

On Export Rivalry and the Greening of Agriculture – The Role of Eco-labels

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Abstract: Why do some countries establish their own national eco-labeling programs and others do not? In this paper, we provide theoretical arguments and empirical evidence suggesting that the answer to this question can shed new light on three questions that have taken center-stage in the trade and environment debate: (i) does trade exacerbate the exploitation of the environment; (ii) are countries competing in export markets engaged in a race to the bottom in environmental performance; and (iii) do market-based environmental instruments benefit the rich and hurt the poor?

Keywords: Eco-labeling in Agriculture, Export Rivalry, Strategic Complementarity.

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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 threaten environmental exploitation in the name of trade (Grossman and Krueger 1995, Basu and Chau 2001). These result in scale, input mix and output composition choices that fail to internalize consumers' preferences with respect to production and process methods (PPMs), or problems associated with local and transnational environmental commons. The second stems from the possibility that international trade unleashes competitive pressure that put emphasis on policies and technology choices that facilitate cost-cutting. 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 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. Major voluntary eco-labeling initiatives targeting industrial production include the German Blue Angel label launched in 1978, the Canadian Environmental Choice Program introduced in 1988, the EcoMark in Japan, the White Swan label in the Nordic Countries, along with the Green Seal of the United States, all founded in 1989.

This paper focuses on the adoption of labeling in the agricultural sector, and does so for two reasons. To begin with, labeling initiatives in the agricultural sector clearly preceded similar efforts in the industrial sector. The earliest agricultural labeling initiatives originated in countries such as Germany, France and Italy, and were established as early as 1924.¹ Second, eco-labeling in agriculture has become a contentious issue, with the interests of developing and developed countries frequently on opposite sides of the debate.² In particular, the question arises as to 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 the labeling program can be afforded or even justified (UNDP 1999). In terms of revenue, differential consumer perceptions about the credibility of labeling programs in developed and developing countries, or country-specific environmental performance standards on which the eco-labels are based, may present terms of trade implications that are equivalent to non-tariff import barriers even when eco-labels are in place (UNDP 1999, Basu and Chau 2001)³.

In assessing the promise of eco-labeling, therefore, a number of pertinent questions arise. First, how does one begin to verify the prevalence of perceived trade gains via a green premium based on eco-labeling? 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, once environmental performance and strategic interactions related factors are accounted for, what are the distributional consequences of eco-labeling?

Existing studies on eco-labeling focus on the first question, and tackle the important task of quantifying the size of the green premium in various product markets either through consumer surveys, or hedonic estimation.⁴ Our approach to understanding the role of eco-

¹This information is based on the eco-labeling data to be discussed in Section 2.

²Indeed, proposals have made to require the use of eco-labels as a means to settle trade disputes involving differing environmental standards across countries, as in the Dolphine-Tuna dispute (WTO, 2002).

³For an extensive discussion of the effect of credible monitoring on consumers' willingness to pay see Basu, Chau and Grote's (2000) analysis on Social Labeling and it's effect on Child Labor in developing countries.

⁴For instance, Robins and Roberts (1997) find that 5 to 15% of consumers may pay a slightly higher price for

labeling 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? As the paper unfolds, we illustrate how the answer to the question can shed light on three questions. First, whether and if so how the adoption pattern of eco-labeling across countries to date reveal information about the prevalence of a perceived green premium? In addition, whether the adoption pattern reveal evidence that countries are indeed *interdependent* in their decisions to implement eco-labeling program, as the race-to-the-bottom conjecture predicts. Finally, whether they may be reasons to believe the perceived gains from eco-labeling to disproportionately favor developed or developing countries.

The tasks that we undertake in this paper are accordingly two-fold. We begin by proposing an analytical framework that lays out the economic incentives giving rise to eco-labeling initiatives. The framework entertains export rivalry in a multi-country setting in two stages. In the first stage, countries elect whether or not to initiate 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. The theoretical framework yields a set of empirical implications in a subgame perfect Nash equilibrium, and highlights: (i) the selection criteria of countries that adopt eco-labeling, and (ii) the endogeneity of labeling incentives and (iii) the welfare consequences of observed labeling initiatives.

In terms of selection criteria, we find that the perceived gains from eco-labeling may be systematically related to a country's: (i) stage of development, (ii) existing environmental performance in the absence of eco-labeling initiatives, and (iii) scale of production. To be appended to this set of essentially non-trade related factors is a set of additional factors that apply in the presence of export rivalry. These include (i) a country's comparative cost advan-

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. Nimon and Beghin (1999) estimate the price premium for various individual attributes of apparel goods.

tage and net export orientation, and (ii) the extent of peer or strategic interactions between export competitors.

By highlighting the endogeneity of labeling incentives directly, our analysis also offers a set of welfare consequences associated with the move towards eco-labeling by some countries and not others. The key, as it turns out, lies not just in the size of a green premium attached to environmentally friendly product, as is frequently alleged in the literature. Indeed, the analysis in the sequel defines an *industry-level* green premium, that applies in a general equilibrium setting, which is in turn crucial to the determination of the welfare consequences of export rivalry via eco-labeling in a subgame perfect Nash equilibrium.

As a second step, this paper tests the theoretical findings by empirically investigating the determinations of the time pattern to adopt eco-labeling. The empirical approach is one of survival estimation, and has the virtue that the question of endogeneity emphasized above does not impinge on the empirical estimates since only data prior to adoption are employed. The objectives are to empirically verify both the relative importance and significance of non-trade and trade related factors associated with the decision to adopt eco-labeling. As the analysis unfolds, we will also present the findings of our empirical estimation of whether systematic divergences in the industry-level green premium between developed and developing countries may be inferred from the time pattern of adoption decisions.

In what follows, section 2 provides an overview of eco-labeling initiatives in agriculture world-wide, and examines the *unconditional* adoption pattern of eco-labeling in agriculture for 66 countries. Section 4 presents a general equilibrium model that yields a set of possible determinants of the incentive to adopt eco-labeling. The empirical methodology and the findings are presented in Section 5. Section 6 concludes.

2 Eco-labeling in Agriculture

2.1 Product coverage and labeling criteria

In the agricultural and food industry sector, certification refers to all kinds of food products (juices, cereals and grain incl. rice, and even alcoholic beverages (wine etc.), sugar, meat, dairy products or eggs) which have been produced based on organic or bio-dynamic farming technologies or on integrated pest management. Certification can also refer to agricultural food and non-food products (coffee, tea, cocoa, flowers) which are produced with less fertilizers and pesticides as opposed to traditional practices on plantations and in monoculture. Very often, these products originate from plantations in tropical developing countries. 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.

For an eco-label to be effective the choice of the eco-labeled products as well as the relevance and significance of the environmental standards and criteria on which basis the label is attributed must be accurate. Next to standards on organic agriculture, a diversity of standards has been developed in some cases. There are for example the standards for organic aquaculture, organic horticulture, organic bee-keeping, sustainable forest management, organic viticulture and the certification of wild grown products. Also for processing, there are standards for individual commodities like meat and meat products, milk and dairy produce, for fruit and vegetables or for breweries.

The criteria for awarding the eco-label differ considerably in terms of stringency and coverage. Traditionally, eco-labeling has focused on only one stage of the product's life cycle, normally the use or disposal stage, as well as one particular environmental aspect. Nowadays, eco-labeling tends to follow a more comprehensive, multi-criteria and life-cycle approach (WTO-CTE July 1997). The life-cycle approach takes into account separate product and processing stages (e.g. raw materials extraction, production of intermediates, production and processing method (PPM), product use and removal) and different categories of environmental aspects

like the resource use, energy, emissions or waste.

A typical environmental claim on food and agricultural products refers to the nonuse of a certain input like pesticide up to the description of a whole life-cycle of a product. Organic labels are also considered as eco-labels, since the organic production process has demonstrated to result in food and agricultural products with lower levels of pesticides and drug residues in livestock as well as often in lower nitrate contents (FAO 2000). In addition to the environmental impact, other process attributes like animal welfare, biotechnology, social welfare and packaging are increasingly considered in labeling schemes.⁵ Traders, certifiers and also processors increasingly use labels to stress that the services they provide or that the inputs they use have been produced in an environmentally sustainable manner.

2.2 Mandatory or voluntary labeling?

The basic concept of eco-labeling is based on the concern of consumers for the environment resulting in their willingness to pay relatively higher prices for agricultural products which have been produced in an environmentally friendly way. On the basis of information about the impact of the production process on the environment, consumers can either choose to purchase a relatively more expensive eco-labeled product, or can continue buying unlabeled products. Also producers can choose to either invest into the production of environmentally friendlier goods which will be labeled as such, or to continue producing according to their current standards. Based on the price premium producers receive for their labeled products, they have the incentive to consider environmental effects of their production processes.

Eco-labeling is generally considered as an attractive environmental policy measure because of its voluntary nature. However, not every labeling scheme is voluntary. Some also have mandatory character: As an example, in 1998, Colombia submitted a paper to the CTE

⁵Van Ravenswaay (1996) distinguishes between environmental labels, eco-labels and organic labels: the environmental labels focus on consumption, not production of a product (e.g. recyclable); eco-labels reduce environmental impacts over the entire life cycle of a product without specifying the production practices; organic labels specify the production method without requiring proof of environmental improvement. In this paper, the term eco-label is used in a broad sense, including environmental and organic labels.

(WTO 1998), raising concerns with respect to the impacts of eco-labels on the Colombian flower market. Colombia had faced a major anti-flower campaign from environmental and consumer groups because of the high water pollution and soil degradation created by flower production and the poor working conditions for employees. To improve the situation in flower production, the introduction of a labeling scheme was suggested to Colombia. However, it refused to participate stating that the suggested labeling scheme was coercive and not voluntary, as anyone who did not accept the scheme was subject to negative pressure from the flower campaign. As a result, the country was facing difficulties in market access and thus developed its own Florverde program which aims primarily at the protection of the environment. It encourages the application of the Environmental Conduct and Social Welfare Code which is voluntary and self-regulatory including practical and legal recommendations on sustainable development and social well-being. The Florverde program is based on the principle of self-management without any external auditing process aiming at gradual but continuous progress (Asocolflores 1999).

2.3 Consumer acceptance and market share of labeled products

The acceptance of consumers has generally and steadily increased over time which can be also witnessed by the growing popularity of organically grown food. Also the willingness to pay for eco-labeled products has been found to be quite high. This is especially true for countries which benefit from a relatively higher level of consumer awareness about the environment, like e.g. in Sweden (OECD 1997b). In developing countries, the domestic market for eco-friendly products is still small due to the lower consumer preference and the limited responsiveness of producers and suppliers. However, it has also increased e.g. in Egypt or the People's Republic of China.

It also has to be taken into account that the effectiveness of labels in providing information about the quality of a product is limited by the ability and willingness of consumers in reading and processing the details of a label in a shopping environment in the presence of numerous products and the short period of shopping time. Too detailed information on the labeling requirements often decreases the transparency of labels (OECD 1997c; Golan et al.

2000).

However, it must be kept in mind that despite prosperous market estimates for the future, the current market shares of certain certified products are still extremely low and thus the overall environmental impact still very limited. For example in the USA, only around 2% of all food produced is sold as certified organic (Brooks and Jacobus 2001). The share of organic products of the food market in developed countries is currently about 0.5% on average, but reaches 2% in Austria, Denmark and Germany (OECD 1997a). In Germany, a market share of 20% is aimed at in the short run.

2.4 The Time Pattern of Eco-labeling Adoption

National eco-labeling programs for agricultural products can be found in most OECD countries but also increasingly in many developing countries (Conway 1996). Our dataset contains macro-economic, environmental, eco-labeling, output, bilateral and aggregate trade information on the food industry of 66 countries.⁶ The eco-labeling data is obtained from information compiled in the Institute for Agriculture and Trade Policy (2002) and EVZ (2002). We also make use of individual country profiles reported in United Nations (2000), where government initiatives that affect changes in green consumption patterns are reported.⁷ This information allows us to ascertain which of the 66 countries have initiated their own labeling schemes. These are summarized in Table 1. For the 31 countries with eco-labeling programs, we further identified the year indicating when labeling schemes or certification were first adopted in the agricultural sector.

We begin with a first and preliminary look at the data by computing a time-varying survival likelihood - the probability that a country has not yet implemented an eco-labeling

⁶Food industry level output, along with bilateral and aggregate food industry trade follows ISIC 3-digit classification code 311, and includes slaughtering preparing and preserving meat, manufacture of dairy products, canning and preserving of fruits and vegetables, canning preserving and processing of fish crustacea and similar foods, manufacture of vegetable and animal oils and fats, grain mill products, manufacture of bakery products, sugar factories and refineries, manufacture of cocoa chocolate and sugar confectionery, manufacture of food products not elsewhere classified.

⁷See Chapter 4, “Changing Consumption Patterns” under each of the country profile entries in United Nations (2000).

program. Specifically, let the probability that country j adopts eco-labeling no later than year $t_j = 1, 2, \dots$ be given by $\nu(t_j)$, with an associated density function $\nu'(t_j)$. The probability of not having implemented an eco-labeling program when time t_j has passed, or, the survival likelihood, is given by $S(t_j) = 1 - \nu(t_j)$. The Kaplan-Meier estimate of the survival function $S(t_j)$ (Neumann 1999) is:

$$\prod_{s=1}^{t_j} \left(1 - \frac{d_s}{n_s} \right).$$

where d_s and n_s respectively denotes the number of countries that have implemented an eco-labeling program at time s , and n_s denotes the total number of countries included in the data at time s . The estimated survival curves for 1976 - 1999 – the likelihood that a country has not yet adopted eco-labeling as a means of promoting green agricultural technologies – are plotted in Figures 1 and 2.

In Figure 1, the survival curves are plotted separately for developed and developing countries. As may be expected, developing countries are more likely to be late adopters of eco-labeling. Indeed, the estimated Kaplan-Meier survival probabilities for developing countries are higher throughout the 24 years between 1976 and 1999. Towards the end of the sample period, the survival probabilities for developing and developed countries are respectively about 0.75 and 0.20.

In Figure 2, the survival curves are plotted separately for net exporting and net importing countries. Net exporting (importing) countries are defined as countries that sustained an annual average of over (less than) 50% of food industry exports in total food industry trade (imports plus exports) during the 1976 - 1999 period (World Bank 2001a), and 33 out of the 66 countries in our data are classified accordingly as net exporting countries. As should be apparent from Table 1, net exporters consist of both developed and developing countries, and span different geographic regions. However, what is particularly notable about the pattern of adoption of eco-labeling once countries are distinguished by their export orientation is that net exporters essentially *overtook* net importing countries in their likelihood of adoption (Figure 2). This is despite the fact that a significant number of net importing countries have already

adopted eco-labeling in agriculture at the beginning of the sample period. With the exception of the United States, these early adopters originate largely from Western Europe, and include countries such as France, Italy, Germany and Norway.⁸

While these preliminary observations have the obvious drawback that other exogenous forces that may be in play are not conditioned for, they nevertheless suggest that the linkage between international trade and the incentives to adopt green agricultural technologies via eco-labeling may likely be significant. This is important in the context of efforts geared towards the greening of agriculture, since environmental performance and net exports tend to be closely correlated. The Pearson correlation coefficient of the export share of total food industry trade and the degree of food industry pollution is positive (0.4329) and significant at the 1% level. Food industry pollution is measured by the contribution of food industry to total biochemical oxygen demand (BOD) emission across countries and over the period 1976 - 1999 (World Bank 2001b)).⁹ This is shown in Figure 3, which presents a scatter plot of these two variables for the 66 countries in the data set during the period 1976 - 1999. We turn next to a theoretical investigation of the possible determinants and exogenous forces that may contribute to the incentives to label.

3 The Basic Model

We consider a setup in which producers in N countries are engaged in the production of two goods: a homogeneous numeraire Y^j , $j = 1, \dots, N$ and an agricultural output X^j . The numeraire commodity employs a composite input, L_y^j , with $Y^j = \omega^j L_y^j$, where ω^j denotes the marginal and average product of input L_y^j .

Production of the agricultural output can be accomplished via either (i) an environmentally sound production technology X_e^j , or (ii) a baseline production technology X_o^j . More

⁸In Figure 3, the data labels 1 and 0 respectively denote countries that do and do not have an eco-labeling program by the end of 1999.

⁹The Pearson correlation coefficient of the average annual export share of total food industry trade and the average annual contribution of food industry to total BOD emission across countries is likewise positive (0.4664) and significant at the 1% level.

specifically, let there be M^j number of competitive agricultural producers in country j . Agricultural production also employs the composite input L_x^j as input, and final agricultural output produced via the two techniques are given by:

$$X_e^j = \left(\frac{L_x^j}{a}\right)^\alpha, \quad X_o^j = (L_x^j)^\alpha,$$

where $a \in (1, \infty)$ is producer-specific, and parameterizes the cost of adopting the environmentally friendly production technique. Also let the cumulative distribution function $F^j(a')$ denote the fraction of producers in country j with $a \leq a'$, and $a, a' \in (1, \infty)$.

3.1 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_ℓ^j be the price of labeled agricultural output produced via the environmentally friendly technology. We allow p_ℓ^j to differ by country-of-origin, in order to incorporate the possibility of country-specific green premium.¹⁰ In particular, the green premium ($p_\ell^j - p_u$) 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.

Producers solve a simple two-stage problem, involving the decision of (i) whether or not to voluntarily adopt the environmentally sound technology, and (ii) the amount of input L_x^j 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 by choice of the environmentally sound technology, $\pi_e^j(a, p_\ell^j)$ (baseline technology, $\pi_o(p_u)$) are given by:

¹⁰See Basu, Chau and Grote (2001) for an analysis of the determination of the endogenous green premium, which depends, among other things, on the country-specific *credibility* of the eco-labeling program.

$$\pi_e^j(a, p_\ell^j) = \max_{L_x^j} p_\ell^j \left(\frac{L_x^j}{a}\right)^\alpha - \omega^j L_x^j \equiv (1 - \alpha) \left(p_\ell^j \frac{\alpha}{a \omega^j}\right)^{\frac{1}{1-\alpha}}, \quad (1)$$

$$\pi_o^j(p_u) = \max_{L_x^j} p_u (L_x^j)^\alpha - \omega^j L_x^j \equiv (1 - \alpha) \left(p_u \frac{\alpha}{\omega^j}\right)^{\frac{1}{1-\alpha}}. \quad (2)$$

Also, let $X_e^j(a, p_\ell^j)$ and X_o^j 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

$$\pi_e^j(a, p_\ell^j) \geq \pi_o^j(p_u) \Leftrightarrow a \leq \left(\frac{p_\ell^j}{p_u}\right)^\alpha \equiv \bar{a}^j.$$

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, $(p_\ell^j/p_u) - 1$, 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 consists of two parts, derived respectively from environmentally friendly (X_e^j) and baseline (X_o^j) production:

$$\begin{aligned} & M^j \left[p_\ell^j \int_1^{\bar{a}^j} X_e^j(a, p_\ell^j) dF^j(a) + p_u \int_{\bar{a}^j}^\infty X_o^j(p_u) dF^j(a) \right] \\ &= M^j \left[(p_u \frac{\alpha}{\omega^j})^\alpha \frac{1}{1-\alpha} \left[(1 - F^j(\bar{a}^j)) + \left(\frac{p_\ell^j}{p_u}\right)^{\frac{1}{1-\alpha}} \int_1^{\bar{a}^j} \left(\frac{1}{a}\right)^{\frac{1}{1-\alpha}} dF^j(a) \right] \right]. \end{aligned} \quad (3)$$

As should be apparent, international differences in producer revenue can be decomposed into two parts, including (i) terms in the first square brackets $(p_u(\frac{\alpha}{\omega^j})^\alpha)^{\frac{1}{1-\alpha}}$, which depend only on pure international cost differences ω^j , and (ii) terms in the second square brackets, which depends 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_ℓ^j is replaced by p_u , as the green premium does not apply to unlabeled products. It follows, therefore, from the definition of \bar{a}^j

that

$$\bar{a}^j = \left(\frac{p_\ell^j}{p_u}\right)^\alpha = 1.$$

Thus, profits of the average producer simply depend on ω^j with:

$$\bar{\pi}^j = (1 - \alpha)(p_u \left(\frac{\alpha}{\omega^j}\right)^\alpha)^{\frac{1}{1-\alpha}}. \quad (4)$$

3.2 The Green Premium and Supply Response

The utility of a representative consumer in country j ($U^j((D_x^j, d_y^j))$) takes as arguments the consumption of the homogeneous numeraire d_y^j , along with an index of effective units of good x consumed, D_x^j , with¹¹,

$$\log U^j(D_x^j, d_y^j) = \beta^j \log D_x^j + (1 - \beta^j) \log d_y^j,$$

where $\beta^j > 0$ denotes the share of consumer expenditure devoted to the consumption of the agricultural output. Let d_e^{ji} be the quantity demand for the eco-friendly output originating from country i , and d_o^j be the quantity demand for the baseline output, effective consumption D_x^j is given by:

$$D_x^j = \sum_{i=1}^N (1 + g^i) d_e^{ji} + \sum_{i=1}^N d_o^j$$

D_x^j consists of two components, which respectively account for both the physical quantities of x consumed, along with an index of green consumption $\sum_{i=1}^N g^i d_e^{ji}$. Thus, the marginal rate of substitution between d_e^{ji} and d_e^{jk} is given by the ratio $(1 + g^i)/(1 + g^k)$ and reflects consumer's relative valuation for eco-friendly production originating from countries i and k . Meanwhile, $1 + g^i$ denotes the marginal rate of substitution between a unit of labeled output, and a unit of unlabeled output from country i .

Clearly, for demand to be positive for both labeled and unlabeled products originating from country i , it must be the case that:

$$\frac{p_\ell^i}{p_\ell^k} = \frac{1 + g^i}{1 + g^k}, \quad \frac{p_\ell^i}{p_u} = 1 + g^i, \quad i, k = 1, \dots, N. \quad (5)$$

¹¹See Dixit and Stiglitz (1977) for a discussion of the use of similar utility indexes when product differentiation is of central concern.

The green premium as defined in equation (5) above can be used in conjunction with equation (3) to show that the aggregate agricultural producer revenue in the presence of eco-labeling in country j depends on the green premium in a predictable way:

$$\begin{aligned}
Q_e^j(p_u) &= (p_u M^j (\frac{\alpha}{\omega^j})^\alpha)^{\frac{1}{1-\alpha}} \left([1 - F^j(\frac{p_\ell^j}{p_u})] + (\frac{p_\ell^j}{p_u})^{\frac{1}{1-\alpha}} \int_1^{(\frac{p_\ell^j}{p_u})^{1/\alpha}} (\frac{1}{a})^{\frac{1}{1-\alpha}} dF^j(a) \right) \\
&= (p_u M^j (\frac{\alpha}{\omega^j})^\alpha)^{\frac{1}{1-\alpha}} \left(1 + (1 + g^j)^{\frac{1}{1-\alpha}} \int_1^{(1+g^j)^{1/\alpha}} [(\frac{1}{a})^{\frac{1}{1-\alpha}} - (\frac{1}{1+g^j})^{\frac{1}{1-\alpha}}] dF^j(a) \right) \\
&\equiv p_u^{\frac{1}{1-\alpha}} \gamma^j (1 + G^j).
\end{aligned}$$

In addition, revenue in the absence of labeling is given by:

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

where $\gamma^j \equiv M^j (\frac{\alpha}{\omega^j})^{\frac{\alpha}{1-\alpha}}$ parameterizes the production cost of country j . $p_u G^j$, on the other hand, 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. Note, in particular that the size of G^j depends jointly on a demand-side and a supply-side effect. On the demand side, the higher the country-specific unit green premium $1 + g^j$, the higher will be the revenue gains in the presence of eco-labeling. Indeed, it can be readily verified that $G^j > 0$ if and only if $g^j > 0$. Meanwhile, the supply-side response depends directly on the cost distribution among producers in country j , F^j . Clearly, countries in which producers are more concentrated along the lower end of the cost distribution $a \in (1, \bar{a}^j)$ are more likely to benefit from eco-labeling.

3.3 General Equilibrium and the Incentives to Adopt Eco-labeling

We now turn to a characterization of the equilibrium price of labeled and unlabeled outputs. To this end, 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 $\omega^j \mathcal{L}^j$ in country j , aggregate world demand for the agricultural output is equal to total producer revenue if and only if:

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

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

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

By inspection, 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 $p_e^j(I, g^j) = p_u(I)(1 + g^j)$. 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 other. 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 $W \equiv \sum_{j=1}^N \beta^j \omega^j \mathcal{L}^j$, the aggregate producer profits in country j with eco-labeling, taking as given the I_{-j} , is given by:

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

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

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

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:¹²

$$\begin{aligned} \Pi_e^j(I_{-j}, G^j) - \Pi_o^j(I_{-j}) &\geq c^j \\ \log G^j &\geq \log\left(\frac{c^j/(1 - \alpha)}{Q_o^j(p_u(I_{-j}))}\right) - \log\left(1 - \frac{c^j/(1 - \alpha)}{W - Q_o^j(p_u(I_{-j}))}\right) \end{aligned}$$

¹²To see this, note from equations (6) and (7), along with the definition $Q_o^j(p_u)$, that $\pi_e^j(I_{-j}) - \pi_o^j(I_{-j}) \geq c^j$ if and only if $c^j/Q_o^j(p_u) \leq G^j(\sum_{i \in I_{-j}} \gamma^i G^i + \sum_{i \neq j} \gamma^i)/(\sum_{i \in I_{-j}} \gamma^i G^i + \gamma^j G^j + \sum_{i=1}^N \gamma^i)$. Equation (8) follows from rearranging terms, and taking logs on both sides.

$$+ \log\left(1 + \frac{\gamma^j}{\sum_{i \in I_{-j}} \gamma^i G^i + \sum_{i \neq j} \gamma^i}\right) \quad (8)$$

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, aggregate output level of country j , $Q_o^j(p_u(I_{-j}))$, 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 , $Q_o^j(p_u(I_{-j}))$, 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 $W - Q_o^j(p_u(I_{-j}))$ is close to zero, $\Pi_e^j(I_{-j}, G^j) - \Pi_o^j(I_{-j}) - c^j$ 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 $\log\left(1 + \frac{\gamma^j}{\sum_{i \in I_{-j}} \gamma^i G^i + \sum_{i \neq j} \gamma^i}\right)$ with respect to $\sum_{i \in I_{-j}} \gamma^i G^i$, we obtain:

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

It follows, therefore, that the *strategic* incentives for country j to adopt an eco-labeling program depends on the interplay of three effects. In particular, adoption is more likely: (i) the larger the production cost advantage of country j in agricultural production ($\gamma^j / \sum_{i \neq j} \gamma^i$), (ii) the larger the cumulative number of countries that have already adopted a labeling program I_{-j} , so long as $G^i > 0$, and finally, (iii) the higher the industry-level green premium of those countries $\gamma^i G^i$ that already have a labeling program in place. Specifically, the higher the industry-level green premium, G^i , the larger will be the added incentives for country j to adopt.

What is important to note is that the cumulative number of countries plays a role in adoption decisions only if the industry level green premia of these countries are strictly positive. In addition, a presumption in popular discussions on the potential and 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 *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 production cost advantage of country j in producing X via the baseline technique γ^j ,*
4. *peer effects that take into account the number of countries that have already implemented an eco-labeling program at any given time period, and the industry-level green premium of these countries.*

3.4 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

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

The welfare comparison conducted in what follows 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.

Aggregate Producer Welfare Implications

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

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

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*

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

In other words, even when incentives are right for a country to engage in labeling, and adopt environmentally friendly production technologies, aggregate producer profits may still decline, relative to a regime where countries compete based only on their comparative cost advantages γ^i . In particular, aggregate profits increase only for a subset of countries with a sufficiently high industry-level green premium.

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:

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

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

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

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

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

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 earnings ω^j) can be expressed as

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

where $K \equiv \beta \log \beta + (1 - \beta) \log(1 - \beta)$ 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: import taxes, or the share of fiscal burden of the labeling program. These are discussed in detail in Basu, Chau and Grote (2001). However, the main thrust of this finding remains robust.

4 Empirical Analysis

In this section, we present the 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 partly 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 affect 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 4.4.

A key issue is thus how observed incidences of eco-labeling may reveal information on producers’ perception of the size of the industry green premium. To this end, we refer to the right hand side of equation (8), which suggests the inclusion of 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 has been already described in Table 1. In addition, 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, $t = 1976 - 1999$ (World Bank 2001b); (ii) the existing level of food industry environmental damage – average food industry water pollution (share of total BOD emission) (World Bank 2001b); and / or (iii) the existence of national commitments via multilateral environmental agreements, such as the Kyoto and the Montreal protocol.

To capture the scale effect, our data contains pre-labeling food industry total output level at time t : $Q_{I-j}^j(t)$, taken from World Bank (2001a). The comparative cost advantage of country j , γ^j , is proxied by the export orientation of the economy – the average share of total exports to total food industry trade, $t = 1976 - 1999$ (Trade and Production Data base, World Bank 2001a).

Tables 2a-b accordingly display the summary statistics of the variables that capture the stage of development, existing pollution levels, the scale effect and the comparative cost advantage in two groups of countries. These include (i) countries that have already instituted an eco-labeling program prior to or during 1976 - 1999, and (ii) countries that have not yet adopted eco-labeling by the end of 1999. Furthermore, Tables 2a-b highlight (i) pre- and post-labeling differences for countries that have adopted eco-labeling, and (ii) differences between countries with and without eco-labeling in place. Consistent with the Kaplan-Meier survival curves as illustrated in Section 3, countries that have instituted an eco-labeling program during the period (1976 - 1999) on average enjoy a higher real income per capita. In addition, countries that have instituted an eco-labeling program in agriculture are on average net food-industry exporters, while countries that do not are on average net food-industry importers.

In terms of the scale of production, a country with an eco-labeling program produces an average of about 3% of the total food-industry output among the 66 countries included in our data set - more than ten times higher than countries that do not have an eco-labeling program in place (Table 2a). Finally, in terms of environmental performance, despite their export orientation in food industry, countries that institute a labeling program appear to already have a relatively low level of food industry share of total water pollution.

While Table 2a presents unconditional comparisons, and does not properly control for the joint and simultaneous impact of all of these variables on adoption decisions, the broad picture embodied in Table 2a is largely consistent with that of equation (8). In terms of fixed cost, Table 2a 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 credible labeling program. In terms of scale effects and cost differences, Table 2a 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.

Table 2b summarizes the percentage change in each of these variables during the period prior and the period after eco-labeling.¹³ For countries that do not have an eco-labeling program, and in the absence of an otherwise more obvious cut-off point, the percentage changes are computed based respectively on 1976 - 1987 and 1988 - 1999 averages. The three variables for which the two groups of countries exhibit diverging patterns of growth are: (i) food industry export share to the US, Western Europe and Japan, (ii) food industry export as a share of total trade, and (iii) food industry share of total water pollution. In particular, exports to the US, Western Europe and Japan rose by an average of 25% by countries with labeling programs, but fell by more than 7% for countries without. Interestingly, the share of exports to total trade actually fell in countries with eco-labeling programs. It may be of interest to note that this observation can nevertheless be consistent with our theoretic discussion. Indeed, from Section 4, industry revenue and export share in a subgame perfect Nash equilibrium rise with labeling only for countries with sufficiently high industry-level green premia, and fall for those with relatively low industry-level green premium. In terms of environmental performance, the two groups of countries also appear to have diverged in such a way that the share of food industry water pollution fell in countries with labeling programs, and rose in countries without.

¹³In may be of interest to point out here that Table 2b serves to illustrate general trends, and is not sufficient to address the important issue of causality. In particular, as has been shown in the analytical section, and will be seen again in the empirical results, eco-labeling is hardly an exogenous event. Instead, its implementation is systematically correlated with stage of development, export orientation, and existing level of environmental performance. These suggest that appropriate tests regarding whether eco-labeling per se raises export potential, for example, should explicitly account for this endogeneity.

Finally, turning to peer effects, countries are divided into peer groups based on a number of criteria. To uncover the impact of trade competition on eco-labeling, a first peer grouping is defined based on whether a country is (on average) a net exporter, or a net importer of food industry output, during the period 1976 - 1999. A second peer grouping takes into account the extent of trade competition at the bilateral trade level. Specifically, each country is assigned a distinct peer group, which includes the top ten food industry export destinations of the country. To allow for a finer distinction between export destinations, we also single out a sub-peer group which includes the top five food industry export destinations of the country. A final peer grouping addresses regional influences, and each country falls into one of the following regional groups: “lac” (Latin American and the Caribbean), “eap” (East Asia and Pacific), “wena” (Western Europe and North America), “ssa” (Sub-saharan Africa), “sa” (South Asia), “mena” (Middle East and North America), and “eca” (East and Central Asia).

Based on these peer groupings, the size of the peer effect for country j at time t is constructed 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 $\frac{\gamma^j}{\sum_{i=1}^N \gamma^i}$ (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 has an eco-labeling program in place up till time $t - 1$ for each country j gives $wcexdest$ at time t , while the variable “ $wcexdestop5?$ ” is similarly constructed based only on the weighted cumulative number of top 5 export destinations that have instituted an eco-labeling program. The variables “ $wcreg$ ” and “ $wcexdum$ ” respectively denote peer effects when peer groupings are based on regional differences, and whether a country is a net importer or a net exporter.

Figure 4 plots these peer effect variables for China, India, Bolivia, and Canada over the period 1976 - 1999. China, India and Bolivia are classified as developing countries whereas

Canada is a developed country. China, India and Canada are net food-industry exporters whereas Bolivia is a net importer. These four countries span the continents of East Asia, South Asia, Latin America and North America. Despite these differences, the eco-labeling programs in China and India were respectively instituted in 1990 and 1991. As shown in Figure 4, the peer effects facing both of these countries are characterized by the predominance of export destination peer effects “wcexdest”, while regional peer effects appear to be the weakest. Both countries saw a jump in “wcexdesttop5” prior to the institution of their respective labeling programs.

Observe also that Bolivia is characterized by a much weaker peer effect based on the export destination country grouping, and a likewise insignificant degree of regional peer effects. Bolivia have not yet instituted an eco-labeling program in 1999. In Canada, the relative sizes of the three peer effect variables are further juxtaposed, wherein the regional peer effect is the highest throughout the sample period except for the last three years, and the peer effect based on net exporting orientation ranks the lowest throughout. The eco-labeling program in Canada nevertheless began in 1988.

4.1 Estimation Results

In order to uncover the empirical determinants of the likelihood of adoption, we work with an empirical framework that allows us to analyze the data on food industry eco-labeling illustrated above. The interest here is to empirically ascertain the likelihood of eco-labeling. We take the approach of estimating a proportional hazard model. More specifically, let \mathbf{x}_{jt} be a vector of time-varying explanatory variables, where $t = 1976, \dots, T_j$, 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

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

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:

$$h(t_j|\mathbf{x}_{jt}) = \hat{h}(t_j)e^{\sum_{k=1}^K \beta_k x_{jkt}}. \quad (9)$$

where \hat{h} denotes the baseline hazard function. The hazard ratio for a unit change in x_{jkt} is thus simply

$$e^{\beta_k} \geq (<)1$$

Parameter estimates of β_k of the Cox proportional hazard model are obtained by maximizing a partial log-likelihood function (Kalbfleisch and Prentice 1980), and has the virtue that the estimation procedure places no restrictions on the unknown functional form of the baseline hazard function.

Empirical estimates of e^{β_k} are presented in three tables. The first table (Table 3) focuses on the prevalence and relative importance of peer effects. Table 4 captures the importance of commitments to multilateral environmental conventions on the decision to adopt. Table 5 summarizes the results of empirical estimates aimed at disentangling the possible differences in industry-level green premium in developed and developing countries. For each of these estimations, we report the number of observations, the number of incidences of eco-labeling that took place after 1976,¹⁴ 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 significance level of less than 1 percent. Each estimation also controls for the group of countries in Western Europe and North America (“wena”), as many of these countries have adopted eco-labeling programs prior to the beginning of the sample period in 1976.

We first turn to a discussion of a number of similarities that emerge in all of our estimations as summarized in Tables 3-5. To begin with, a higher real per capita GDP is associated

¹⁴This gives the number of incidences of eco-labeling applicable in the estimation at 22 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 (Tables 3 -5) that are included in our estimations.

with a higher likelihood of eco-labeling, as the estimated coefficients β are strictly greater than one, and significant at the 1% or 5% level. Based on our theoretical discussion in Section 4, there are a number of possible interpretations of this finding. These include the possibilities that higher income countries (i) are more capable of bearing the fixed cost of eco-labeling; (ii) have in place technologies that are more in line with the production criteria on which eco-labeling programs are typically based, and (iii) have higher industry-level green premium based on perceived or actual credibility of the eco-labeling programs, once one is put into place. Clearly, the first two of these possibilities are relevant to fixed costs considerations (Proposition 1.1) which may naturally put developing countries at a disadvantage. The third of these possibilities imply a potentially more contentious problem that cannot be solved simply via technological transfers. We will return to this question in our discussion of the last part of our estimation results.

A second common feature in our estimations is that of the existing level of food-industry related water pollution. In particular, all of the estimated coefficients associated with the existing level of pollution are strictly less than one, and significant at the 5% or 10% level with two exceptions in Tables 3 - 5. Interpreting the degree of food-industry water pollution as a proxy for the level of monitoring that may be expected to become necessary once a labeling program is in place, our findings here are consistent with the fact that the fixed cost of labeling may be jointly determined by a number of factors. These include the access to green technologies, along with the existing degree of departure from environmentally friendly production practices.

A third common feature relates to the scale effect, as captured by the food industry output share of a country. A food industry output squared term is also included to capture any non-linearity that is suggested by our theoretical discussion and in equation (8). As should be apparent, the scale of the food-industry has a significant and positive impact on the likelihood of eco-labeling, though at a rate that is decreasing with the scale of production. Thus, scale matters and it matters positively, but at a decreasing rate.

The fourth common feature across our estimates is the role of comparative cost advan-

tage, as proxied in our estimations by the food industry share of exports to total trade of the country. In equation (8), comparative cost advantage $\gamma^j / (\sum_{i=1}^N \gamma^i)$ enters into the determination of the likelihood of adoption in a positive way, and our estimation results likewise indicate that the higher the export share of food-industry trade, the more likely it is that a country adopts eco-labeling. In Tables 3 - 5, the estimated coefficients are strictly greater than unity, and significant at the 1% or 5% level.

Once all of the above effects are controlled for, we now turn to strategic interaction between countries based on the peer groupings discussed above. The first set of results is summarized in Table 3. The estimated coefficients respectively for the three peer effect measures are strictly greater than unity, indicating that an increase in the weighted cumulative number of countries in a peer group is associated with an increased likelihood of eco-labeling. Of these three peer effect measures, however, only two are significant. Respectively, these are the regional peer effect (“wcreg”), along with the bilateral export destination peer effect for the top five exporting destinations (“wcexdest5”). In addition, when both regional and bilateral export destination peer effect are both included (Column V of Table 3), the bilateral export destination peer effect is singled, and is the only peer effect variable that continues to be significant. Based on our theoretical discussion and equation (8), therefore, these findings may be interpreted as an indication of *strategic complementarity* between countries, and particularly those that are engaged in trade competition. Thus, notwithstanding the argument that international trade tends to encourage the exploitation of the environment, resulting in the possibility of a “race to the bottom” as countries engage in minimizing costs, our findings here suggest the possibility of a reversal of these tendencies in the context of eco-labeling. In particular, countries that are most likely to exploit the market-based incentives made available through eco-labeling are those that are engaged in export competition. In addition, rather than a “race to the bottom”, our findings suggest that a “race to the top” may be a more appropriate characterization in the context of food-industry eco-labeling initiatives.

Table 4 turns to an examination of the role of multilateral environmental commitments such as the Kyoto Protocol, and the Montreal Protocol, in determining the likelihood of “vol-

untary” mechanisms towards the greening of agriculture, as is the case with eco-labeling. Two sets of regression results are shown, one with all the basic variables and the ratification of the two multilateral environmental agreements, but without the peer effects, and a second set includes the export destination peer effects. The variables “*kyoto*” and “*montreal*” are both binary variables that take on a value of one (zero) at time t for country j if the corresponding multilateral environmental agreement is (is not) ratified by country j at any time $s < t$. Our findings indicate that neither of the two multilateral agreements appears to have significant influence on the likelihood of adoption. Indeed, in the four estimation results displayed in Table 4, none of the estimated coefficients are significant. Comparing these findings with the data presented in Table 4, the result should perhaps not be entirely surprising. In particular, while eco-labeling is prevalent mostly in developed countries, and / or in countries that are export oriented, the ratification of the two multilateral environmental conventions is almost *universal*.

As discussed in Section 4, countries that perceive a higher industry-level green premium are more likely to have a stronger influence on the labeling decision of other countries (equation (8)). This analytical finding suggests one possible way of trying to ascertain whether developed and developing countries may have differential industry-level green premium, as is popularly argued in the North-South debate surrounding the potential distributional consequences of eco-labeling. Specifically, we construct three additional variables based on the peer effect variables established above. “*wcdevexdum*” , “*wcdevexdest*” and “*wcdevreg*” respectively denote the weighted cumulative number of *developing* countries that have adopted a labeling program respectively in the three peer groupings. The inclusion of each of these three additional variables into the estimation thus allows the strategic impact of labeling programs initiated in developing countries to be singled out. Accordingly, if the estimated coefficient of these new variables are less than (greater than) unity, we may infer that the industry-level green premium of developing countries are strictly lower (higher) than that of developed countries.

The results are presented in Table 5. As should be apparent, none of the estimated coefficients on developing country peer effects are significant at 5% or less. However, the estimated coefficients of developing country peer effects are less than one (including “*wcdevreg*,

“wcdevexdum and “wcdevexdest), which would have indicated that the industry-level green premium of developing countries may be less, but certainly never significantly higher than that of developed countries. Returning to our discussion earlier in this section, having to do with the possibility that a country’s stage of development may play a role in determining the perceived credibility of eco-labeling programs, our findings here would suggest that at least for the case of food-industry labeling, and given the set of countries under consideration, systematic and / or significant evidence suggesting that industry green premia respectively of developed and developing countries diverge in a predictable way has yet to be found.

5 Conclusion

This paper began with an observation that while eco-labeling in agriculture has been long-standing in developed countries in Western Europe, the spread of this practice is beginning to take hold in developing countries worldwide. The data that we assembled for this paper, regarding the time to adoption pattern of eco-labeling programs in 66 countries, reveal further that food industry export orientation appear to be correlated with the speed with which countries implement their own eco-labeling programs.

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, the observations made at the outset of this paper raise a number of questions. First, can the market incentives made available through eco-labeling entice countries engaged in export competition to improve environmental performance? Second, how do countries engaged in export 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? 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?

The theoretical model proposed in this paper suggests two sets of results, having to do with the selection criteria of the adoption of labeling, and the welfare consequences of eco-labeling in a subgame perfect Nash equilibrium. In terms of selection criteria, the model suggests that so long as countries perceive a strictly positive green premium, the speed of adoption depends on: (i) the fixed cost of eco-labeling programs, (ii) a scale effect, and (iii) the comparative cost advantage of the industry in question. Interestingly, the model also suggests the likely prevalence of strategic interactions, so that the decision to adopt by one country depends on the decision to adopt by other countries. Comparing producer welfare with and without competition based on eco-labeling, the theoretical discussion indicates that while countries that find themselves satisfying these selection criteria in a subgame perfect Nash equilibrium are not necessarily made better off, countries that do not satisfy these selection criteria will be worse off for sure.

The empirical findings suggest that there are economic, trade and environmental variables that are systematically correlated to the likelihood of eco-labeling. These findings, in turn, are largely consistent with the theoretical discussion, and suggest in particular that countries behave as though they perceive a strictly positive green premium. Interestingly, the peer effect variables with peer grouping based on the degree of export competition is also significant and positive, indicating that the nature of interdependence between countries is of the strategic complement variety.

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 quite to the contrary of a “race to

the bottom” may in fact be in play.

Finally, while we find no significant difference between the industry-green premium between developed and developing countries based on observed patterns of adoption and strategic interdependence, developing countries are nevertheless late adopters, due possibly to their inability to shoulder the cost of having a credible labeling program. This finding confirms in part the concerns regarding the negative terms of trade consequence of eco-labeling particularly for developing countries.

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.

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Table 1: Environmental Initiatives, Stage of Development and Regional Distribution by Export Orientation

Net Exporters						Net Importers					
Country Name	Eco-Label	Montreal Protocol	Kyoto Protocol	Developing Country	Region*	Country Name	Eco-Label	Montreal Protocol	Kyoto Protocol	Developing Country	Region*
Argentina	X	X	X	X	lac	Armenia	-	X	X	X	eca
Australia	X	X	X	-	eap	Austria	X	X	X	-	wena
Bulgaria	-	X	X	X	eca	Bangladesh	-	X	X	X	sa
Canada	X	X	X	-	wena	Bolivia	-	X	X	X	lac
Chile	X	X	X	X	lac	Cameroon	-	X	X	X	ssa
China	X	X	X	X	eap	Cyprus	-	X	X	-	wena
Colombia	X	X	X	X	lac	Egypt, Arab Rep.	X	X	X	X	mena
Costa Rica	-	X	X	X	lac	Finland	X	X	X	-	wena
Denmark	X	X	X	-	wena	France	X	X	X	-	wena
Ecuador	-	X	X	X	lac	Germany	X	X	X	-	wena
Ethiopia	-	-	X	X	ssa	Greece	X	X	X	-	mena
Guatemala	-	X	X	X	lac	Hong Kong, China	-	-	-	-	eap
Honduras	-	X	X	X	lac	Iran, Islamic Rep.	-	X	X	X	mena
Hungary	-	X	X	X	eca	Italy	X	X	X	-	wena
India	X	X	X	X	sa	Japan	X	X	X	-	eap
Indonesia	-	X	X	X	eap	Jordan	-	X	X	X	mena
Ireland	X	X	X	-	wena	Korea, Rep.	X	X	X	X	eap
Kenya	-	X	X	X	ssa	Kuwait	-	X	X	-	mena
Malawi	-	X	X	X	ssa	Latvia	-	X	X	X	eca
Malaysia	-	X	X	X	eap	Macao, China	-	-	-	-	eap
Moldova	-	X	-	X	eca	Mexico	-	X	X	X	lac
Netherlands	X	X	X	-	wena	Morocco	-	X	X	X	mena
New Zealand	X	X	X	-	eap	Nepal	-	X	X	X	sa
Norway	X	X	X	-	wena	Pakistan	-	X	X	X	sa
Peru	-	X	X	X	lac	Panama	-	X	X	X	lac
Philippines	-	X	X	X	eap	Poland	X	X	X	X	eca
South Africa	X	X	X	X	ssa	Portugal	X	X	X	-	mena
Spain	X	X	X	-	wena	Romania	-	X	X	X	eca

Table 1 (cont'd)

Net Exporters						Net Importers					
Country Name	Eco-Label	Montreal Protocol	Kyoto Protocol	Developing Country	Region*	Country Name	Eco-Label	Montreal Protocol	Kyoto Protocol	Developing Country	Region*
Sri Lanka	X	X	X	X	sa	Singapore	-	X	X	-	eap
Thailand	X	X	X	X	eap	Sweden	X	X	X	-	wena
Turkey	X	X	-	X	eca	Trinidad and Tobago	-	X	X	X	lac
United States	X	X	X	-	wena	United Kingdom	X	X	X	-	wena
Uruguay	-	-	X	X	lac	Venezuela, RB	-	X	X	X	lac
	18(33)	31(33)	31(33)	24(33)			13(33)	31(33)	31(33)	18(33)	

*Regions: ``lac" (Latin American and the Caribbean), ``eap" (East Asia and Pacific), ``wena" (Western Europe and North America), ``ssa" (Sub-saharan Africa), ``sa" (South Asia), ``mena" (Middle East and North America), and ``eca" (East and Central Asia)

Sources: Author's compilation.

Table 2a: Trade Links and Output Pre and Post Eco-labeling

Variable	Pre*	sd	Post**	sd	NA***	sd
Real per capita Income (US\$ 1995 const.)	9924.070	9341.742	12994.840	12052.590	3529.190	4700.855
Food Ind. Export Orientation (% export to total food ind exports and imports)	59.843	21.501	56.244	22.134	48.303	25.488
Food Ind Export Share to US, WE & JPN (% export to US, WE, JPN to total export)	53.517	20.529	55.768	20.532	47.341	25.299
Food Ind Output Share (% total world output)	3.234	6.927	3.602	6.997	0.214	0.249
Food Ind water-pollution (% total BOD emission)	44.203	10.298	43.707	9.955	51.043	16.291

*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.

Table 2b: Export and Environmental Performance Growth

Variable	Labeling*		NA**	
	mean	sd	mean	sd
Real per capita Income				
% change	41.629	35.036	14.417	29.371
Food Ind. Export Orientation				
% change	-4.705	25.331	12.899	48.964
Food Ind Export Share to US, WE & JPN				
% change	20.361	89.216	-7.447	46.123
Food Ind Output Share				
% change	25.654	35.105	12.664	51.817
Food Ind water-pollution				
% change	-0.655	8.502	4.547	18.454

*Computed based on pre- and post- labeling averages

** Computed based on 1976-1987 and 1988 -1999 averages.

Table 3: Proportional Hazard Regression: Export Destination and Export Orientation Peer Effects

Hazard Ratios	I	II	III	IV	V
Real per capita Income	1.00006 ***	1.00004	1.00006 ***	1.00007 ***	1.00006 **
	0.00002	0.00002	0.00002	0.00002	0.00003
food ind. output share	1.37669 **	1.47759 ***	1.38389 ***	1.32939 **	1.37842 **
	0.17335	0.19192	0.16860	0.18389	0.19734
food ind. output share-squared	0.99225 **	0.99008 ***	0.99207 **	0.99408	0.99286 *
	0.00367	0.00381	0.00357	0.00408	0.00427
food ind water-pollution	0.95502 ***	0.95782 **	0.95521 ***	0.95936 **	0.96272 *
	0.01667	0.01679	0.01666	0.01881	0.01930
food ind exports share	1.05002 ***	1.04650 ***	1.05081 ***	1.04639 ***	1.04258 **
	0.01501	0.01501	0.01445	0.01786	0.01823
wcreg		1.02316 ***			1.01649
		0.00908			0.01039
wcexdum			0.98684		
			0.03882		
wcexdest				0.99878	1.00015
				0.00533	0.00554
wcexdest5				1.06088 ***	1.05127 ***
				0.02076	0.02117
No. of observations	1088	1088	1088	1088	1088
Incidences of Eco-labelling	22	22	22	22	22
Log Likelihood	-67.229	-65.759	-67.206	-64.291	-63.588
Wald chi^2	36.350	35.260	51.140	49.210	49.460
Prob > chi^2	0.000	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 4: Proportional Hazard Regression: Multinational Environmental Agreements

Hazard Ratios	I	II	III	IV	V	VI
Real per capita Income	1.00006 ***	1.00006 **	1.00007 ***	1.00006 **	1.00006 **	1.00005 *
	0.00002	0.00002	0.00002	0.00003	0.00003	0.00003
food ind. output	1.37340 **	1.31966 *	1.33013 **	1.30428 *	1.37847 **	1.34743 *
	0.17401	0.19517	0.18458	0.20620	0.19769	0.22017
food ind. output-squared	0.99231 **	0.99350	0.99407	0.99459	0.99286 *	0.99348
	0.00369	0.00429	0.00408	0.00459	0.00427	0.00482
food ind water-pollution	0.95459 ***	0.95137 ***	0.95948 **	0.95586 **	0.96273 *	0.95853 **
	0.01660	0.01729	0.01898	0.01911	0.01944	0.01942
food ind exports share	1.04998 ***	1.04823 ***	1.04640 ***	1.04649 ***	1.04258 **	1.04279 **
	0.01499	0.01424	0.01787	0.01717	0.01824	0.01742
wcreg					1.01649	1.01512
					0.01040	0.01029
wcexdesttop10			0.99875	0.99879	1.00014	1.00010
			0.00533	0.00553	0.00556	0.00569
wcexdesttop5			1.06118 ***	1.05573 ***	1.05129 **	1.04675 **
			0.02076	0.02149	0.02117	0.02184
kyoto	1.54428		0.87573		0.99052	
	1.10851		0.63896		0.70706	
montreal		3.72308		3.10222		2.94311
		3.12322		2.51565		2.28805
No. of observations	1088	1088	1088	1088	1088	1088
Incidences of Eco-labelling	22	22	22	22	22	22
Log Likelihood	-67.195	-65.677	-64.289	-63.232	-63.588	#REF!
Wald chi^2	39.060	49.130	49.350	64.660	49.510	#REF!
Prob > chi^2	0.000	0.000	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 5: Proportional Hazard Regression: Industry Premium Differentials

Hazard Ratios	I	II	III	IV
Real per capita Income	1.00005 ** 0.00002	1.00006 *** 0.00002	1.00008 *** 0.00002	1.00007 *** 0.00003
food ind. output	1.43569 *** 0.18746	1.40528 *** 0.17674	1.34224 ** 0.17920	1.30183 * 0.19468
food ind. output-squared	0.99073 ** 0.00388	0.99167 ** 0.00362	0.99387 0.00390	0.99430 0.00447
food ind water-pollution	0.93828 *** 0.01627	0.95603 ** 0.01786	0.95711 ** 0.01864	0.94345 *** 0.01809
food ind exports share	1.05343 *** 0.01301	1.05216 *** 0.01373	1.04723 *** 0.01816	1.05046 *** 0.01525
wcreg	1.02278 ** 0.00960			1.01805 * 0.01105
wcexdum		0.99099 0.03748		
wcexdesttop10			1.01285 0.01234	0.99074 0.02109
wcexdesttop5			1.05622 *** 0.02098	1.05584 *** 0.01989
wcdevreg	0.48781 * 0.18234			0.42862 0.19159
wcdevexdum		0.95005 0.19500		
wcdevexdest			0.93625 0.04522	1.02504 0.08744
No. of observations	1088	1088	1088	1088
Incidences of Eco-labelling	22	22	22	22
Log Likelihood	-62.999	-67.175	-63.922	-60.458
Wald chi^2	33.740	54.170	42.800	78.970
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.

Figure 1. Kaplan-Meier survival estimates, by stage of development

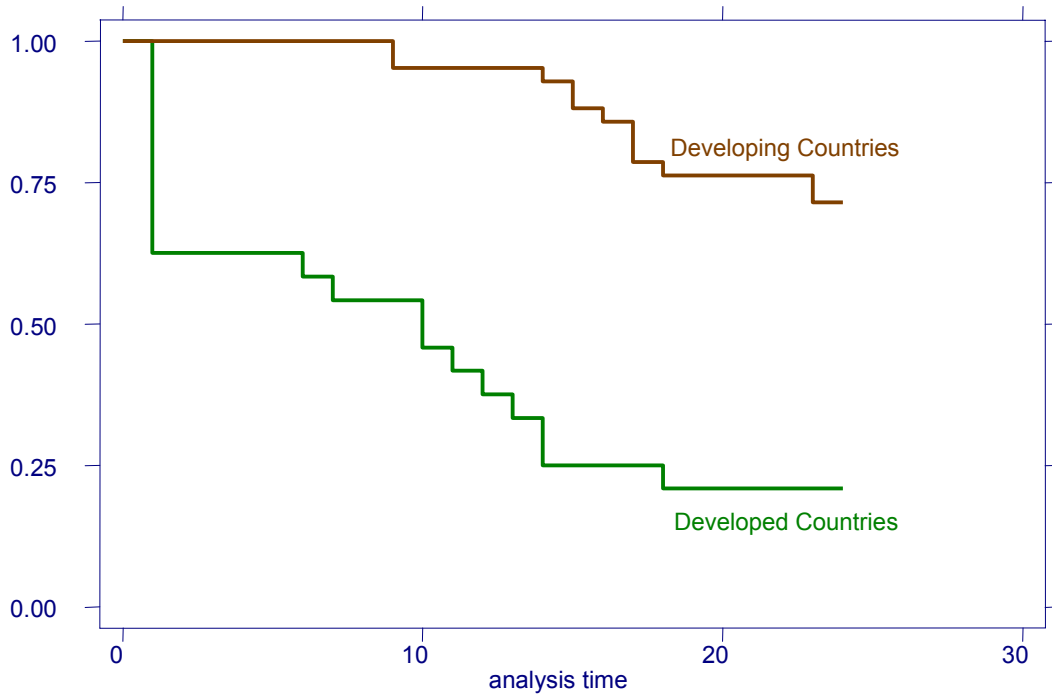


Figure 2. Kaplan-Meier survival estimates, by export orientation

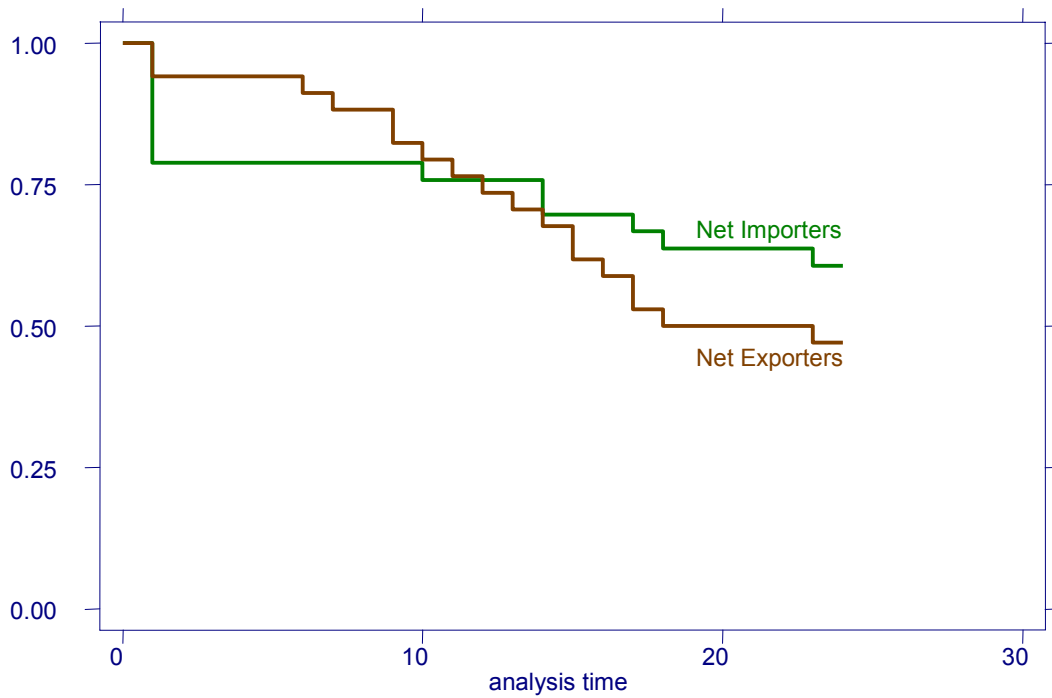


Figure 3. Linkage between exports and
and food industry water pollution (1976-99).

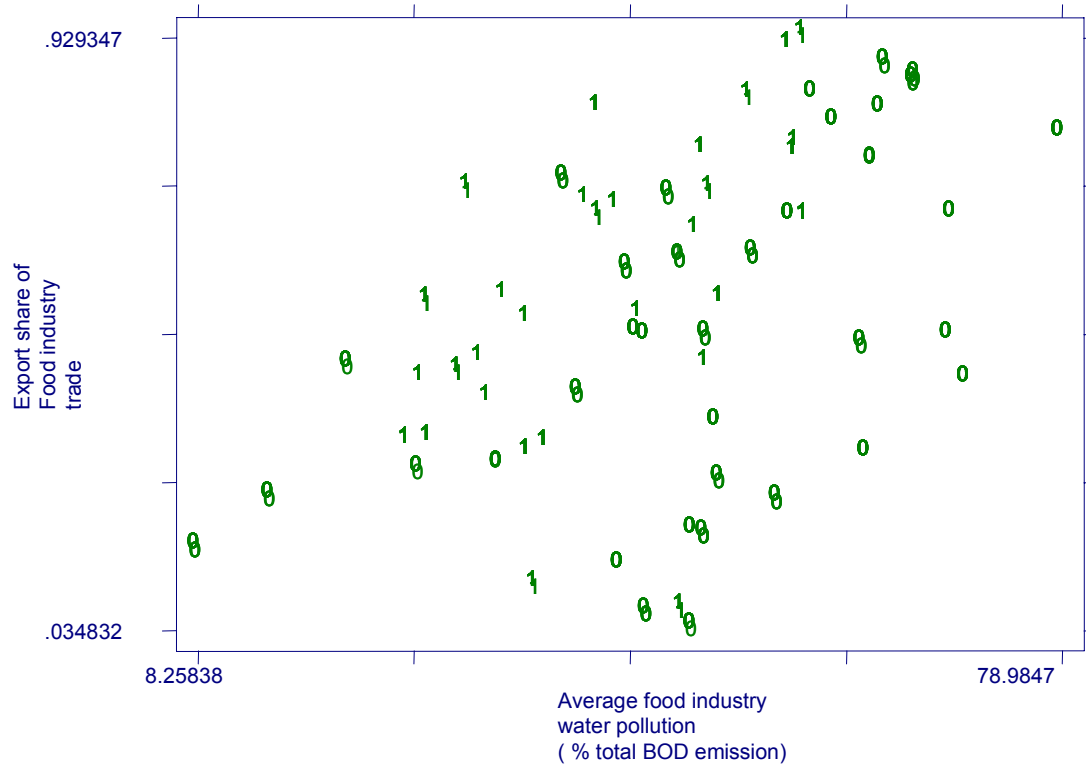
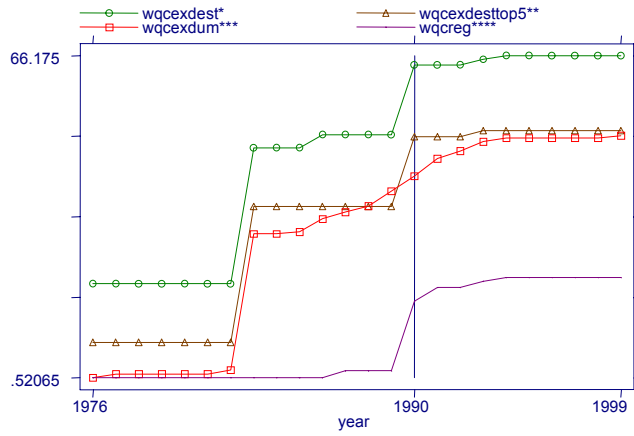
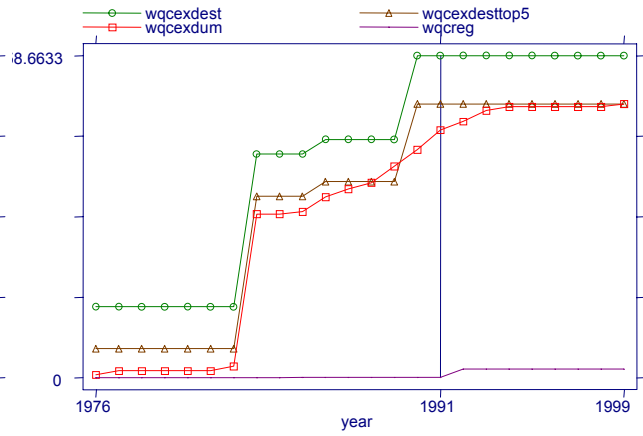


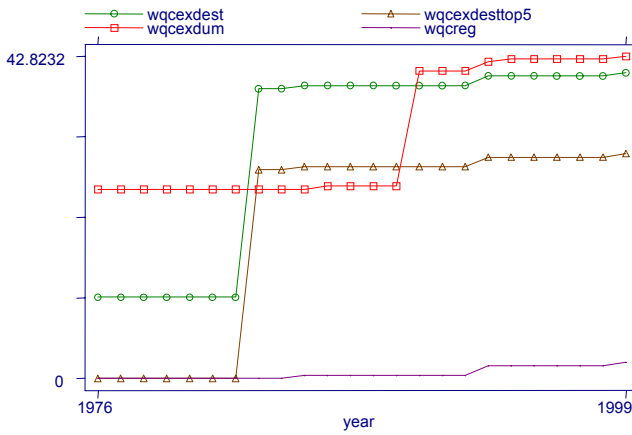
Figure 4. Peer effects and Eco-labeling



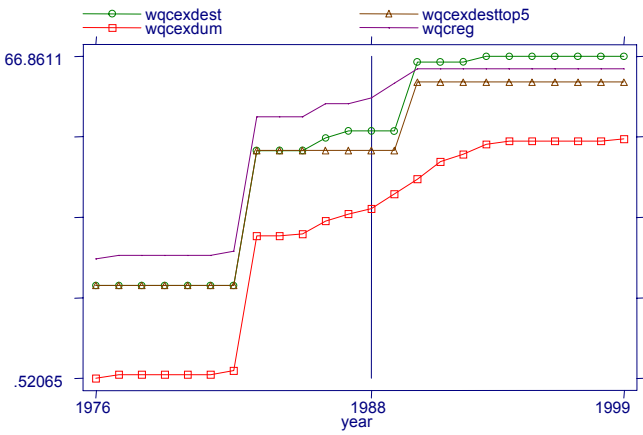
China



India



Bolivia



Canada

- *wexadest: Major export destination peer effect
- **wexadesttop5: Top 5 export destination peer effect
- ***wcxedum: Net exporter / importer peer effect
- **** wcreg: Regional peer effect