Eco-labeling and Strategic Rivalry in Export Markets

Arnab K. Basu, Nancy H. Chau and Ulrike Grote

1 Introduction

There are two linkages that constitute the interface between international trade and the environment. The first arises when purely trade driven incentives, rather than environmental considerations, guide production decisions in such a way that environmental exploitation in the name of trade is threatened. These result in scale, composition and technique choices that fail to internalize consumers' preferences with respect to production and process methods (PPMs), or society's preferences with respect to local and transnational environmental commons (Grossman and Krueger 1995, Copeland and Taylor 1994, 1995). The second stems from the possibility that international trade unleashes competitive pressure that put emphasis on policies and technology choices that facilitate cost-cutting (Frankel and Rose 2002, Porter and van der Linde 1995). Here, the concern is over a potential race to the bottom in environmental performance standards, in which trade ties between countries and a vicious cycle of environmental policy *interdependence* are inextricably linked.

In this context, eco-labeling - the provision of information about the environmental externalities associated with the production and consumption processes - holds the promise of cutting through both of these knots. By re-establishing the link between marginal environmental gains and revenue incentives, eco-labeling offers to provide market-based rewards to producers that practice green production methods through a green premium. Concurrently, by rendering the adoption of green technology to a profitable enterprise, incentives to participate in the race to cut costs may be moderated by competition that is based jointly on comparative cost and reputational advantage, backed by the credibility of an environmental performance guarantee.

It is thus perhaps not all that surprising that the adoption of eco-labels in both industrial and agricultural sectors has grown worldwide (Basu, Chau and Grote 2003). Labeling initiatives in agriculture, for example, are particularly notable for their relatively early start. In countries such as Germany, France and Italy, food industry eco-labeling initiatives have been in existence as early as the 1920's. In addition, since global agricultural trade impacts the interests of developed and developing countries, another question that arises is whether eco-labeling can exacerbate income disparities between developed and developing countries, when the latter may be at a disadvantage based both on cost and revenue grounds. In terms of costs, the effectiveness of eco-labeling depends on whether green technologies are readily accessible, and accordingly whether the costs involved in implementing labeling programs can be afforded or even justified (UNDP 1999). In terms of revenue, the relative credibility of labeling programs in developed and developing countries - whether perceived or realistic - may impact terms of trade facing developing country exports in ways that are similar to other non-tariff import barriers (UNDP 1999, Basu and Chau 2001).

In assessing the promise of eco-labeling, therefore, a number of pertinent questions arise. First, do producers behave as though a green premium indeed exists? Second, do strategic interactions between trading partners in their decision to adopt labeling prevail, and if so, has there been a race to the bottom, or a race to the top? Finally, accounting for the economic, environmental and other strategic interactions related factors that drive labeling incentives, what are the income distributional consequences of eco-labeling?

Existing studies on eco-labeling focus on the first question, and quantify the size of the green premium in various product markets either through consumer surveys, or hedonic price estimation.[1] More broadly, recent empirical studies on trade and the environment focus on how the relationship between trade liberalization and various environmental *outcome measures*, such as the intensities of air and water pollution, can be ascertained (Dean 2000, Antweiler, Copeland and Taylor 2001, Frankel and Rose 2002). Our approach here in this paper takes a different tact. Rather than focusing on the consumption end of the market for green products in which eco-labels are already in place, we begin instead by proposing the question, why do some countries have national eco-labeling programs and others do not? Meanwhile, our approach to uncover the link

[1] For instance, Robins and Roberts (1997) find that 5 to 15% of consumers may pay a slightly higher price for more environmentally friendly goods. A consumer survey in China indicated that close to 80% of consumers are willing to purchase green food (China Council for International Cooperation (1996). Also see Shams (1995) for the case of developing countries and Willer and Yuseffi (2001) for the case of eco-labeled apples in the United States. Also, Nimon and Beghin (1999) estimate the price premium for various individual attributes of apparel goods.

between eco-labeling and trade explicitly recognizes the endogeneity of environmental policy formation, and addresses the question of how the adoption of eco-labeling - a market-based environmental policy initiative - depends on a country's trade orientation, stage of development and other strategic concerns.

Following the analytical framework set out in Basu, Chau and Grote (2004), we consider a multi-country setting of export rivalry in two stages. In the first stage, countries determine whether or not to adopt eco-labeling. In the second stage, countries compete in a horizontally differentiated product market consisting of goods produced via a green production method and goods produced via a baseline production method. This frame-work yields a set of empirical implications in a subgame perfect Nash equilibrium, and highlights the selection criteria of countries that adopt eco-labeling. Consistent with recent empirical studies on the interlink between trade and the environment (Dean 2000, Antweiler, Copeland and Taylor 2001, Frankel and Rose 2002), it is shown that participation in world trade, the scale of production, and the stage of development of an economy are positively associated with the likelihood of eco-labeling. Taking these established results a step further, our findings also indicate the presence of strategic interdependence, in which the likelihood to adopt labeling is positively correlated with the popularity of labeling among a country's major export destinations. Thus, while the popular characterization of export competing countries as participants in a “race" may indeed be apt, the nature of such strategic interactions should perhaps be more appropriately termed a race to the top, rather than a race to the bottom.

In this paper, the findings of Basu, Chau and Grote (2004) are extended in two directions. In terms of analytics, a set of welfare consequences associated with the move towards eco-labeling by some countries and not others will be examined. By highlighting the endogeneity of labeling incentives directly, we find that the key lies not just in the size of the green premium, as is frequently alleged in the literature. Indeed, we will define an *industry-level* green premium in general equilibrium, which is key to the welfare consequences of export rivalry based on eco-labeling in a subgame perfect Nash equilibrium.

In terms of empirical analysis, an important question that has yet to be explored is whether the prior focus exclusively on export rivalry may have ruled out possible strategic interactions via import competition. Indeed, are labeling programs oriented towards foreign consumers' preferences in export markets, or are they possibly also instigated by the penetration of environmental friendly import competition?

In what follows, Section 2 presents a general equilibrium model that yields a set of possible determinants of the incentive to adopt eco-labeling.

Section 3 presents the welfare consequences of eco-labeling. The empirical methodology and the findings are presented in Section 4. Section 5 concludes.

2 The Basic Model

Producers in N countries are engaged in the production of two goods: a homogeneous numeraire Y^j, $j = 1,...,N$ and an agricultural output X^j. Production of the numeraire commodity employs a composite input, L^j_y, with $Y^j = \omega^j L^j_y$, where ω^j denotes the marginal and average product of input L^j_y.

Producers in agriculture also employ the composite input, and choose in addition between (i) an environmentally sound production technology X^j_e, or (ii) a baseline production technology X^j_o, with

$$X^j_e = (L^j_x /a)^{\alpha}, \qquad X^j_o = (L^j_x)^{\alpha},$$

where $a \in (1,\infty)$ is producer-specific, and parameterizes the cost of adopting the environmentally friendly production technique. The cumulative distribution function X^j_e $F^j(a')$ denotes the fraction of producers in country j with $a \le a'$, and $a, a' \in (1,\infty)$. Let M^j be the number of competitive agricultural producers in country j.

2.1 Voluntary Adoption of Green Production Technique

Whether or not a producer in country j adopts the eco-friendly method of production is an outcome of a two-stage decision making problem, and depends in particular on the extent to which eco-labeling allows producers to internalize consumers' willingness to pay for eco-friendly production techniques. Let p_u be the price of unlabeled agricultural output produced via the baseline technique, and p^j_l be the price of labeled agricultural output produced via the environmentally friendly technology. We allow p^j_l to differ by country-of-origin, in order to account for the possibility that the green premium (p^j_l - p_u) may differ across countries due to differing consumers' perception about the credibility of eco-labeling programs across countries, or simply due to differing consumers' perception about the location-specific environmental benefits, and hence, their willingness to pay for the implementation of green production techniques.

Each producer in agriculture first determines whether or not to voluntarily adopt the environmentally sound technology, and conditional on technology adoption choices, determines the amount of input L^j_x to employ. Beginning from the second stage, and taking as given the competitively determined cost of employing a unit of the composite input, ω^j, it is straightforward to verify that maximal profits respectively by choice of the environmentally sound technology, $\pi^j_e(a, p^j_l)$, and the baseline technology, $\pi^j_o(p_u)$, are given by:

$$\pi^j_e(a, p^j_l) = \max_{L^j_x} \; p^j_l(\frac{L^j_x}{a})^\alpha - \omega^j L^j_x \equiv (1-\alpha)\left(p^j_l(\frac{\alpha}{a\omega^j})^\alpha\right)^{\frac{1}{1-\alpha}}, \tag{1}$$

$$\pi^j_o(p_u) = \max_{L^j_x} \; p_u(L^j_x)^\alpha - \omega^j L^j_x \equiv (1-\alpha)\left(p_u(\frac{\alpha}{\omega^j})^\alpha\right)^{\frac{1}{1-\alpha}}, \tag{2}$$

Also, let $X^j_e(a, p^j_l)$ and X^j_o respectively denote the profit maximizing output levels associated respectively with equations (1) and (2). It follows, therefore, that a producer in country *j* benefits from adopting the environmentally friendly production method if and only if

$$\pi^j_e(a, p^j_l) \geq \pi^j_o(p_u) \Leftrightarrow a \leq \left(\frac{p^j_l}{p_u}\right)^{\frac{1}{\alpha}} \equiv \bar{a}^j .$$

In other words, the parameter $\bar{a}^j$ singles out the marginal producer who is just indifferent between the two techniques. Clearly, the higher the green premium, (p^j_l / p_u)-1, the higher will be the fraction of producers $F^j(\bar{a}^j)$ who benefit from green agricultural production.

The definition of $\bar{a}^j$ also implies that the value of aggregate agricultural production in country *j* is made up of two parts, derived respectively from environmentally friendly (X^j_e) and baseline (X^j_o) production:

$$\begin{aligned} &M^j\left[p^j_l \int_1^{\bar{a}^j} X^j_e(a, p^j_l)dF^j(a) + p_u \int_{\bar{a}^j}^{\infty} X^j_o(p_u)dF^j(a)\right] \\ &= M^j[p_u(\frac{\alpha}{\omega^j})^\alpha]^{\frac{1}{1-\alpha}}\left[(1-F^j(\bar{a}^j)) + (\frac{p^j_l}{p_u})^{\frac{1}{1-\alpha}} \int_1^{\bar{a}^j}(1/a)^{\frac{\alpha}{1-\alpha}} dF^j(a)\right]. \end{aligned} \tag{3}$$

As should be apparent, international differences in revenue per producer can be decomposed into two parts, including (i) terms in the first square brackets ($p_u(\alpha/(\omega^j)^{\alpha})^{1/(1-\alpha)}$), which depend on international cost differences ω^j , and (ii) terms in the second square brackets, which depend on the self-selection among producers in employing the two agricultural production techniques ($\bar{a}^j$), and the green premium.

Note in particular that producer profits in countries where no eco-labeling programs prevail is in fact a special case of equation (3) above, in which p^j_l is replaced by p_u, as the green premium does not apply to unlabeled products. It follows, therefore, from the definition of $\overline{a}^j$ that $\overline{a}^j = (p^j_l / p_u)^{1/\alpha} = 1$. Thus, profits of the average producer simply depend on ω^j with:

$$\overline{\pi}^j = (1-\alpha)(p_u(\frac{\alpha}{\omega^j})^{\alpha})^{\frac{1}{1-\alpha}}. \tag{4}$$

2.2 The Green Premium and Supply Response

Consumer preferences in country j are characterized by a utility function ($U^j(D^j_x, d^j_y)$), which accounts for consumption of the homogeneous numeraire d^j_y, and a consumption index of good x, D^j_x, with,[2]

$$\log U^j(D^j_x, d^j_y) = \beta^j \log D^j_x + (1-\beta^j) \log d^j_y,$$

where $\beta^j > 0$ denotes the share of consumer expenditure devoted to the consumption of the agricultural output. In addition,

$$D^j_x = \sum_{i=1}^{N}(1+g^j)d^{ji}_e + \sum_{i=1}^{N} d^j_o$$

D^j_x is made up of two components, accounting respectively for the physical quantities of x consumed, $\sum_{i=1}^{N} d^{ji}_e$ and an index of green consumption $\sum_{i=1}^{N} g^i d^{ji}_e$. The ratio $(1+g^i)/(1+g^k)$ gives the marginal rate of substitution between d^{ij}_e and d^{ik}_e and reflects consumer's relative valuation for eco-friendly production originating from countries i and k. The marginal rate of substitution between a unit of labeled output from country i, and a unit of unlabeled output is simply $1+g^i$.

In equilibrium, relative prices must reflect these consumer preferences for there to be positive demand for all goods, and hence

$$\frac{p^i_l}{p^k_l} = \frac{1+g^i}{1+g^k}, \quad \frac{p^i_l}{p_u} = 1+g^j, i,k = 1,...,N. \tag{5}$$

[2] See Dixit and Stiglitz (1977) for a discussion of the use of similar utility indexes when product differentiation is of central concern.

It follows that aggregate agricultural producer revenue in the presence of eco-labeling in country *j* depends on the green premium, since:

$$Q_e^j(p_u) = M^j[p_u(\frac{\alpha}{\omega^j})^{\alpha}]^{\frac{1}{1-\alpha}}$$

$$\left[(1-F^j((\frac{p_l^j}{p_u})^{1/\alpha})) + (\frac{p_l^j}{p_u})^{\frac{1}{1-\alpha}} \int_1^{(\frac{p_l^j}{p_u})^{1/\alpha}} (1/a)^{\frac{\alpha}{1-\alpha}} dF^j(a)\right]$$

$$= M^j[p_u(\frac{\alpha}{\omega^j})^{\alpha}]^{\frac{1}{1-\alpha}}$$

$$\left[1+(1+g^j)^{\frac{1}{1-\alpha}} \int_1^{(1+g^j)^{1/\alpha}} [(\frac{1}{a})^{\frac{\alpha}{1-\alpha}} - (\frac{1}{1+g^j})^{\frac{1}{1-\alpha}}]dF^j(a)\right]$$

$$\equiv p_u^{\frac{1}{1-\alpha}}\gamma^j(1+G^j).$$

In the absence of labeling, agricultural producer revenue in country *j* is given by:

$$Q_o^j(p_u) = p_u^{\frac{1}{1-\alpha}}\gamma^j.$$

with $\gamma^j \equiv M^j(\alpha/\omega^j)^{\frac{\alpha}{1-\alpha}}$. γ^j parameterizes the production cost in the agricultural sector of country *j*. Note also that $p_u\ G^j$ is an industry-level green premium, and represents the increase in industry-level revenue, holding p_u constant, that may be expected subsequent to eco-labeling. The size of G^j depends jointly on a demand-side and a supply-side effect. The demand effect is given by the country-specific green premium $1+g^j$, and G^j rises with g^j for every country *j*, with $G^j > 0$ if and only if $g^j > 0$. On the supply side, the cost distribution among producers in country *j*, F^j, matters, and a popular prevalence of producers at the lower end of the cost distribution implies a larger industry-level green premium.

2.3 Nash Equilibrium

In a Nash equilibrium, countries' decisions to adopt labeling are interdependent. We seek conditions under which a country will adopt eco-labeling in a Nash equilibrium, taking into account the endogenous terms of trade consequences of these adoption choices. To begin with, let *I* be the set of all countries in which an eco-labeling program is in place, and I_{-j} be the set of all countries in I but country j. With consumer income (aggregate earnings of composite input owners) equal to $\omega^j L^j$ in country j, aggregate world demand for the agricultural output is equal to total producer revenue if and only if:

$$\sum_{j=1}^{N} \beta^j \omega^j L^j = \sum_{j \in I} (p_u(I))^{\frac{1}{1-\alpha}} \gamma^j (1+G^j) + \sum_{j \notin I} (p(I))^{\frac{1}{1-\alpha}} \gamma^j .$$

It follows, therefore, that the price of unlabeled (eco-unfriendly) agricultural output is given by:

$$p_u(I) = \left(\frac{\sum_{j=1}^{N} \beta^j \omega^j L^j}{\sum_{j \in I} \gamma^j G^j + \sum_{j=1}^{N} \gamma^j} \right)^{\frac{1}{1-\alpha}} .$$

Note that the price of eco-unfriendly products is strictly decreasing in the number of countries that have instituted an eco-labeling program, as long as $G^j > 0$ for $j \in I$. Indeed, the same is true of the price of labeled products, since $p^j_l(I, g^j) = p_u(I)(1+ g^j)$. These terms of trade effects accordingly highlight the negative externality that one country's decision to implement labeling programs imposes on the welfare of producers in other countries.

What remains to be seen, however, is how the decision to adopt eco-labeling in one country depends on that of another. To this end, let W be the sum total of consumer expenditure in the N countries to be devoted to the consumption of the agricultural output, with $W \equiv \sum_{j=1}^{N} \beta^j \omega^j L^j$. Aggregate producer profits in country j with eco-labeling, taking as given the I_{-j}, is given by:

$$\Pi^j_e(I_{-j}, G^j) = \frac{(1-\alpha) W \gamma^j (1+G^j)}{\sum_{i \in I_{-j}} \gamma^i G^i + \gamma^j G^j + \sum_{j=1}^{N} \gamma^j} . \quad (6)$$

In contrast, if country j abstains from encouraging green production techniques via eco-labeling, aggregate producer profits in country j is equal to:

$$\Pi_o^j(I_{-j}) = \frac{(1-\alpha)W\gamma^j}{\sum_{i\in I_{-j}}\gamma^i G^i + \sum_{j=1}^N \gamma^j}. \tag{7}$$

Thus, if c^j denotes the fixed cost required to put in place a credible labeling program in country *j*, aggregate producer profits rise with market-based voluntary green production via eco-labeling, taking as given the adoption decisions of the rest of the N -1 countries, if and only if $\Pi_e^j(I_{-j}, G^j) - \Pi_o^j(I_{-j}) \geq c^j$, or[3]

$$\log G^j \geq \log(\frac{c^j/(1-\alpha)}{Q_o^j(p(I_{-j}))}) - \log(1-\frac{c^j/(1-\alpha)}{W - Q_o^j(p(I_{-j}))}) + \log(1+\frac{\gamma^j}{\sum_{i\in I_{-j}}\gamma^i G^i + \sum_{i\neq j}\gamma^j}). \tag{8}$$

As such, the decision to implement an eco-labeling program reflects a number of factors that are simultaneously in play. To begin with, the larger the industry-level green premium G^j, the more likely it is that the inequality in equation (8) is satisfied. In addition, the value of aggregate output of country *j*, $Q^j_o(p_u(I_{-j}))$, also plays a key role in the determination of labeling incentives. First, the larger the output level in the absence of an eco-labeling program in country *j*, $Q^j_o(p_u(I_{-j}))$, the more able are producers in country *j* in shouldering the fixed cost of labeling. However, and contrary to the first effect, a country that has a sufficiently large market share to begin with may also have little to gain from market share rivalry via eco-labeling. To see this, note that if country *j* is large enough so that $W - Q^j_o(p_u)$ is close to zero, $\Pi^j_e(I_{-j}, G^j) - \Pi^j_o(I_{-j}) - c^j$ is always less than zero, for $c^j > 0$.

The third term in equation (8) denotes the magnitude and the nature of peer effects between the *N* countries. In particular, linearizing

[3] To see this, note from equations (6) and (7), along with the definition $Q^j_o(p_u)$, that $\pi^j_e(I_{-j}) - \pi^j_o(I_{-j}) > c^j$ if and only if $c^j / Q^j_o(p_u) \leq G^j(\sum_{i\in I_{-j}}\gamma^i G^i + \sum_{i\neq j}\gamma^j)/(\sum_{i\in I_{-j}}\gamma^i G^i + \gamma^j G^j + \sum_{i=1}^N \gamma^i)$.

Equation (8) follows from rearranging terms, and taking logs on both sides.

$\log(1+\frac{\gamma^j}{\sum_{i\in I_{-j}}\gamma^i G^i+\sum_{i\neq j}\gamma^j})$ with respect to $\gamma^j/\sum_{i\neq j}\gamma^j$, we obtain

$$\log(1+\frac{\gamma^j}{\sum_{i\in I_{-j}}\gamma^i G^i+\sum_{i\neq j}\gamma^j})\approx\log(1+\frac{\gamma^j}{\sum_{i\neq j}\gamma^j})-\frac{\gamma^j}{\sum_{i\neq j}\gamma^j}\left(\sum_{i\in I_{-j}}\frac{\gamma^i}{\sum_{i=1}^N\gamma^i}G^i\right).$$

Among other things, adoption is more likely: (i) as the cumulative number of countries that have already adopted a labeling program I_{-j} increases, so long as $G^i > 0$, and (ii) as the industry-level green premium of those countries $\gamma^i G^i$ that already have a labeling program in place also increase. In addition, the comparative production cost advantage of country j in baseline agricultural production ($\gamma^j/\sum_{i\neq j}\gamma^j$) can have a positive impact on labeling incentives, so long as the industry green premium of country j's export rivals ($\sum_{i\in I_{-j}}\gamma^i G^i$) is sufficiently large.

Notably, the cumulative number of countries with labeling programs plays a role in adoption decisions *only if* the industry level green premia of the exports of these same countries are strictly positive. In addition, a presumption in popular discussions on the potential detrimental effect of eco-labeling on market access is that developing countries bear a disproportionate disadvantage with eco-labeling precisely because the industry level green premium is smaller for developing countries. This may be due to the possibilities that: (i) consumers attach a smaller premium to labeled products from developing countries (a smaller g^i); and / or (ii) producers in developing countries have an inherent disadvantage in producing the environmentally friendly output (F^i of a developing country stochastically dominates F^j of a developed country). From the definition of G^j, both of these possibilities can contribute to a reduction in the industry level green premium. In the context of our analysis, therefore, equation (8) also opens up a way of testing whether these allegations apply, by examining whether developed and developing countries exert differential influence on the adoption behavior of countries that have yet to adopt eco-labeling. Proposition 1 summarizes these observations:

Proposition 1:

In a Nash equilibrium, the incentives to adopt a voluntary eco-labeling program in country j depends systematically on:

1. the fixed cost of eco-labeling;

2. a scale effect that is represented by the size of existing output prior to labeling;
3. the comparative production cost advantage of country j in the baseline technique of production $\gamma^j / \sum_{i \neq j} \gamma^i$,
4. peer effects as determined by the number of other countries that have already implemented an eco-labeling program, and the industry-level green premium of these countries.

3 Welfare Implications

We now turn to the welfare implications of eco-labeling. In any Nash equilibrium with export rivalry based on eco-labeling, two sets of countries can be identified. The first group includes a Nash equilibrium set $\tilde{I}$ of countries that willingly incur the fixed cost c^j and implement an eco-labeling program, with

$$\Pi_e^j(\tilde{I}_{-j}, G^j) - \Pi_o^j(\tilde{I}_{-j}) \geq c^j$$

Meanwhile, a second group of countries are characterized by the lack of incentives to adopt labeling, since

$$\Pi_e^j(\tilde{I}_{-j}, G^j) - \Pi_o^j(\tilde{I}_{-j}) < c^j$$

In what follows, the welfare comparison conducted takes the case where no country adopts eco-labeling as a baseline. We evaluate the welfare of the two groups of producers enumerated above, along with the welfare of the representative consumer in a Nash equilibrium wherein at least one country adopts eco-labeling.

3.1 Aggregate Producer Welfare Implications

From the definition in equation (6), for all country $i \notin \tilde{I}$, aggregate producer profits are given by

$$(1-\alpha)(p_u(\tilde{I}))^{\frac{1}{1-\alpha}} \gamma^i$$

Thus, aggregate producer profits necessarily decline, relative to a regime in which no country adopts eco-labels, via a terms of trade effect that impacts on the price of unlabeled products. In particular, the higher the Nash equilibrium number of countries that have adopted eco-labeling, the larger will be the profit reduction facing producers in this group.

For countries that do adopt eco-labeling in a Nash equilibrium, however, the aggregate producer profits derived from eco-labeling depend jointly on the terms of trade effect, and the country-specific industry level green premium. To see this, recall that aggregate producer profits are given by

$$(p_u(\tilde{I}))^{\frac{1}{1-\alpha}}\gamma^i(1+G^i)$$

Making use of the equilibrium price level $p_u(\tilde{I})$, it is straightforward to verify that country *j* is strictly better off *only if*

$$G^j > \sum_{i\in I_{-j}} \frac{\gamma^i}{\sum_{i\neq j}^N \gamma^i} G^i.$$

Thus, even if incentives are right for a country to engage in labeling, aggregate producer profits may still decline relative to a regime in which no country adopts eco-labeling. In particular, aggregate profits increase only for a subset of countries with a sufficiently high industry-level green premium.

3.2 Individual Producer Welfare Implications

While the discussion above focuses on the country-level producer welfare implications of eco-labeling in a Nash equilibrium, a similar comparison can be conducted by focusing on the impact of eco-labeling on individual producers. In particular, since individual producer profits in the absence of labeling are given by:

$$\pi_o^j(p_u(\tilde{I})) = (1-\alpha)\left(p_u(\tilde{I})(\frac{\alpha}{\omega^j})^\alpha\right)^{\frac{1}{1-\alpha}},$$

it follows that producers in any country *j* who do not adopt environmentally sound production techniques (with $a \geq \bar{a}^j$), and therefore cannot take advantage of the green premium made available via eco-labeling, are necessarily worse off. These profit losses are a direct consequence of the price decline subsequent to the adoption of eco-labeling by any country.

Meanwhile, for the rest of the producers who voluntarily adopt environmentally sound production technologies, their profits in a Nash equilibrium are given by

$$\pi_e^j(a, p_l^j) = (1-\alpha)\left(p_l^j (\frac{\alpha}{a\omega^j})^{\alpha} \right)^{\frac{1}{1-\alpha}}.$$

It follows that the impact of eco-labeling on the profits of these producers depends once again on the joint impact of a terms of trade effect through a reduction in $p_u(\tilde{I})$, along with the green premium g^j. In particular, producers in country j who adopt the environmentally friendly production technique are strictly better off if and only if

$$g^j > \sum_{i \in I_{-j}} \frac{\gamma^i}{\sum_{i \neq j}^N \gamma^i} G^i.$$

3.3 Aggregate Consumer Welfare Implications

Finally, turning to the impact of eco-labeling on the welfare of consumers, we note that the indirect utility of a consumer in country j (with labor income ω^j) can be expressed as

$$\log \omega^j - \beta^j \log(p_u(\tilde{I})) + K,$$

where $K \equiv \beta^j \log \beta^j + (1-\beta^j)\log(1-\beta^j)$ is a constant. It follows, therefore, that since eco-labeling decreases the price of unlabeled products, consumer welfare strictly improves in each country i as long as at least one country adopts a labeling program in a Nash equilibrium. There are a number of other possible considerations that may be incorporated into the basic analysis, including import taxes, or the share of fiscal burden of the labeling program. These are discussed in detail in Basu, Chau and Grote (2003). However, the main thrust of this finding remains robust.

4 Empirical Analysis

National eco-labeling programs for agricultural products can be found in most OECD countries but also increasingly in many developing countries (Conway 1996). In the agricultural and food industry sector, certification refers to a wide array of food products (juices, cereals and grain including rice, and even alcoholic beverages, sugar, meat, dairy products or eggs) produced either by organic or bio-dynamic farming technologies or through integrated pest management (FAO 2000). Certification can also refer to agricultural food and non-food products (coffee, tea, cocoa, and flower) which are produced with less fertilizers and pesticides as opposed to traditional practices on plantations and in monoculture. Also, other non-food agricultural products like animal feeds (for production of organic meat, dairy products and eggs), grain seeds, natural pesticides and insecticides, cosmetics and textiles (cotton, leather and leather goods) may also be certified if they meet certain environmental criteria.

In this section, we present an empirical approach to answer the three questions enumerated at the outset of this paper. Specifically, we are interested in determining whether there exists a competition-induced limit to the threat of environmental exploitation in the face of increasing international trade. In particular, does the export orientation of a country determine at least in part its decision to adopt environmentally friendly production technologies via eco-labeling? In addition, we will approach the question of whether there is a race to the bottom by examining how the cumulative adoption of eco-labeling by other countries affects the incentives to adopt by developed and developing countries alike. Finally, by uncovering the potential determinants of eco-labeling adoption, we can infer the potential welfare impacts of eco-labeling on developed and developing countries, based on our findings elaborated in section 3.4.

A key issue is thus how observed incidences of eco-labeling may reveal information on producers' perception of the size of the industry level green premium. To this end, we refer to the right hand side of equation (8), which suggests the inclusion of the following regressors to capture and control for (i) the cost of eco-labeling; (ii) scale effects; (iii) production cost and (iv) peer effects.

The eco-labeling data on which our empirical analysis is based is described at length in Basu, Chau and Grote (2004). It tracks the prevalence of national level food industry eco-labeling initiatives from 1976 to 1999 in 66 countries, and if present, the time of adoption. Of the 66 countries, 30 countries have instituted an eco-labeling program by the end of 1999, about two-thirds are developing economies, and about half are on average net food industry importers (exporters) over the course of 1976 - 1999. In addition, we assembled macroeconomic, bilateral trade, and food industry environmental performance data for these countries. Summary statistics are reproduced in Table 1. To capture the fixed (administrative) cost of eco-labeling, c^j is taken to depend on: (i) the stage of development of an economy -- real gross domestic product per capita, (World Bank 2001b) and (ii) the existing level of food industry environmental damage -- average pre-labeling food industry water pollution (share of total BOD emission) (World Bank 2001b)[4]. To capture scale effects, we have assembled data on the average pre-labeling food industry total output share of the 66 countries, and these are taken from World Bank (2001a). The comparative cost advantage of country *j* is proxied by the export orientation of the economy -- the average pre-labeling share of total exports to total food industry trade (Trade and Production Database, World Bank 2001a).

While Table 1 presents unconditional comparisons, and does not properly control for the joint impact of all of these variables on adoption decisions, it paints a picture that is largely consistent with that of equation (8). In terms of fixed cost, Table 1 shows that developed countries, and countries with relatively low levels of food-industry pollution, appear to be more capable of bearing the cost of instituting a labeling program. In terms of scale effects and cost differences, Table 1 also shows that countries with higher output levels and a comparative cost advantage appear to be favorably selected in the set of countries with eco-labeling programs.

With respect to peer effects, and to uncover the impact of trade competition on eco-labeling, we consider two types of peer groupings in this paper: "wcexdest_t^j" and "wcimori_t^j". As in Basu, Chau and Grote (2004), the variable "wcexdest_t^j" is constructed for country *j* at time *t* by computing the weighted cumulative number of countries in the peer group other than country *j* that have adopted eco-labeling since 1976 till time *t*-1. The weights are taken to be the food industry output $\gamma^j / \sum_{i=1}^{N} \gamma^i$ (equation (8)) of country *j* as a share of the total output of the 66 countries. For example, to compute the peer effect based on bilateral export competition at any time *t*, food industry bilateral trade data is employed to identify top ten export destinations for each country *j*. The weighted cumulative number of these export destinations that have an eco-labeling program in place up till time *t*-1 for each country *j* gives "wcexdest_t^j" at time *t*. In order to consider the possible impact of import competition on eco-labeling incentives, we construct an analogous variable "wcimorit_t^j". Here, the relevant peer group is the top ten import origins of food industry imports for each country *j*. The weighted cumulative number of the country's top ten import origins that have an eco-labeling program in place up till time *t*-1 for each country *j* gives "wcimorit_t^j".

---

4 All averages used as regressors in our estimation are computed for years that fall between 1976 - 1999, but prior to (and not including) the year during which eco-labeling is adopted for each country.

Table 1. Trade links and output pre and post eco-labeling

Variable	Pre*	sd	Post**	sd	NA***	sd
Real per capita Income (US$ 1995 const.)	10299.750	9400.600	13505.990	12103.420	3487.938	4639.820
Food ind. export orientation (% export to total food ind. exports & imports)	60.157	21.953	56.469	22.628	48.426	25.143
Food ind. export share to US, WE & JPN (% export to US, WE, JPN to total export)	53.378	21.001	56.622	20.593	47.567	24.983
Food ind. output share (% total world output)	3.234	6.927	3.602	6.997	0.222	0.250
Food ind. water-pollution (% total BOD emission)	44.203	10.298	43.707	9.955	51.046	16.056

*Mean country annual averages during the pre-labeling periods for countries that instituted a labeling program after 1976.
**Mean country annual averages during the post-labeling periods for countries that instituted a labeling program after 1976.
***Mean country annual averages from 1976 to 1999 for countries that never instituted a labeling program.
Source: Basu, Chau and Grote (2004).

Finally, in order to examine the possibility that the industry level green premium of developing countries, and hence their impact on the labeling incentives of other trading partners, may be significantly different from that of their developed country counterpart, we construct two additional peer effect variables: “wcdevexdestt^j_t” and “wcdevimorit^j_t”. Respectively, these are the weighted cumulative number of developing country trade partner (export destinations and import origins) of country *j* that instituted a labeling program from 1976 up until time *t*-1.

4.1 Estimation Results

We take the approach of estimating a proportional hazard model. Let $\mathbf{x}_{jt}$ be a vector of time-varying explanatory variables, where t= 1976,...,T_j, when country j implements an eco-labeling program.

The hazard rate at t_j -- the probability of adoption when t_j years have passed given that adoption has not yet taken place -- is simply

$$h(t_j \mid \mathbf{x}_{jt}) = \frac{\nu'(t_j \mid \mathbf{x}_{jt})}{1-(\nu(t_j \mid \mathbf{x}_{jt}))}.$$

We assume a model with proportional hazard (Cox 1972), and specify in addition that each of the K time-varying covariates enter into the determinant of the hazard rate as follows:

$$h(t_j \mid \mathbf{x}_{jt}) = \hat{h}(t_j)e^{\sum_{k=1}^{K}\beta_k x_{jkt}}.$$

where $\hat{h}$ denotes the baseline hazard function. Thus, $e^{\beta_k} \geq (<)1$ represents the hazard ratio for a unit change in x_{jkt}. These estimates are obtained by maximizing a partial log-likelihood function (Kalfleisch and Prentice 1980). Since only data prior to adoption will be used, the problem of endogeneity of x_{jkt} subsequent to labeling does not arise. In addition, the estimation procedure does not place restriction on the unknown functional form of the baseline hazard function.

Table 2. Proportional hazard regression

Hazard Ratios	I	II	III	IV
Real per capita Income	1.00007 ***	1.00007 ***	1.00008 ***	1.00008 ***
	0.00002	0.00002	0.00002	0.00003
food ind. output share	1.36124 ***	1.38671 ***	1.36086 **	1.38472 ***
	0.16898	0.17345	0.17665	0.18058
food ind. output share -squared	0.99256 **	0.99228 **	0.99213 **	0.99185 **
	0.00362	0.00362	0.00381	0.00381
food ind. water pollution	0.95269 ***	0.95018 ***	0.94623 ***	0.94340 ***
	0.01728	0.01785	0.01711	0.01782
food ind. exports share	1.05236 ***	1.05232 ***	1.05604 ***	1.05536 ***
	0.01615	0.01917	0.01676	0.02012
wcexdest		1.01866 *		1.02306 ***
		0.01087		0.01135
wcdevexdest		0.91896 **		0.90885 ***
		0.03870		0.03917
wcimori			0.96072	0.95070 *
			0.02412	0.02500
wcdevimori			0.63903	0.66809
			0.22910	0.23382
No. of observations	1089	1089	1089	1089
Incidences of eco-labeling	21	21	21	21
Log Likelihood	-63.249	-62.488	-61.423	-60.460
Wald chi^2	35.220	34.440	32.730	39.900
Prob > chi^2	0.000	0.000	0.000	0.000

Robust standard errors (Lin and Wei, 1989) in parenthesis.
*significant at the 10% level
**significant at the 5% level
***significant at the 1% level.

Table 2 presents our findings. The first column replicates the result of Basu, Chau and Grote (2004),[5] and shows in particular that a higher real per capita GDP, and a lower existing level of food industry related water pollution are both associated with high likelihood of eco-labeling, as the estimated coefficients β are strictly greater than one, and significant at the 1% or 5% level.

The scale effect figures prominently as well, having a significant and positive impact on the likelihood of eco-labeling. The results also indicate that scale effects are nonlinear, in that the rate of increase in the likelihood of eco-labeling decelerates with scale. In addition, the export orientation of the food industry matters, and the likelihood of eco-labeling is positively associated with the share of food industry export to total food industry trade.

Finally, with respect to the two types of peer effects, the bilateral export destination peer effect continues to be strictly greater than unity and significant, whereas the import competition peer effect is not significant. These may be interpreted as an indication of *strategic complementarity* between countries, and particularly those that are engaged in export competition. Our findings also lend support to the importance of labeling as an export promotion device, rather than an import deterring instrument. The estimated coefficient on developing country peer effects “wcdevexdest” is significant and less than one, with the interpretation that for controlling for other factors, the influence that a developing country may have on Nash equilibrium labeling initiatives is indeed smaller. In the context of our theoretical discussion, one possible reason behind this could be that the industry green premium of developing country exports is small relative to their developed country counterparts.

We believe that we have merely taken the first steps to examine whether developing countries may indeed be subject to reputational / technological disadvantage in green production compared to developing countries. Further research based, for example, on eco-labeling initiatives in other

---

[5] For each of these estimations, we report the number of observations, the number of incidences of eco-labeling that took place after 1976, the log likelihood and Wald Chi-squared statistics of the estimation. The hypothesis that all of the estimated coefficients are all equal to one is rejected in all of our estimations, at a significance level of less than 1%. Also, note that the number of incidences of eco-labeling applicable in the estimation is 21, as comparable pre-labeling data on output share, trade orientation and the like are not available to us. As shown, nine countries (Austria, Finland, France, Germany, Italy, New Zealand, Norway, Sweden and the United Kingdom) instituted their eco-labeling programs prior to 1976. This leaves a total of 57 countries that are included in our estimations.

product markets, or using other plausible peer effect variables as in Basu, Chau and Grote (2004), may well shed light on the pervasiveness of reputational concerns and technological disadvantage unveiled in our findings here.

5 Conclusion

In the context of the role of voluntary and market-based policy instruments that elicit environmentally friendly production practices, as well as popular concerns regarding the threat of environmental exploitation in the face of increasing international trade, this paper raised a number of questions. First, we ask whether market incentives made available through eco-labeling entice countries engaged in export competition to improve environmental performance? Second, how do countries engaged in trade competition interact with one another when the strategic variable in question is the need to establish reputational comparative advantage in a segmented market where consumers have a choice between products manufactured via environmentally friendly and environmentally unfriendly means (Basu and Chau 1998)? Finally, is there a development and environment trade-off when countries compete based not just on comparative cost advantages, but also on their ability to shoulder the costs associated with a credible eco-labeling program?

Based on the model developed in Basu, Chau and Grote (2004), we set out to comparing producer welfare with and without competition based on eco-labeling. The key, as it turns out, lies in the size of the industry level green premium, which depends on both (i) a demand side consumption green premium effect, and (ii) a supply side cost of green technological adoption effect. Interestingly, we find that in the absence of international coordination of technology adoption, and an appropriate way in which the gains from eco-labeling can be shared, countries that find themselves voluntarily engaged in eco-labeling initiatives in a subgame perfect Nash equilibrium are not necessarily made better off. Meanwhile, countries that opt out are worse off because of the terms of trade effect of eco-labeling on products made using the baseline technology.

In terms of empirical findings, this paper takes the result of Basu, Chau and Grote (2004) a step further, and examines the extent to which eco-labeling should be viewed as an export promotion device, or an import deterring mechanism. Our findings based on our construction of the import peer effect variable is in favor of the former, with the peer effect variables with peer grouping based on the degree of export competition showing up again as significant and positive, though the peer effect based on import penetration is not significant.

Taken together, these findings indicate a set of possible answers to the three questions posed at the outset of this paper, and suggest additional research questions. To begin with, while production specialization induced by international trade may encourage environmental exploitation when the exportable industry is pollution intensive, our findings suggest that the export orientation of an industry can itself be a driving force that makes the practice of eco-labeling an attractive option. Meanwhile, with strategic complementarity in adoption as shown in the theoretical and empirical discussions of this paper - at least insofar as eco-labeling in the food industry is concerned - our findings suggest that a race to the top may in fact be in play.

While this paper has focused on the determinants of eco-labeling, a natural course for future research will clearly be to determine the consequences of eco-labeling, in terms of the greening of agriculture, welfare and market access. What the findings of this paper suggest in terms of research strategy, however, is that eco-labeling is far from an exogenous event. Rather, the adoption of eco-labeling is itself conditional on environmental performance, the stage of development of a country, and trade-related factors.

References

Antweiler W, Copeland BR, Taylor MS (2001) Is free trade good for the environment? American Economic Review 91:877-908

Basu AK, Chau NH (1998) Asymmetric country-of-origin effects on intra-industry trade and the international quality race. Review of Development Economics 2:140-166

Basu AK, Chau NH (2001) Market access rivalry and eco-labeling standards: are eco-labels non-tariff barriers in disguise? Department of Applied Economics and Management Working Paper, Cornell University, WP 2001-15

Basu AK, Chau NH, Grote U (2003) Eco-labeling and stages of development. Review of Development Economics 7:228-247

Basu AK, Chau NH, Grote U (2004) On export rivalry, eco-labeling and the greening of agriculture. Agricultural Economics 31:135-147

Conway T (1996) ISO 14000 standards and China: a trade and sustainable development perspective. International Institute for Sustainable Development (IISD); Prepared for the China Council for International Cooperation on Environment and Development, Working Group on Trade and Development (1996) China's green food development and environmental protection. http://www.iisd.org/pdf/isochina.pdf

Copeland BR, Taylor MS (1994) North-south trade and the environment. Quarterly Journal of Economics 109:755-787

Copeland BR, Taylor MS (1995) Trade and transboundary pollution. American Economic Review 85:716-737

Cox DR (1972) Regression models with life-tables. Journal of the Royal Statistical Society Series 34:187-220

Dean JM (2000) Does trade liberalization harm the environment? A new test. CIES Policy Discussion Paper #0015, University of Adelaide, Centre for International Economic Studies, Adelaide

Dixit A, Stiglitz JE (1977) Monopolistic competition and optimum product diversity. American Economic Review 67:297-308

FAO (2000) Food safety and quality as affected by organic farming. Paper (ERC/00/7) for the Twenty Second FAO Regional Conference for Europe in Porto, Portugal, 24-28 July 2000

Frankel JA, Rose A (2002) Is trade good or bad for the environment? Sorting out the causality. NBER Working Papers no 9201 National Bureau of Economic Research

Grossman GM, Krueger AB (1995) Economic growth and the environment. Quarterly Journal of Economics 110:353-77

Kalfleisch JD, Prentice RL (1980) The statistical analysis of failure time data. John Wiley & Sons, New York

Lin DY, Wie LJ (1989) The robust inference for the cox proportional hazards. Model Journal of the American Statistical Association 84:1074-1078

Nimon W, Beghin J (1999) Are eco-labels valuable? Evidence from the apparel industry. American Journal of Agricultural Economics 81:801-811

Porter ME, van der Linde C (1995) Toward a new conception of the environment-competitiveness relationship. Journal of Economic Perspectives 9:97-118

Robins N, Sarah R (ed) (1997) Unlocking trade opportunities case studies of export success from developing countries. International Institute for Environment and Development for the UN Department of Policy Coordination and Sustainable Development, London

Shams R (1995) Eco-labelling and environmental policy efforts in developing countries. Intereconomics 30:143-149

UNDP (1999) Human development database 11. UNDP, New York

UN (1997) Trade effects of eco-labelling. Proceedings of a seminar held in Bangkok 17-18 February, United Nations, New York

Willer H, Yussefi M (2001) Ökologische agrarkultur weltweit 2001. Stiftung Ökologie und Landbau, Bad Dürkheim

World Bank (2001) Trade and production database. The World Bank, Washington DC. http://www.worldbank.org/research/trade

World Bank (2001) World development indicators 2001. The World Bank, Washington DC