{\theta}) \int_{\underline{\theta}}^{\widehat{\theta}} F(\theta)d\theta. \tag{8}$$

Now define

$$G(x) = \int_{\underline{\theta}}^{x} F(\theta)d\theta,$$

so that $G'(x) = F(x)$ and $G''(x) = f(x)$ for any x in the support of the random variable θ. Given this, we can rewrite (8) as

$$G''(x)G(x) - [G'(x)]^2 < 0. \tag{9}$$

Remark 3 in the Appendix of Bagnoli and Bergstrom (2004) shows that $G(x)$ is log-concave if and only if (9) holds. Furthermore, Theorem 1 of Bagnoli and Bergstrom (2004) establishes that log-concavity is inherited, that is, if $f(x)$ is log-concave, then so are $F(x)$ and $G(x)$. Hence, because $f(x)$ is log-concave, so is $G(x)$, which implies immediately that (9) holds. ■

It may be helpful to present a special case with simple closed-form solutions as a reference point. For this purpose we will work with the assumption that $F(\theta)$ is uniform on $[0,1]$ and that the function $p(s)$ is a simple quadratic that takes the form $p(s) = p(0) + s - s^2/2$. Then the NGO's first-order condition becomes $p'(s) = 1 - s^N = \theta^N - \theta^N = 0$. Thus $s^N = 1$. Using equation (1), we find that $\theta^N = 1/2$, that is, half of the firms elect to be certified with the NGO label. Total abatement is $s^N F(\theta^N) = 1/2$.

For the case with a uniform distribution and quadratic willingness-to-pay, the industry's first-order condition becomes

$$p'(s) = 1 - s^I = \theta^I - \frac{\int_0^{\theta^I} \theta d\theta}{\theta^I} = \frac{\theta^I}{2}.$$

. Thus $s^I = 1 - \theta^I/2$. At the same time, by (1), we know $\theta^I \equiv (p(s^I) - p(0))/s^I = (s^I - (s^I)^2/2)/s = 1 - s^I/2$. Solving these two expressions jointly yields $s^I = 2/3$ and $\theta^I = 2/3$. Total abatement under the industry ecolabel is $s^N F(\theta^N) = 4/9$. Thus, the industry ecolabel is weaker, but attracts more participation, than does the NGO. Total abatement under the industry ecolabel is less than under the NGO ecolabel.

6 Combining NGO and Industry Labels

We turn now to the interaction between the two ecolabels when they coexist. We begin with the case in which the NGO sets a label first, and the industry then responds. We then turn to the opposite case.

6.1 Industry Response

Suppose the NGO has set a standard s^N and the industry chooses a best response. We conduct the analysis by considering first the case where the NGO standard is above the industry response, then the opposite. Throughout we will use subscript "A" for "autarky" to denote standards when only one entity sets a standard, and the subscript "B" to denote the case where both labels exist. Where it will not cause confusion we drop the subscripts in order to economize on notation.

6.1.1 NGO Standard Higher than Industry Response

If industry chooses a standard $s^I < s^N$ then $\theta^I > \theta^N$. Industry profits are then

$$\Pi(s^I; s^N) = \int_{\underline{\theta}}^{\theta^N} (p(s^N) - \theta s^N) f(\theta) d\theta + \int_{\theta^N}^{\theta^I} (p(s^I) - \theta s^I) f(\theta) d\theta + \int_{\theta^I}^{\overline{\theta}} p(0) f(\theta) d\theta$$

At the cutoff cost factor θ^I, the alternative to the industry label is still no label, so $\theta^I \equiv (p(s^I) - p(0))/s^I$ as before.

The first-order condition is now

$$\begin{aligned}\frac{\partial \Pi(s_B^I)}{\partial s^I} &= \int_{\theta^N}^{\theta^I} (p'(s^I) - \theta) f(\theta) d\theta + \frac{\partial \theta^I}{\partial s^I}(p(s^I) - \theta s^I - p(0)) f(\theta^I) \\ &= \int_{\theta^N}^{\theta_B^I} (p'(s_B^I) - \theta) f(\theta) d\theta = 0,\end{aligned}$$

recalling that the second part drops out by the definition of θ^I. Note that this has the same form as (4) except that the lower limit of the integral is now θ^N instead of $\underline{\theta}$. If we evaluate the above condition at the autarky standard we see that:

$$\frac{\partial \Pi(s_B^I)}{\partial s^I} = \int_{\underline{\theta}}^{\theta_A^I} (p'(s_0^I) - \theta) f(\theta) d\theta < \int_{\underline{\theta}}^{\theta_A^I} (p'(s_0^I) - \theta) f(\theta) d\theta = 0.$$

Thus, marginal profits are negative at the autarky standard, due to less participation from competition with the NGO label, which implies that industry wants to choose a lower standard than it would in the absence of an NGO label. We record this result in the following lemma.

Lemma 2 *If the NGO sets a standard s^N, and industry responds with a less stringent standard s_B^I, it must be the case that $s_B^I < s_A^I$.*

6.1.2 NGO Standard Lower than Industry Response

If industry chooses a standard $s^I > s^N$ (and hence $\theta^I < \theta^N$) then industry profits are

$$\Pi(s^N) = \int_{\underline{\theta}}^{\theta^I} (p(s^I) - \theta s^I) f(\theta) d\theta + \int_{\theta^I}^{\theta^N} (p(s^N) - \theta s^N) f(\theta) d\theta + \int_{\theta^N}^{\overline{\theta}} p(0) f(\theta) d\theta.$$

Note that we have two conditions determining which label a firm signs up for. A firm of type θ will choose the NGO standard rather than no standard if $p(s^N) - \theta s^N > p(0)$, or

$$\theta < \theta^N \equiv \frac{p(s^N) - p(0)}{s^N}.$$

A firm of type θ will choose the industry standard rather than the NGO standard if $p(s^I) - \theta s^I > p(s^N) - \theta s^N$, or

$$\theta < \theta_B^I \equiv \frac{p(s^I) - p(s^N)}{s^I - s^N}.$$

Differentiating with respect to s^N we obtain

$$\frac{\partial \theta^I}{\partial s^N} = \frac{p(s^I) - p(s^N) - p'(s^N)(s^I - s^N)}{(s^I - s^N)^2} < 0.$$

The inequality can easily be shown by a geometric argument. If $p(s)$ were linear, then the numerator would be zero. However, $p(s)$ is actually concave, so $p'(s^N)(s^I - s^N) > p(s^I) - p(s^N)$. If $s^N = 0$, then we would have $\theta_B^I = \theta_A^I$, the autarky level. Now, however, we have $s^N > 0$, so $\theta_B^I < \theta_A^I$ for any given level of s^N.

The industry's first-order condition is now

$$\begin{aligned}\frac{\partial \Pi(s^I)}{\partial s^I} &= \int_{\underline{\theta}}^{\theta_A^I} (p'(s^I) - \theta) f(\theta) d\theta + \frac{\partial \theta^I}{\partial s^I}(p(s^I) - \theta^I s^I - (p(s^N) - \theta^I s^N)) f(\theta^I) \\ &= \int_{\underline{\theta}}^{\theta_B^I} (p'(s^I) - \theta) f(\theta) d\theta = 0\end{aligned}$$

This condition has exactly the same form as (4), so at first glance it appears as if industry wants to set the same standard as in the absence of the NGO standard. However, since $\theta_B^I < \theta_A^I$, marginal profits are lower than they would be in autarky; therefore, the industry will again choose a weaker standard than in the absence of an NGO label. Hence we have the following lemma.

Lemma 3 *If the NGO sets a standard s^N, and industry responds with a more stringent standard s_B^I, it must be the case that $s_B^I < s_A^I$.*

Combining this result and that of the preceding lemma implies that the industry always chooses to loosen its standard in response to the presence of an NGO label. We present this result in the following proposition.

Proposition 4 *If the NGO sets a standard and then industry responds with a standard s_B^I, it must be the case that $s_B^I < s_A^I$, that is, industry sets a less stringent standard than it would if there were no NGO label.*

The intuition behind this result is that, with the lower-cost firms having the option to choose the more stringent NGO label, the industry can raise profits by lessening the

cost burden on the remaining firms and increasing participation by loosening its standard somewhat.

6.2 NGO Response

Now suppose industry sets a standard s^I and then the NGO responds with a standard s_B^N .

6.2.1 Industry Standard Lower than NGO Response

If the NGO chooses a higher standard $s_B^N > s^I$ then $\theta^I > \theta^N$. Now, the relevant comparison for the cut-off firm at θ^N is not being unlabeled, but rather adopting the lower industry standard. A firm of type θ will choose the industry standard rather than no standard if $p(s^I) - \theta s^I > p(0)$, or

$$\theta < \theta^I \equiv \frac{p(s^I) - p(0)}{s^I}.$$

A firm of type θ will choose the NGO standard rather than the industry standard if $p(s_B^N) - \theta s_B^N > p(s^I) - \theta s^I$, or

$$\theta < \theta_B^N \equiv \frac{p(s_B^N) - p(s^I)}{s_B^N - s^I} < \theta^I.$$

By the same logic as in the industry case, we can show that $\theta_B^N < \theta_A^N$. In other words, by offering another option besides no label, the industry label reduces participation in the NGO label and lowers the relevant threshold cost for adopting the NGO label. Note that

$$\frac{\partial \theta^N}{\partial s^N} = \frac{(s^N - s^I)p'(s^N) - (s^N - s^I)\theta^N}{(s^N - s^I)^2} = \frac{p'(s^N) - \theta^N}{(s^N - s^I)}.$$

The NGO's objective function is

$$D(s^N; s^I) = \int_{\underline{\theta}}^{\theta^N} (Z - s^N) f(\theta) d\theta + \int_{\theta^N}^{\theta^I} (Z - s^I) f(\theta) d\theta + \int_{\theta^I}^{\overline{\theta}} Z f(\theta) d\theta.$$

Its first-order condition is now

$$\begin{aligned} \frac{\partial D}{\partial s^N} &= -\int_{\underline{\theta}}^{\theta^N} f(\theta) d\theta + \frac{\partial \theta^N}{\partial s^N}(Z - s^N - (Z - s^I)) f(\theta^N) = 0. \\ &= -F(\theta^N) - (p'(s^N) - \theta^N) f(\theta^N). \end{aligned}$$

Thus, once again we appear to recover the same first-order condition as in autarky:

$$p'(s^N) = \theta^N - \frac{F(\theta^N)}{f(\theta^N)}.$$

However, recall that $\theta_B^N < \theta_A^N$. This has a direct effect of reducing the first term on the right-hand side of this equation, but it also reduces the cumulative distribution and has an ambiguous impact on the density. Therefore, the NGO may respond to the industry standard by either tightening or loosening its standard, or not at all, depending on the relative size of these factors. If we return to the uniform distribution, we see again that $p'(s^N) = \underline{\theta}$, and thus the NGO does not respond to the presence of a looser industry standard. The benefits of any additional tightening (or loosening) of standards by participants are just offset by changes in participation in the NGO standard.

We summarize these findings in the following lemma.

Lemma 5 *If the industry sets a standard s^I and then the NGO responds with a higher standard $s_B^N > s^I$, it is possible for $s_B^N > s_A^N$ but also possible for $s_B^N \leq s_A^N$.*

6.2.2 Industry Standard Higher than NGO Response

Suppose now that the industry sets a standard, and the NGO responds with a lower one such that $s_B^N < s^I$. In this case,

$$\theta^I \equiv \frac{p(s^I) - p(s^N)}{s^I - s^N} < \theta_B^N \equiv \frac{p(s^N) - p(0)}{s^N}.$$

Damages are

$$D(s^N; s^I) = \int_{\underline{\theta}}^{\theta^I} (Z - s^I) f(\theta) d\theta + \int_{\theta^I}^{\theta^N} (Z - s^N) f(\theta) d\theta + \int_{\theta^N}^{\overline{\theta}} Z f(\theta) d\theta.$$

The NGO's first-order condition is now

$$\begin{aligned} \frac{\partial D}{\partial s^N} &= -\int_{\theta^I}^{\theta^N} f(\theta) d\theta + \frac{\partial \theta^N}{\partial s^N}(Z - s^N - Z)) f(\theta^N) = 0. \\ &= F(\theta^I) - F(\theta^N) - (p'(s^N) - \theta^N) f(\theta^N). \end{aligned}$$

Rearranging terms, we get

$$p'(s_B^N) = \theta^N - \frac{F(\theta^N) - F(\theta^I)}{f(\theta^N)} \tag{10}$$

Comparing this to (3), the NGO's first-order condition under autarky, it is clear that the

right-hand side of (10) is strictly larger, since it includes the additional term $F(\theta^I)/f(\theta^N)$. Since $p''(s) < 0$, this implies that $s_B^N < s_A^N$. Thus, the effect of the industry standard is to reduce the share of firms conforming to the NGO standard, so the NGO to responds to the presence of a higher industry standard by lowering its standard, relative to autarky. We summarize this result in the following lemma.

Lemma 6 *If the industry sets a standard s^I and then the NGO responds with a lower standard $s_B^N < s^I$, then $s_B^N < s_A^N$.*

Combining the results of this lemma and the previous one leads to the following proposition regarding how the NGO responds to an industry standard.

Proposition 7 *If the industry sets a standard s^I and the NGO responds with a standard s_B^N, then if $s_B^N < s^I$ it must be the case that $s_B^N < s_A^N$. However, if $s_B^N > s^I$, it is possible for $s_B^N > s_A^N$ but also possible for $s_B^N \leq s_A^N$.*

It is interesting that the NGO's response to the presence of a pre-existing competing label is more contingent than is the industry's response, which is always to relax its standard. Intuition suggests that the most likely scenario is one in which $s_B^I < s_A^I < s_A^N$, and that $s_B^N > s_B^I$, but whether $s_B^N > s_A^N$ or $s_B^N \leq s_A^N$ depends upon details of the probability distribution of θ, as shown in the discussion of Lemma 5 above. Section 7 presents simulation analyses of this issue.

6.3 Effects of Label Competition

It seems unlikely that industry would set a standard higher than the NGO, given that its autarky standard is lower and its response to an NGO standard is to further loosen its own standard. Therefore, we focus on cases in which $s_B^N > s_B^I$. With a uniform distribution, of course, the Nash equilibrium is straightforward, since $s_B^N = s_A^N > s_A^I > s_B^I$.

6.3.1 Profits

By definition, the addition of an industry-chosen label to a market with an NGO label must weakly raise profits. The question is, how do profits compare to the situation in which the industry chooses the sole label?

Recall that since $s_A^I > s_B^I$, we also have $\theta_B^N < \theta_A^I < \theta_B^I$. Then we can compare

$$
\begin{aligned}
& \Pi(s_B^I; s_A^N) - \Pi(s_A^I; 0) \\
= & \int_{\underline{\theta}}^{\theta_B^N} \underbrace{(p(s_B^N) - p(s_A^I) - \theta(s_B^N - s_A^I))}_{+} f(\theta) d\theta \\
& - \int_{\theta_B^N}^{\theta_A^I} \underbrace{(p(s_A^I) - p(s_B^I) - \theta(s_A^I - s_B^I))}_{+} f(\theta) d\theta + \int_{\theta_A^I}^{\theta_B^I} (p(s_B^I) - \theta s_B^I - p(0)) f(\theta) d\theta \\
> & \int_{\underline{\theta}}^{\theta_B^N} \underbrace{(p(s_B^N) - p(s_A^I) - \theta(s_B^N - s_A^I))}_{+} f(\theta) d\theta - \int_{\theta_B^N}^{\theta_A^I} \underbrace{(p(s_A^I) - p(s_A^I) - \theta(s_A^I - s_A^I))}_{0} f(\theta) d\theta \\
& + \int_{\theta_A^I}^{\theta_A^I} \underbrace{(p(s_A^I) - \theta s_A^I - p(0))}_{0} f(\theta) d\theta > 0
\end{aligned}
$$

Thus, having an NGO standard alongside the industry standard raises profits. The proof relies on the fact that if any firm following the industry standard instead chooses to follow

the NGO standard, profits must be higher than otherwise. Subsequently, if the industry chooses to adjust its standard, it only does so if it raises industry profits. Thus, we show that the extra profits from adding the NGO standard are strictly positive when industry sticks with the autarky standard. Those extra profits and the extra participation achieved with the optimal standard necessarily outweigh the lower prices from the looser standard. This yields the following proposition.

Proposition 8 *Industry profits are higher when an industry label and an NGO label coexist than when there exists only the industry label.*

6.3.2 Damages

It is easy to compare damages between the autarky systems; obviously, since the NGO minimizes damages, they will be lower with an NGO label than with an industry label. However, what happens to damages when the industry introduces its own label alongside the NGO label?

Suppose that $s_B^N = s_A^N > s_B^I$, as in the uniform distribution case; then $\theta_B^N < \theta_A^N < \theta_A^I < \theta_B^I$. The change in damages is

$$\begin{aligned} D(s_A^N; s_B^I) - D(s_A^N; 0) &= \int_{\underline{\theta}}^{\theta_B^N} (Z - s_A^N) f(\theta) d\theta + \int_{\theta_B^N}^{\theta^I} (Z - s_B^I) f(\theta) d\theta \\ &\quad + \int_{\theta_B^I}^{\overline{\theta}} Z f(\theta) d\theta - \int_{\underline{\theta}}^{\theta_A^N} (Z - s_A^N) f(\theta) d\theta - \int_{\theta_A^N}^{\overline{\theta}} Z f(\theta) d\theta \\ &= \int_{\theta_B^N}^{\theta_A^N} (s_A^N - s^I) f(\theta) d\theta - \int_{\theta_A^N}^{\theta_B^I} (s_B^I) f(\theta) d\theta \end{aligned}$$

Thus, the change in damages depends whether the lost reductions from those firms who switch from the NGO label to the industry one outweigh the additional reductions from former non-adopters who now adopt the industry standards. Note that if $s_B^N \neq s_A^N$, then damages must be lower, since the NGO minimizes damages. Thus, the above evaluation of the change in damages represents an upper bound.

With the uniform distribution, it can be shown that the change in damages is

$$\begin{aligned} D(s_A^N; s_B^I) - D(s_A^N; 0) &= f\left((s_A^N - s_B^I)(\theta_A^N - \theta_B^N) - s_B^I(\theta_B^I - \theta_A^N)\right) && (11) \\ &= f\left(s_A^N(\theta_A^N - \theta_B^N) - s_B^I(\theta_B^I - \theta_B^N)\right) = 0 && (12) \end{aligned}$$

Thus, in this particular case, adding the industry label to the NGO label does exactly as much good as harm, in terms of environmental damages. This gives us the following proposition.

Proposition 9 *With a uniform distribution $F(\theta)$, adding an industry label to an existing NGO label has no effect on environmental damages.*

7 Simulations

Our analysis thus far has yielded some sharp results, such as the fact that in autarky the NGO sets a more stringent label than does industry, and that industry weakens its label further if both labels coexist. However, we also showed that it is unclear in general how

the NGO responds to the presence of the industry label, and unclear whether environmental damages increase or decrease with label competition. To shed further light on these questions, we conduct simulation analyses.

We consider two possible willingness-to-pay functions, a quadratic function of the form $p(s) = ys - ms^2/2$, with two parameter combinations for y and m, and a logarithmic function of the form $p(s) = \ln(1+s)$. (We analyzed the former under the assumption of a uniform distribution $F(\theta)$ in section 5 above.) Figure 1 displays these price functions; the parameter combinations $y = 1, m = 1$ follow the log function more closely at low levels of stringency, while the combinations $y = .2, m = .005$ follow the log function better at higher stringency levels. The marginal price functions are quite different, though.

For the density $f(\theta)$, we use the Beta distribution, which is defined as

$$f(\theta; a, b) = \frac{\theta^{a-1}(1-\theta)^{b-1}}{\int_0^1 u^{a-1}(1-u)^{b-1}du} = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)}\theta^{a-1}(1-\theta)^{b-1}.$$

where $\Gamma(u)$ is the gamma function.[3] The Beta distribution is defined on the interval $[0, 1]$, has mean $E(\theta) = a/(a+b)$, and is log-concave if $a \geq 1$ and $b \geq 1$. (Bagnoli and Bergstrom 2005) The Beta distribution is convenient because it can take on a great variety of shapes depending upon the values of a and b. For example, if $a = b$, the density is unimodal with mean $1/2$, and if in addition $a = b = 1$, we have the uniform distribution. When $a < b$, the density skews to the left, while if $a > b$, the density skews to the right. Figure two gives examples of different combinations of these distribution parameters.

[3] There is no closed-form representation for the Beta distribution.

Figure 1: Simulation Price Functions

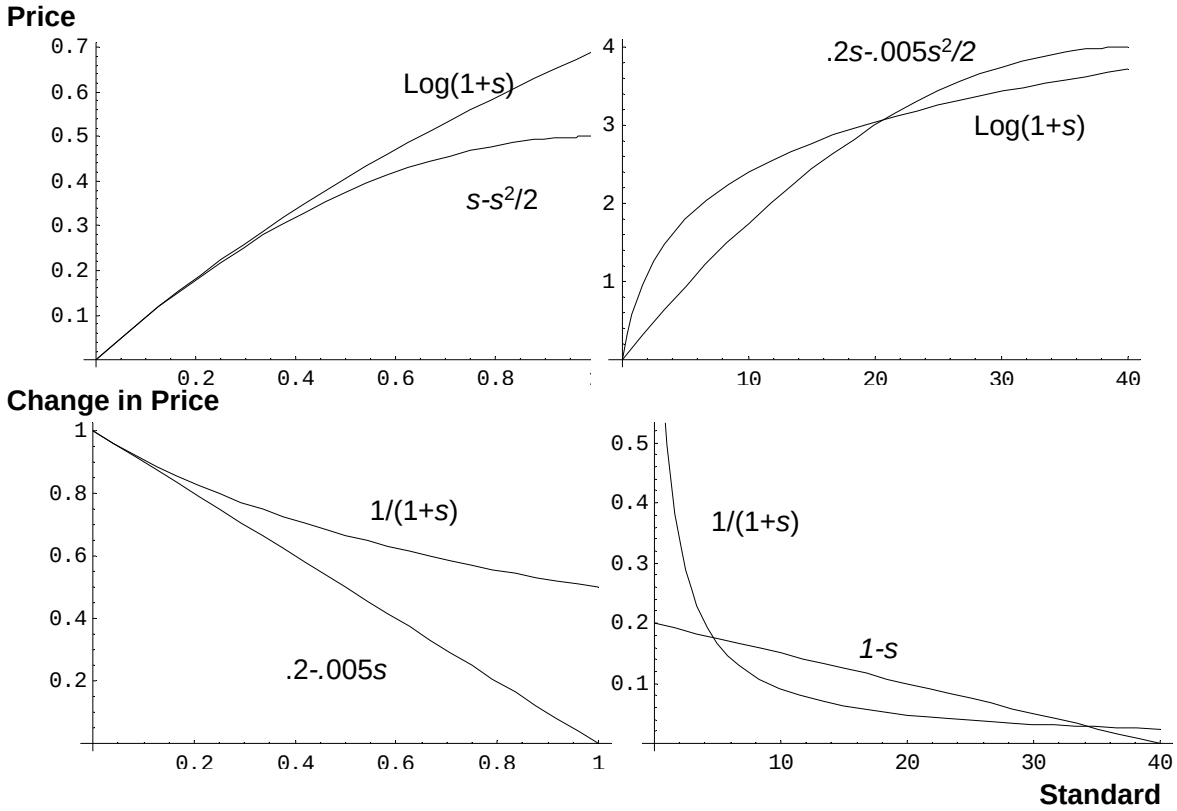

Figure 2: Example Distribution Functions for θ

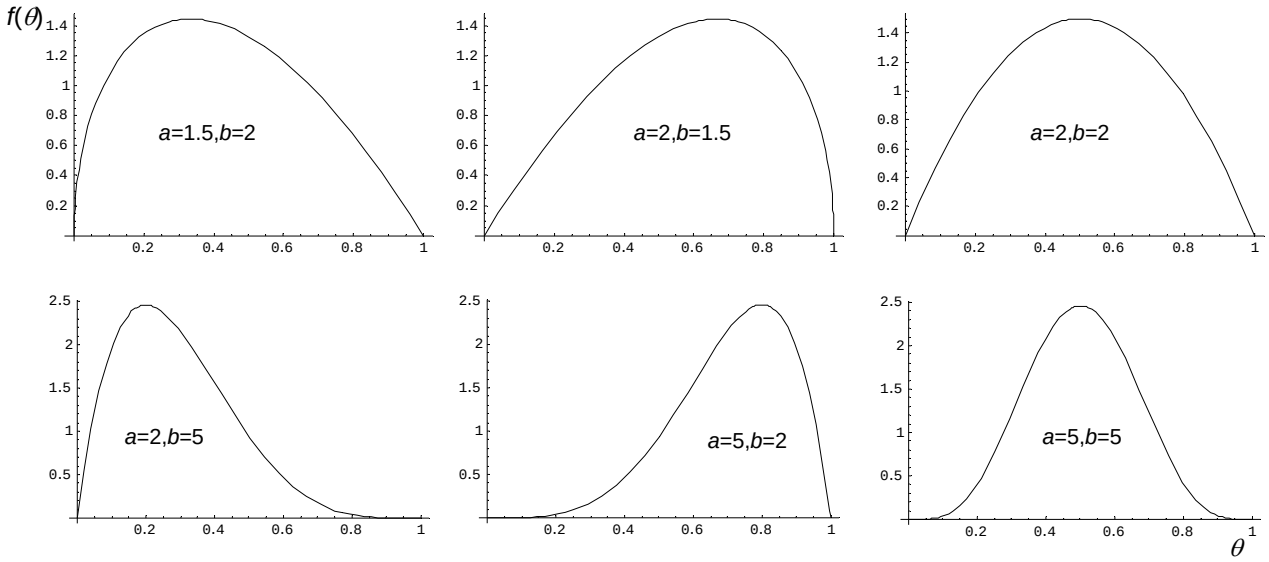

Figure 3:

The first table reports simulation results assuming the log price function and different distribution functions for θ. In all cases, the equilibrium industry standard and price premium is lower than in autarky, while the NGO targets a higher premium than in autarky. Participation rates in the industry label are sometimes slightly higher, sometimes slightly lower with both labels compared to autarky. For the NGO label, however, participation always drops precipitously when the industry label is present. In some cases, there are larger changes in damages (more reductions) with both labels in the market, while in others–notably, for tighter distributions (higher values of a and b)–damages are higher (fewer reductions) with both standards than with the NGO label alone.

The second table reports simulations exploring the role of the price function. In the last case, the NGO responds to the presence of an industry label by loosening its own standard. In

Figure 4: Simulation Results with Different Distributions (Log Price Function)

Distribution Parameters		*Prices*				*Participation Rates*				*Change in Damages*		
a	b	pIA	pIB	pNA	pNB	%IA	%IB	%NA	%NB	Industry	NGO	Both
2	5	0.64	0.60	1.23	1.54	82%	80%	29%	5%	-2.75	-4.62	-4.14
1.5	2	0.58	0.55	1.42	1.90	59%	60%	11%	2%	-1.64	-2.71	-3.03
2	2	0.46	0.41	0.89	1.15	59%	60%	22%	5%	-1.12	-1.49	-1.55
5	5	0.34	0.33	0.53	0.81	84%	84%	53%	2%	-1.00	-1.26	-1.06
2	1.5	0.42	0.38	0.80	1.19	51%	52%	20%	3%	-0.83	-1.05	-1.17
5	2	0.21	0.20	0.30	0.67	59%	60%	41%	1%	-0.38	-0.41	-0.40

Figure 5: Simulation Results with Different Price Functions ($a = 2, b = 3$)

Price Function	*Prices*				*Participation Rates*				*Change in Damages*		
	pIA	pIB	pNA	pNB	%IA	%NA	%IB	%NB	Ind.	NGO	Both
Log[1+s]	0.53	0.49	1.03	1.38	71%	25%	70%	4%	-1.67	-2.45	-2.44
(.2-.005s/2)s	2.60	2.55	3.07	3.92	1.4%	1.2%	1.4%	0.0%	-0.23	-0.24	-0.23
(1-s/2)s	.127	.125	.192	.191	90%	71%	88%	3%	-.576	-.688	-.578

all of these cases, damages are higher than with the NGO label alone. Additional simulations using different distributions with the quadratic price forms all produced the result in which damages are most reduced by the NGO label alone.

8 Conclusions

We have presented a formal economic model of voluntary ecolabels developed by an environmental NGO and by industry. We showed that an NGO label is more stringent than an industry ecolabel, assuming there is only one label present in the market at a time. When an NGO label is added to a market with an industry label, industry weakens its standard and

industry profits increase. Since the NGO only enters the market if it can reduce damages, environmental quality necessarily improves relative to the industry label alone. However, when an industry label is added to a market with an NGO label, the NGO may strengthen or weaken its label, depending on whether it prefers to extract greater improvements out of its remaining participants or rather regain market share. Furthermore, environmental damages may rise or fall with two labels, relative to a situation with the NGO label by itself. These latter results are sensitive both to the distribution of compliance costs among firms and to the willingness to pay for increasingly stringent standards. Our simulations indicate that dueling labels are more likely to be beneficial to the environment if firm types are broadly distributed, leaving more room for differentiation; else the two label sponsors are competing within a tight range of potential participants, leaving the NGO with little market share.

While the introduction of an additional label can have ambiguous effect on the environment, the industry will generally be better off with additional voluntary labels, which offer additional choices for increasing profits. A societal objective function would likely balance profits and environmental damages (and consumer surplus), meaning that the optimal single standard would lie in between the industry and NGO autarky standards. However, the fact that multiple labels may not be improving for the environment indicates incentives on the part of NGOs to work with industry groups to avoid excess competition. There may also be a potential role for the government in influencing the number of labels and their criteria.

Several simplifications in this analysis merit exploration in further research. We have

assumed that consumer willingness to pay for one label depends only on the standard for that label; in reality, ecolabels may function as substitutes, meaning prices would depend on the qualities of the other labels as well. Adding this feature would create additional interactions between competing labeling schemes. We have also assumed that standards set targets for reductions in damages. While this assumption may be applicable for some voluntary programs, many environmental labels set absolute standards, in which case the labeling groups would face more complicated twin distributions of firms by costs and by emissions. We would expect that including these additional complications would tend to reinforce ambiguity in the environmental effectiveness of competing ecolabels.

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