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Market Access Rivalry and Eco-labeling Standards: Are Eco-labels Non-tariff Barriers in Disguise?

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Market Access Rivalry and Eco-labeling Standards: Are Eco-Labels Non-tariff Barriers in Disguise?*

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Abstract: Despite the merits of eco-labeling as a consumer information and market-based environmental policy alternative, the promise that green consumerism holds in encouraging environmentally conscious production decisions also raises concerns over whether eco-labeling deters the market access of developing countries in high income countries, and effectively serves the role of a non-tariff barrier to trade. In this paper, we disentangle the role of eco-labeling in world trade, and show that (i) imperfectly informed consumption decision making in the absence of labeling has a *pro-trade bias*; (ii) eco-labeling can guide green consumption and production decisions to reach the efficiency frontier, provided that (iii) the choice of eco-labeling standards in the two countries are *not* subject to coordination failure. Taking labeling standards as endogenously determined by market share rivalry between the two countries, we show that strategic use of eco-labeling gives rise to opposing incentives, and results in a "tariff-like" outcome that further reduces the volume of trade. Specifically, net importers deviate from the efficiency frontier by choosing labeling standards that are too high, while net exporters choose labeling standards that are too low.

Keywords: Eco-Labeling, Market Access, Strategic Environmental Standards.

JEL Classification: F13, L15, Q28.

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1 Introduction

The practice of providing environmental performance and efficiency related product information to consumers – more popularly referred to as eco- or green labeling – has gained increasing popularity in recent years. Products with labels promoting attributes like "recyclable", "degradable" or "ozone-friendly" has flooded the market along with eco-labeled products promoting environmentally friendly process and production methods (PPMs) like "dolphin-safe tuna", furniture made from wood harvested from sustainably managed forests and fish from sustainable fisheries. The popularity of eco-labeled products is primarily based on its market-driven approach to achieve environmental goals. The increased concern of consumers for the environment and food safety, reflected by their willingness to pay relatively higher prices for products that has been produced in an environmentally friendly manner provides a positive incentive for producers to choose techniques that minimizes the adverse effects on the environment and improves the quality of final products. As Table I indicates, the incidence of both developed and developing countries that undertake voluntary labeling programs has risen dramatically to keep pace with rising consumer demand for eco-friendly products over the last decade.

The popularity of eco-labeling programs notwithstanding, the controversy about eco-labeling lies in the differential impacts that such programs are alleged to have on market access, and on the welfare of developing exporters and their developed counterparts. In particular, there are genuine concerns as to whether eco-labeling will offset the expansion in world trade achieved after decades of effort devoted to multilateral trade liberalization and whether eco-labeling should be treated as a Trade Related Environmental Measure (TREM), and be placed under the discipline of existing trade agreements — particularly, since the WTO, as currently structured, does not explicitly discipline the use of eco-labels through the rules of the WTO, nor does it require member nations to establish standards. Thus, whether or not labeling-related environmental justifications for the use of trade restricting policies should be part of the Technical Barriers to Trade (TBT) and / or Sanitary and Phytosanitary Measures (SPS) has become a central issue in the ongoing negotiations amongst WTO members (Nordström and Vaughan, 2000; WTO-CTE, 2000 and 1996)[1].

These observations constitute a new dimension to the North-South divide in the trade and environment debate, and highlight how the promise of legitimate, market-based efforts to entice producer adoption of environmental conscious production techniques may conflict with trade interests. Specifically, developing economies are concerned with the possible manipulation of green labeling standards as a non-tariff barrier in disguise. Meanwhile, countries concerned with product safety and the growth of green consumerism may favor multilateral trade agreements to move beyond traditional trade policies and cover product standard issues. The tuna/dolphin dispute between the United States and Mexcio, and Austrian labeling of tropical timber are but two of the relatively high profile cases in point[2].

It bears emphasis at the very outset that there are key differences between eco-labeling and more traditional forms of environmental policies. Governments bound by commitments to liberalize trade in the absence of environmental commitments may strategically *lower* emission taxes to replace explicitly protectionist border taxes or export subsidies (Barrett, 1994; Ulph, 1996 and Kennedy, 1994) at the expense of an increase in domestic or transnational pollution. Lax environmental standards and import barriers are thus (imperfect) substitutes in protecting industries against competitive pressures from abroad. In this context, trade agreements that encompass multilateral cooperation to avoid a "race-to-the-bottom" in environmental policies, may prevent countries from undermining environmental performance in the name of trade (Barrett, 1990; and Nordaus and Yang, 1996)[3].

[1]A proposal to impose countervailing duties on imports produced under lax environmental standards has also been raised in the United States (S 984, introduced by Senator David Boren in 1991).

[2]The Marine Mammal Protection Act in the United States prohibited imports of tuna from Mexico unless the dolphin protection standards set out in the Act is met. The dispute panels decided in 1991 and 1994 in favor of Mexico, on the grounds that (i) the import ban is based on the production and process methods of the product (PPMs), and (ii) GATT's general exceptions including Article XX (which acknowledges the right of individual nations in taking actions (including import restrictions) to protect human, plant life, health, and the conservation of exhaustible resources), do not apply to measures intended to achieve the environmental objectives beyond a nation's jurisdictions. Instead, the US introduced an eco-label scheme for "dolphin-safe" tuna, which was recognized as being in conformance with GATT (Wright, 1996).

[3]Bagwell and Staiger (1997) examines the role of trade sanctions in eliciting cooperative behavior in a trade agreement within a framework of repeated games.

In contrast, there are at least four reasons why eco-labeling is different both from an analytical standpoint as well as in practice. These have to do with the way in which eco-labeling: (i) takes advantage of green consumerism; (ii) induces voluntary adoption of eco-friendly production techniques; (iii) gives rise to trade repercussions when labeling standards differ across trading partners, and (iv) constitutes yet another potential source for multilateral coordination failures concerning the choise of labeling standards. To begin with, eco-labeling has the virtue of allowing consumers to internalize the environmental consequences / product safety concerns of their consumption decision making (Srinivasan, 1998; Nordström and Vaughan, 2000 and UNCTAD, 1995). These subjective preferences favoring eco-friendly products are reflected in market prices via a green premium, and allows discrimination between "like" products with differentiated environmental, health, or safety consequences.[4] Second, the success of eco-labeling hinges on voluntary producer adoption of eco-friendly production techniques in response to the green premium. For example, at the industry level, reputation of a green profile has been shown to enable improvements in environmental performance *and* profits, even when the additional costs of higher standards are taken into account (Repetto, 1995; Cohen and Fenn, 1997; Lanoie et al. 1997; and Dasgupta et al. 1998). Third, concerns over eco-labeling arise precisely when trade partners acknowledge these consumption and production (and hence, trade) consequences of eco-labeling. In particular, it is not at all clear that a refusal to tap into green consumerism via lax labeling standards can indeed substitute for trade / production subsidies.

Finally, even when labeling standards are manipulated to reap terms of trade gains and to protect domestic interests in the name of the environment, the promise of eco-labeling as a marketing device, as opposed to an implicit tax, makes it even more difficult to apply traditional "race-to-the-bottom" type coordination failure arguments when considering the potential efficiency and redistribution consequences of international cooperation (UNCTAD 1995, Cameron 1998, Hoekman and Leidy 1992, and Hoekman and Koestaki 1995). As such, the presumption that a environmental race to the bottom is inevitable remains to be shown in the context of eco-labeling.

[4]See UNCTAD (1995) and Shams (1995) for survey results on consumers' willingness to pay of products attached with an eco-label.

In this paper, we construct a two-country (North and South) model, characterized by asymmetries in consumer income, to explore the economic rationale behind the seemingly complementary role of eco-labeling and import protection when the North (South) as a net importer (exporter) of eco-friendly products. We consider three groups of decision makers in each country — environmentally conscious consumers who prefers goods produced via eco-friendly methods (Srinivasan 1995); producers who may voluntarily participate in an eco-labeling program; and governments that are bound by an agreement to pursue free trade — and analyze how the volume of trade is affected as a consequence of strategic competition between the two governments on voluntary domestic producer adoption of eco-labeling standards.

First and foremost, we show that imperfectly informed consumption and production decision making in the absence of eco-labeling has an inherent pro-trade bias. This market failure occurs when consumers in high income countries wherein environmental standards are high attach shadow prices to eco-friendly products that underestimate the actual utility gains. Meanwhile, absent any means of identifying the environmental performance of final products, the same shadow price overestimates the utility gains from eco-unfriendly products. The resulting volume of trade can be shown to strictly exceed that which apply under perfect information. In this context, labeling should be viewed as a market-driven policy which *corrects for* this pro-trade bias of imperfect information.

Quite distinct from the role of eco-labeling as a corrective device to improve consumer information, strategic use of labeling opens up the possibility of a second round adverse impact on market access. We show that when eco-labeling standards are manipulated in order to reap terms of trade gains in a strategic environment, unilateral attempts to raise voluntary labeling standards shift consumption expenditure in favor of the eco-friendly output and put downward pressure on the price of eco-friendly products, or equivalently, the Southern terms of trade. Multilateral coordination failure in the context of eco-labeling takes the form of labeling standards that are set too high (low) in the importing North (exporting South) relative to the Pareto Optimal benchmark. The result is a tariff-like volume of trade response, as the strategic choices of labeling standards shift the market share in favor of the importing North. It is thus the choice of labeling standards in a non-cooperative environment, rather than the information embodied in eco-labels *per se*, which constitute an important reason as to why eco-labeling unnecessarily limits market access, to detriment of the welfare of Southern exporters. In order to illustrate these findings, the paper concludes with the results of a numerical simulation, based on which the implication of our findings in terms of multilateral cooperation in setting eco-labeling standards are discussed.

2 The Model

We envisage a world with two countries (North (n) and South (s)), where differences in consumer income constitute the source of comparative advantage. There are two goods: a homogeneous numeraire commodity (y^i), along with an output x^i, $i = n, s$. With eco-labeling, producers are given the option to voluntarily adopt an environmentally sound production technique $e^i > 1$, or an eco-unfriendly technique $e = 1$, where $e \in (1, \infty)$ denotes the level of environmental standard, or the intensity of pollution abatement in the production process. Without loss of generality, we assume that the North is a net importer of x in general equilibrium. We are interested in environment externalities of the producer-to-consumer variety, in the sense that consumers derive utility from the consumption of good x based on both the physical quantity of good x consumed *and* the eco-friendliness of the production process.

2.1 Production

Two sectors y^i and x^i constitute the production side of the North and the South. Production of the numeraire $y^i = L^i_y$ employs a resource input, L^i_y. Total endowment of resource input in the two countries is given by $\mathcal{L}$, of which country i's share is given by β^i, with $\beta^s + \beta^n = 1$. With mobility of input resources between the two sectors within each country, the economy-wide price of input resources in units of the numeraire is thus unity in both the North and the South. Thus, $\beta^i\mathcal{L}$ also denotes the total income in units of the numeraire that resource owners can maximally devote to the consumption of the two goods.

There are a large number (N) of competitive producers engaged in the production of good x^i in country i. Each individual producer is endowed with one unit of capital, that may be invested in the production of x depending on the environmental standard to be adopted. To focus on the decision-making problem with respect to the choice of production technique, the production function of x^i is given by:

$$x^i = x(e^i) = min\{1, \frac{\ell}{(e^i)^\gamma b}\}, \quad \gamma > 1. \tag{1}$$

where ℓ denotes input resources employed in the production of $x^i(e)$. γ parameterizes the cost of adopting eco-friendly production technique. We assume that $\gamma > 1$ so that the unit cost of production $(e^i)^\gamma b$ is increasing and strictly convex in e^i. $b \in [0, b^+]$ denotes a firm-specific technological parameter, and captures any heterogeneity among the N producers' access to cost-efficient production technologies. In addition, producers in both countries are uniformly distributed along the $[0, b^+]$ interval.

2.2 Green Consumption

The utility of a representative consumer $U(D_x^i, d_y^i)$ takes as arguments the consumption of the homogeneous numeraire d_y^i, along with an index of effective units of good x consumed, D_x^i, with[5],

$$\log U(D_x^i, d_y^i) = \alpha \log D_x^i + (1-\alpha) \log d_y^i,$$

where $\alpha > 0$ denotes the share of consumer expenditure devoted to good x. Let E^i be the set of eco-friendly production techniques available to consumers in country i, where $E^i = \{e^n, e^s, 1\}$ with eco-labeling. $d_x^i(e)$ is the demand for x associated with production technique e. Green consumption, D_x^i, is thus given by:

$$D_x^i = \sum_{e \in E^i} d_x^i(e) + \sum_{e \in E^i} (e-1) d_x^i(e) = \sum_{e \in E^i} e d_x^i(e). \tag{2}$$

Effective green consumption D_x^i thus consists of two components, and account for both the physical quantity of x consumed, along with the associated environmental standard adopted, $(\sum_{e \in E^i}(e-1)d_x^i(e))$. In particular, a unit increase in the consumption of good x produced via production technology $e = 1$ $(e > 1)$ increases effective green consumption by exactly

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

(more than) one unit. In addition, the ratio $e/\bar{e}$ (> 1 whenever $e > \bar{e}$) denotes the marginal rate of substitution between $d_x^i(e)$ and $d_x^i(\bar{e})$ and reflects consumer's valuation for eco-friendly production.

3 Pro-trade Bias of Information Asymmetry

3.1 Production Incentives under Imperfect Information

In the absence of labeling, producers are bound by environmental regulation to adopt $e = \bar{e}^i$. Since consumers cannot differentiate between products based on firms' choice of production methods, a uniform price $\bar{p}$ applies regardless of the eco-friendliness of the underlying production process.[6] A producer in country i with unit cost $(\bar{e}^i)^\gamma b$ makes positive profits if and only if

$$\bar{p} \geq (\bar{e}^i)^\gamma b \Leftrightarrow b \leq \bar{b}^i \equiv \frac{\bar{p}}{(\bar{e}^i)^\gamma}.$$

$\bar{b}^i$ represents the marginal producer in country i who is just indifferent between exiting the industry or not. Since producer profits are monotonically decreasing in b, producers in country i with $b \leq \bar{b}^i$ make positive profits. It follows that aggregate supply (in physical units) in the two countries ($\bar{X}^n$ and $\bar{X}^s$) are given by:

$$\bar{X}^n = \frac{N}{b^+}\bar{b}^n = \frac{N}{b^+}\frac{\bar{p}}{(\bar{e}^n)^\gamma} \leq \frac{N}{b^+}\frac{\bar{p}}{(\bar{e}^s)^\gamma} = \bar{X}^s. \tag{3}$$

whenever $(\bar{e}^n)^\gamma \geq (\bar{e}^s)^\gamma$. Thus, international asymmetry in environmental regulations $\bar{e}^n$ has a direct, and negative bearing on the comparative advantage of the North, at constant world price $\bar{p}$.

3.2 Consumption Decision under Imperfect Information

Let $\bar{d}_x^i = \sum_{e \in E^i} d_x^i(e)$ be the total physical units of x consumed. With imperfectly informed consumers, the (inverse) demand $\bar{p}$ of good x depends only on quantity consumed in physical units, with

[6]Clearly, with a uniform price,

$$\bar{p} - (e)^\gamma b < \bar{p} - (\bar{e}^i)^\gamma b$$

whenever $e > \bar{e}^i$. As should be expected, voluntary supply of green production e^i is impossible in the absence of price incentives.

$$\bar{p} = \alpha W^i / \bar{d}_x^i, \tag{4}$$

where W^i is the amount of disposable income available to consumers in country i. Clearly, if $\bar{e}^n > \bar{e}^s$, consumption demand fail to reward Northern producers who undertake eco-friendly production methods since *the marginal rate of substitution between* $d_x^i(\bar{e}^n)$ *and* $d_x^i(\bar{e}^s)$ *exceeds the relative market price of goods produced via eco-friendly, and eco-unfriendly means* if and only if $1 = (\bar{p}/\bar{p}) < \bar{e}^n/\bar{e}^s$.

Also denote $\lambda^i(e) = d_x^i(e)/\bar{d}_x^i$ as the fraction of x consumed in country i that is produced via production technique e. Since the South is a net exporter, we have, $\lambda^s(\bar{e}^s) = 1$, as domestic output (with standard $\bar{e}^s$ is more than sufficient to satisfy domestic demand. Meanwhile, $\lambda^n(\bar{e}^s) > 0$ and $\lambda^n(\bar{e}^n) > 0$ as the North imports strictly positive amounts from the South. The shadow price of Southern output ($\bar{e}^s\pi^i$) in country i can therefore be expressed as[7]

$$\begin{aligned} \frac{\partial U^i/\partial d_x^i(\bar{e}^s)}{\partial U/\partial d_y^i} &= \bar{e}^s U_{D_x}^i/U_y^i \\ &\equiv \bar{e}^s \pi^i = \frac{\bar{e}^s \bar{p}}{\lambda^i(\bar{e}^n)(\bar{e}^n - \bar{e}^s) + \bar{e}^s} \leq \bar{p}. \end{aligned} \tag{5}$$

whenever $\lambda^i(\bar{e}^n)(\bar{e}^n - \bar{e}^s) \geq 0$. Thus, in the exporting South, where $\lambda^s(\bar{e}^n) = 0$, the shadow price of Southern output is exactly equal to $\bar{p}$. Meanwhile, in the importing North, with $\lambda^n(\bar{e}^n) > 0$, $\bar{p}$ *overstates the shadow value of Southern outputs* in the presence of incomplete consumer information whenever $\bar{e}^n > \bar{e}^s$.

Similarly, the shadow price of Northern output is given by $(U_{D_x}^i/U_y^i)\bar{e}^n = \pi^i\bar{e}^n$. As such,

$$\bar{p} - \pi^i \bar{e}^n = \bar{p} - \frac{\bar{e}^n \bar{p}}{\lambda(\bar{e}^n)(\bar{e}^n - \bar{e}^s) + \bar{e}^s}$$

[7] To see this, note that

$$\begin{aligned} \frac{\partial U^i/\partial d_x^i(\bar{e}^s)}{\partial U^i/\partial d_y^i} &= \bar{e}^s U_{D_x}^i/U_y^i \equiv \bar{e}^s \pi^i \\ &= \bar{e}^s \frac{\alpha/D_x^i}{(1-\alpha)/d_y^i} = \bar{e}^s \frac{\bar{p}\bar{d}_x^i/d_y^i}{D_x^i/d_y^i} \\ &= \bar{e}^s \frac{\bar{p}}{\lambda^i(\bar{e}^n)(\bar{e}^n - \bar{e}^s) + \bar{e}^s} \end{aligned}$$

where the second equality follows since α and $1-\alpha$ are respectively the consumer's expenditure share on x and y, and the third equality follows from the definition of $\lambda^i(e)$.

$$= \quad \bar{p}\frac{(\lambda^i(\bar{e}^n)-1)(\bar{e}^n-\bar{e}^s)}{\lambda(\bar{e}^n)(\bar{e}^n-\bar{e}^s)+\bar{e}^s} \leq 0 \tag{6}$$

as long as $\bar{e}^n > \bar{e}^s$ and $(1-\lambda^i(\bar{e}^n)) > 0$. Thus, $\bar{p}$ *understates the shadow value of Northern outputs.*

Proposition 1 summarizes these observations, by accouting for producer incentives as summarized in equation (3), together with the relationship between shadow and market price as in equations (4) - (6),

Proposition 1 *With information asymmetry, and* $\bar{e}^n > \bar{e}^s$*:*

$$\bar{b}^n(\bar{e}^n)^\gamma = \bar{p} < \bar{e}^n\pi^n = \frac{\partial U^n/\partial d^n_x(\bar{e}^n)}{\partial U^n/\partial d^n_y}; \;\; \bar{b}^s(\bar{e}^s)^\gamma = \bar{p} > \bar{e}^s\pi^n = \frac{\partial U^n/\partial d^n_x(\bar{e}^s)}{\partial U^n/\partial d^n_y}.$$

In addition,

$$\bar{b}^s(\bar{e}^s)^\gamma = \bar{p} = \bar{e}^s\pi^s = \frac{\partial U^s/\partial d^s_x(\bar{e}^s)}{\partial U^s/\partial d^s_y}.$$

Proposition 1 highlights the potential for conflict of interests between the North and the South in environmental regulatory debate when consumer information is imperfect, and when existing environmental standards in the two countries differ. Specifically, Northern producers who are bound by stricter environmental standards receive a price that is strictly less than the shadow value that Northern consumers attach to their products ($\bar{p} < \pi^n\bar{e}^n$). In addition, Northern consumers pay a price that is strictly higher then their shadow value of Southern exports ($\bar{p} > \bar{e}^s\pi^n$).

For precisely these reasons, the absence of eco-labeling has a *pro-trade bias*, in the sense that the unit cost of production incurred by the marginal producer in the North $\bar{b}^n(\bar{e}^n)^\gamma$ is strictly less than the shadow value that Northern consumers attach to Northern outputs. In contrast, the marginal cost of production incurred by the Southern marginal producer $\bar{b}^s(\bar{e}^s)^\gamma$ is strictly higher than Northern consumers' shadow valuation. In the context of our discussion regarding the entry and exit decisions of producers, where the marginal producer is given by $b^i_1 = \bar{p}$, Proposition 1 thus implies that there is an excessive number of Northern producers exiting from the industry once international trade opens up, and too many Southern producers operate at costs above shadow value.

3.3 Market Access and Information Asymmetry

To confirm the role of information asymmetry on market access when environmental standards in the two countries differ, note that market access can be determined in general equilibrium by accounting for product market clearance between the North and the South. Specifically,

$$\frac{\alpha(W^n + W^s)}{\bar{p}} \quad = \quad (\bar{X^n} + \bar{X}^s) = \frac{N}{b^+}\frac{\bar{p}}{(\bar{e}^n)^\gamma} + \frac{N}{b^+}\frac{\bar{p}}{(\bar{e}^s)^\gamma}$$

We assume, in addition, that monitoring environmental standard is costly. Thus, let $M(e)$ be the cost, in units of the numeraire, required to establish and monitor standard e. $M(e)$ is assumed to be strictly increasing and convex in the level of labeling standard to be adopted e, with $M(1) = M'(1) = 0$. Thus, gross disposable income in country i is given by $W^i = \bar{p}\bar{X}^i + y^i$, with

$$y^i = \mathcal{L}^i - \frac{N}{b^+}\int_0^{\bar{b}^i}(\bar{e}^i)^\gamma bdb - M(\bar{e}^i) = \mathcal{L}^i - \frac{N}{2b^+}\frac{\bar{p}^2}{(\bar{e}^i)^\gamma} - M(\bar{e}^i), \tag{7}$$

where the second equality follows from equation (3). The cost of monitoring $M(\bar{e}^i)$ is borne by the government in country i, and a lump sum tax of the amount $M(\bar{e}^i)$ on consumers and producers balances the government budget constraint.

The uniform market price $\bar{p}$, as given by product and input market clearance (equations (7) and (8)), thus solves

$$\bar{p} = \frac{\alpha}{1-\frac{\alpha}{2}}\sum_{i=n,s}(\mathcal{L}^i - M(\bar{e}^i))\left(\frac{N}{b^+}\frac{\bar{p}}{(\bar{e}^n)^\gamma} + \frac{N}{b^+}\frac{\bar{p}}{(\bar{e}^s)^\gamma}\right)^{-1}. \tag{8}$$

Let the market share of the South $\bar{s}_p^s$ be given by

$$\bar{s}_p^s(\bar{e}^n, \bar{e}^s) = \frac{\bar{X}^s}{\bar{X}^n + \bar{X}^s} = 1 - \bar{s}_p^n(\bar{e}^n, \bar{e}^s). \tag{9}$$

It can be readily verified that the volume of trade between the North and the South (in units of the numeraire) can be expressed as:

$$\bar{p}\bar{X}^s - \alpha W^s \quad = \quad \alpha(\bar{s}_p^s - \beta^s)\mathcal{L} + \alpha[\bar{s}_p^n M(\bar{e}^s) - \bar{s}_p^s M(\bar{e}^n)]. \tag{10}$$

Thus, when both countries adopt the baseline eco-unfriendly production standard, with $\bar{e}^n = \bar{e}^s = 1$, a necessary and sufficient condition for the South to be a net exporter is that

Southern producer market share $\bar{s}^s_p$ is greater than Southern share of consumption income derived from resource ownership β^s. Clearly, the volume of trade is increasing in the producer market share of the South, and decreasing in her consumption income share β^s. Finally, since output in country i is strictly decreasing in $\bar{e}^i$, we have the following result:

Proposition 2 *1. In the presence of information asymmetry, raising environmental standard in the North (South) always increases (decreases) the volume of trade if the marginal cost of monitoring $M'(\bar{e}^i)$ is sufficiently small.*

2. Under the same condition, the uniform market price $\bar{p}$ is increasing in environmental standard $\bar{e}^i$, $i = n, s$.

Proof: See Appendix A.

Since an increase in $\bar{e}^n$ (i) increases Southern market share, and (ii) decreases total Northern disposable income as the cost of monitoring increases, strict environmental standard in the North unambiguously increases the volume of North-South trade whenever the market share effect dominates. It can be readily shown that so long as β^n is greater than β^s, a higher product standard in the North relative to the South is not only intuitively plausible, but can in fact be the outcome of unilateral welfare maximization of the two countries.[8]

Summarizing our observations so far, stricter environmental standards in the North with information asymmetry drives a wedge between shadow valuation of green consumption and the uniform market price (Proposition 1). Thus, the subsequent failure on the part of producers to equate unit cost to shadow valuations implies that even though consumers are environmentally conscious, raising environmental standards in the North can only *increase* the total volume of eco-unfriendly imports from the South! Indeed, Propositions 1 and 2 combined imply that that raising environmental standards in the North encourages entry of Southern producers, as $\bar{b}^s = \bar{p}$ is strictly increasing in $\bar{e}^n$, but induces exit of Northern producers. For consumers, higher environmental standards come at the cost of a higher price $\bar{p}$. We turn next to examine the role of eco-labeling in determining the market access consequences of environmental standards.

[8]A more detailed proof of this relegated to Appendix A.

4 Trade with Eco-labeling

4.1 Production Incentives and Standards with Eco-labeling

Consider now the incentives to adopt high environment standards in the presence of eco-labeling. Producers solve a simple two-stage problem, involving the decision of (i) whether to remain in or exit the industry and (ii) whether to voluntarily adopt the environmentally sound technology $e^I > 1$ or the eco-unfriendly technique $e = 1$. We begin with the second stage problem.

Let $p(e)$ denote the label-specific price of output produced using production techniques e, a producer in country i strictly benefits from voluntarily adopting the clean technology $e^i > 1$ if and only if[9]

$$p(e^i) - (e^i)^\gamma b \geq p(1) - b \Leftrightarrow b \leq \frac{p(e^i) - p(1)}{(e^i)^\gamma - 1} \equiv b_e^i. \tag{11}$$

b_e^i thus singles out the marginal producer who is just indifferent between adopting the eco-friendly labeling standard, or the eco-unfriendly technology. Note that $b_e^i((e^i)^\gamma - 1)$ measures the additional resource cost of producing one more unit of $x^i(e)$ by the marginal producer, while $p(e^i) - p(1)$ represents the marginal revenue gains from doing so. Clearly, as long as $p(e^i) > p(1)$, relatively low cost producers (with relative low unit cost b) are favorably selected in the set of eco-friendly producers[10].

Equation (11) yields the supply schedule of *voluntary* green-production $X_e^i = b_e^i N/b^+$, with $X_e^i \geq 0$ if and only if $p(e^i) - p(1) \geq 0$. Turning now to the first stage, note that producers who adopt the status quo technology makes positive profits if and only if

$$b \leq p(1) \equiv b_1^i. \tag{12}$$

b_1^i thus represents the cost parameter of the marginal producer who is just indifferent between producing positive output or exiting the industry. It follows from the definitions of b_e^i and b_1^i

[9] The commitment to improve environmental standard is backed by third party monitoring, the cost of which is paid for by government sponsorship.

[10] This is in accordance with studies that demonstrate a bias in the cost of meeting environmental standards against small and medium sized enterprises (WTO-CTE, July 1996).

that the supply of good x produced via the baseline eco-unfriendly technology X_1^i is given by $\frac{(b_1^i - b_e^i)N}{b^+}$[11].

Thus, international trade in the presence of eco-labeling yields production levels that are given once label specific prices $p(e^i)$ and $p(1)$ are determined. We now turn to examine how consumer valuation of environmental standards impact market prices $p(e^i)$ and $p(1)$.

4.2 Consumer Decision under Eco-labeling

In the presence of credible third party monitoring, labeled (unlabeled) products originating from country i are synonymous with products that are made via production technology $e = e^i$ ($e = 1$). Meanwhile, international arbitrage implies that the price of like products are equalized across the two countries. It follows, therefore, that consumers maximize utility by consuming positive quantities of goods with the lowest cost per unit green consumption. In other words, demand is positive for both labeled and unlabeled products, originating from the North and the South if and only if

$$\frac{p(e^n)}{e^n} = \frac{p(e^s)}{e^s} = p(1). \tag{13}$$

In addition, shadow price of the eco-friendly Southern output in country i, $e^s \pi^i$ ($i = n, s$), is given by

$$\begin{aligned} e^s \pi^i &= \frac{\partial U^i / \partial d_x^i(e^s)}{\partial U^i / \partial d_y^i} = e^s \frac{\alpha / D_x^i}{(1-\alpha)/d_y^i} \\ &= e^s \frac{\sum_{e \in E^i} p(e) d_x^i(e) / D_x^i}{d_y^i / d_y^i} = \frac{p(e^s) \sum_{e \in E^i} e d_x^i(e) / D_x^i}{d_y^i / d_y^i} = p(e^s). \end{aligned} \tag{14}$$

where the last equality follows from equation (qe) above, and $\sum_{e \in E^i} e d_x^i(e) = D_x^i$. Thus, international trade in x guarantees that

$$e^s \pi^n = p(e^s) = e^s \pi^s, \tag{15}$$

[11]Note that $b_e^i \leq b_1^i$, since $(e^i - 1)/((e^i)^\gamma - 1) < 1$. Thus, producers who voluntarily adopt the eco-friendly technology also makes positive profits since for producers with $b \leq b_e^i$,

$$p(e^i) - (e^i)^\gamma b \geq p(1) - b \geq p(1) - b_1^i = 0.$$

and *eco-labeling in the presence of free trade implies that the shadow price of Southern output in the two countries are equal.* Similar reasoning yields:

$$e^n \pi^n = p(e^n) = e^n \pi^s, \tag{16}$$

and *international trade with eco-labeling equalizes the shadow price of eco-friendly Northern output in the two countries.* Finally, the price of the eco-unfriendly output produced in either country, is derived by substituting $e^i = 1$ in equations (15) and (16) above. Specifically,

$$\pi^i = p(1). \tag{17}$$

Thus, the shadow price of a unit of green consumption (π) is given exactly by $p(1)$. Taken together, these observations imply that consumers pay a label-specific green premium,

$$\frac{\pi^n e^i - \pi^n}{\pi^n} = \frac{p(e^i) - p(1)}{p(1)} = e^i - 1 = \frac{\pi^s e^i - \pi^s}{\pi^s}, \quad i = n, s.$$

It follows, therefore, that *the marginal rate of substitution between outputs produced in the two countries (e^n/e^s) is equal to the corresponding relative market price $p(e^n)/p(e^s) = e^n/e^s$.* In addition, *the shadow price of both Southern and Northern outputs in the two countries relative to the homogeneous numeraire is equal to their respective relative market prices,* since $\pi^i e = p(e), \quad e = \{e^s, e^n, 1\}$, in countries $i = n, s$. Further, making use of the producer responses in the presence of eco-labeling (equations (11) and (12)), we have,

Proposition 3 *With eco-labeling,*

$$p(1) = \pi^i = b_1^i, \quad i = n, s.$$

In addition,

$$p(e^i) - p(1) = p(1)(e^i - 1) = b_e^i((e^i)^\gamma - 1), \quad i = n, s.$$

Thus, eco-labeling gives rise to entry and exit decisions that are based on consumers' marginal valuation of eco-unfriendly production methods. In addition, the marginal resource costs required to produce eco-friendly products in the two countries are equated to their corresponding green premia.

4.3 Market Access and Eco-labeling

To determine the price of eco-unfriendly products in general equilibrium, note that product market clearance requires that total consumption expenditure on x is equal to aggregate producer revenue, thus:

$$\alpha(W^n + W^s) = \sum_{i=n,s} p(e^i)X_e^i + p(1)X_1^i = p(1)\sum_{i=n,s}(X_e^i e^i + X_1^i) \equiv p(1)\sum_{i=n,s} X^i \qquad (18)$$

where the third equality follows as consumers equate the marginal rate of substitution between $d_x^i(e^i)$ and $d_x^i(1)$ with the relative market price $p(e^i)/p(1)$. In addition, X^i denotes country i's effective green output, where

$$X^i \equiv X_e^i e^i + X_1^i = p(1)\frac{N}{b^+}\left(\frac{(e^i-1)^2}{(e^i)^\gamma - 1} + 1\right) \qquad (19)$$

where the second equality follows from the equations (11) and (12). We thus have,

Lemma 1 *In the presence of eco-labeling, effective green output in country i (X^i) is strictly increasing in e^i, $i = n, s$ if $\gamma < 2$.*

Proof: See Appendix B.

The intuition of the above result is straightforward. Recall from the definition of X^i (equation (11)) that an increase in e^i has the direct effect of raising the environmental standard per unit labeled output. Meanwhile, an increase in e^i also raises the cost of production, and induces eco-friendly producers to adopt eco-unfriendly production methods (an increase in X_1^i, but a reduction in X_e^i). It follows that the former effect dominates whenever γ is sufficiently small.

In the sequel, we will assume throughout that the condition on γ in lemma 1 is satisfied, so that total effective green production is increasing in e^i. Indeed, we show in section 4.2 that unless this is the case, raising voluntary labeling standard can never benefit environmentally conscious consumers.

Note that gross disposable income in country i is given by

$$W^i = p(e^i)X_e^i + p(1)X_1^i + y^i = p(1)X^i + y^i,$$

where

$$
\begin{aligned}
y^i &= \beta^i \mathcal{L} - \frac{N}{b^+}\left(\int_0^{b_e^i} (e^i)^\gamma b db + \int_{b_e^i}^{b_1^i} b db\right) - M(e^i) \\
&= \beta^i \mathcal{L} - \frac{N}{b^+}\left(\frac{\bar{p}^2}{2}(\frac{(e^i-1)^2}{(e^i)^\gamma - 1} + 1)\right) - M(e^i), \qquad (20)
\end{aligned}
$$

where the second equality follows from equations (11) and (12). Making use of the definition of X^i, and upon rearranging terms, the shadow price of green consumption $\pi = p(1)$ in general equilibrium is given by:

$$
p(1) = \frac{\alpha}{1-\frac{\alpha}{2}} \frac{\sum_{i=n,s}(\mathcal{L}^i - M(e^i))}{X^n + X^s}. \qquad (21)
$$

Thus, the price of eco-unfriendly products, p(1), is inversely related to total effective green output in the two countries $X^n + X^s$.

Market access in general equilibrium can now be obtained by noting first that the market share of the South s_p^s given by

$$
s_p^s(e^s, e^n) = \frac{X^s}{X^n + X^s} = 1 - s_p^n(e^s, e^n),
$$

while Southern revenue in excess of consumption expenditure is expressed as:

$$
\begin{aligned}
p(e^s)X_e^s + p(1)X_1^s - \alpha W^s &= p(1)(X_e^s e^s + X_1^s) - \alpha W^s \\
&= p(1)X^s - \alpha W^s \\
&= \alpha(s_p^s - \beta^s)\mathcal{L} + \alpha[s_p^n M(e^s) - s_p^s M(e^n)]. \qquad (22)
\end{aligned}
$$

Therefore, key to the determination of market access is once again the Southern market share. Since effective green output X^i, and hence s_p^i, is increasing in the voluntary labeling standard e^i, we have,

Proposition 4 1. *In the presence of eco-labeling, raising voluntary labeling standard in the North (South) always decreases (increases) the volume of trade if the marginal cost of monitoring $M'(e^i)$ is not too high.*

2. *Under the same condition, the price of eco-unfriendly products is strictly decreasing in e^i, $i = n, s$.*

Proof: See Appendix B.

To see this, note from lemma 1 that stricter voluntary labeling standards in the North increases the aggregate supply of effective green production. Thus, raising labeling standards in the North drives a wedge between the market price of eco-friendly Northern products and eco-unfriendly Southern imports via the green premium. The result is a tariff-like outcome, wherein the terms of trade of the South $p(1)$ decreases with e^n. Meanwhile, the volume of trade also declines, as higher labeling standard shifts the market share (s_p^i) in favor of the North. Thus, part (ii) of Proposition 4 shows that raising labeling standards in the North induces *exit* of eco-unfriendly producers in both the North and the South, as $b_1^i = p(1)$ is decreasing in e^n.

A natural question that arises, however, is that since consumers' relative preference for eco-friendly products is already reflected in the green premium, how may consumer welfare vary when the voluntary labeling standard rise even further in either country? To this end, part (ii) of Proposition 4 provides the basis for a consumer welfare gain upon an increase in e^i, even after the increase in the green premium is accounted for. Indeed, since the price premium attached to eco-friendly products is given by

$$\frac{p(e^n)}{e^n} = \frac{p(e^s)}{e^s} = p(1),$$

it must be the case the price that consumers pay per unit green consumption, $\frac{p(e^n)}{e^n} = \frac{p(e^s)}{e^s} = p(1)$, is also strictly decreasing in e^i; $i = n, s$, since $p(1)$ is strictly decreasing in e^i from Proposition 4.[12]

5 How green should the labels be?

We have shown that stricter labeling standard in the North can behave in a manner similar to an import barrier, and lowers the trade volume while worsening the Southern terms of trade. What remains to be shown, therefore, is whether the incentives are indeed *right* for the two countries to select asymmetric environmental standards that give rise to a de facto import barrier in the presence of eco-labeling. To this end, we proceed to endogenize the

[12]Specifically, the indirect utility function of resource owners in country i is given by $V_c^i = \beta^i \mathcal{L}/p(1)^\alpha$. Proposition 4 thus implies that V_c^i is strictly increasing in e^i.

choice of standards in the North and the South. This is done by examining the nature of Nash competition between the two countries in their choice of labeling standards and comparing this result to the Pareto-Optimal benchmark. To make the strategic use of standards in the market share rivalry of the two countries as transparent as possible, we focus on North-South interaction based on differences in resource endowment (β^i).

5.1 The Pareto Optimal Benchmark

We now turn to a comparison of the equilibrium provision of eco-friendly products illustrated above, with the Pareto Optimal benchmark. In particular, consider a planner's problem, involving the maximization of the welfare of country i, $U(D_x^i, d_y^i)$, by choice of a pair of eco-friendly standards e_{PO}^n, e_{PO}^s for countries n and s, a pair of producer allocations $\{\tilde{b}_e^i, \tilde{b}_1^i\}$ for country i, as well as the consumption allocations $\{\tilde{d}_x^i(e_{PO}^n), \tilde{d}_x^i(e_{PO}^s), \tilde{d}_x^i(1), \tilde{d}_y^i)\}$ in the two countries, subject to:

$$U(D_x^j, d_y^j) \geq \bar{U}^j,$$

and the material balance restriction in equation (18). In addition, consumption allocations in the two countries are subject to production constraints, with

$$\begin{aligned} \tilde{d}_y^n + \tilde{d}_y^s &\leq y^n + y^s, \\ \tilde{d}_x^n(e^i) + \tilde{d}_x^s(e^i) &\leq \tilde{X}_e^i, i = n, s, \\ \tilde{d}_x^n(1) + \tilde{d}_x^s(1) &\leq \sum_{i=n,s} \tilde{X}_1^i. \end{aligned}$$

We have the following result:[13]

Proposition 5 *Pareto Optimal allocation of resources and consumption in the two countries, $i = n, s$ satisfy:*

$$\tilde{\pi}^n e_{PO}^i = \tilde{\pi} e_{PO}^i = \tilde{\pi}^s e_{PO}^i; \tag{23}$$

$$\tilde{\pi} = \tilde{b}_1^i; \tag{24}$$

$$\tilde{\pi}(e_{PO}^i - 1) = \tilde{b}_e^i((e_{PO}^i)^\gamma - 1); \tag{25}$$

$$\tilde{\pi}\tilde{X}_e^i = \frac{N}{b^+}\int_{b^-}^{\tilde{b}_e^i} b\gamma(e_{PO}^i)^{\gamma-1}db - M'(e_{PO}^i). \tag{26}$$

[13]See Appendix for details.

where $\pi^i = U^i_{D_x}/U^i_y$ denotes the shadow price of effective green consumption in country i.

Proof: See Appendix B.

As should be expected, Pareto Optimality requires that consumers in both countries attach the same shadow price to eco-friendly products originating from the North, and also to eco-friendly products originating from the South (equation (23)). But this is exactly what would be the case under eco-labeling (equations (13) - (15)). The next two conditions (equations (24) and (25)) require that the marginal eco-unfriendly producer equate his unit cost of production to the shadow price $\tilde{\pi}$, and the marginal eco-friendly producer to equate the green premium to the increment in unit production costs. Again, this corresponds to the market response to eco-labeling as Proposition 2 illustrates. We have,

Corollary 1 *If the choice of voluntary eco-labeling standards in the North and the South coincides with $\{e^n_{PO}, e^s_{PO}\}$, the allocation of productive resources and consumption across countries is Pareto Optimal.*

What remains to be shown, therefore, is whether the pair of Pareto Optimal standards can be achieved under eco-labeling. Specifically, equation (26) requires that environmental standards be set such that the shadow value of an increase in e^i, $\tilde{\pi}\tilde{X}^i_e$, be equal to the marginal resource and monitoring costs of doing so $(N/b^+)\int_0^{\tilde{b}^i_e} \gamma(e^i_{PO})^{\gamma-1} bdb - M'(e^i_{PO})$ in country i.

Thus, equation (18) shows that income asymmetries between the North and the South alone is not sufficient to justify North-South asymmetries in labeling standards, in fact,

Corollary 2 *If resource endowment β^i constitute the only difference between the North and the South, Pareto Optimality prescribes a pair of harmonized standards, $e^n_{PO} = e^s_{PO}$.*

Corrollary 2 is of interest for two reasons. First, since the common shadow value of effective green consumption in the two countries is given by π when free trade and eco-labeling prevail, Pareto Optimality requires that both countries adopt the same labeling standard provided that consumer income is the only difference between the North and the South. Second, Corollary 2 also singles out the informational role of eco-labeling, when labeling standards are *not* manipulated in the name of market share rivalry between the two countries, and green consumerism does not impinge on Southern comparative advantage simply because there exist international differences in costs of complying to higher environmental standards that unambiguously favor the North. Specifically, note that if $e^n_{PO} = e^s_{PO}$, and $\beta^n > \beta^s$ constitutes the only difference between the North and the South, the volume of trade between the two countries is given, via equation (22), by:

$$
\begin{aligned}
& \alpha(s^s_p(e^s_{PO}, e^n_{PO}) - \beta^s)\mathcal{L} + \alpha[s^n_p(e^s_{PO}, e^n_{PO})M(e^s_{PO}) - s^s_p(e^s_{PO}, e^n_{PO})M(e^n_{PO})] \\
= \; & \alpha(s^s_p(1,1) - \beta^s)\mathcal{L} + \alpha[s^n_p(1,1) - s^s_p(1,1)]M(e^n_{PO}) \\
= \; & \alpha(s^s_p(1,1) - \beta^s)\mathcal{L}
\end{aligned}
$$

where the second equality follows from the pair of common labeling standards $e^n_{PO} = e^s_{PO}$, and since $s^s_p(e^s_{PO}, e^n_{PO}) = s^n_p(e^s_{PO}, e^n_{PO}) = s^s_p(1,1) = s^n_p(1,1)$ whenever $e^n = e^s$. Thus, the higher environmental standard made possible by eco-labeling alone yields exactly the same volume of trade as would be the case when both countries adopt the baseline eco-unfriendly production process.

5.2 Non-cooperative Labeling Standards

We now return to a non-cooperative setting, and compare the Pareto Optimal labeling standards to the Nash equilibrium outcome when the two countries compete in choosing the intensities of the voluntary environmental standards to be certified by eco-labels. International trade summarized by equations (11) - (22) above determine payoffs to consumers and producers in the two countries. The objective function of country i is given by the indirect utility function[14]:

$$V^i(e^s, e^n) = \kappa \frac{W^i}{(p(1))^\alpha}, \tag{27}$$

[14] V^i is just the sum of the indirect utility functions of producers in the two sectors, along with resource input owners in country i, deflated by a (shadow) price index π^α. To see this, note that since α is the share of consumer income on x, we have,

$$\alpha W^i = \sum_{e \in E^i} p(e) d^i_x(e) = \sum_{e \in E^i} p(1) d^i_x(e) e.$$

It follows that $D^i_x = \sum_{e \in E^i} d^i_x(e) e = \alpha W^i / p(1)$. In addition, $d^i_y = (1-\alpha)W^i$ as consumers devote $1-\alpha$ fraction of their income on y. Equation (33) thus follows from by substituting D^i_x and d^i_y into the utility function.

where $\kappa = \alpha^\alpha(1-\alpha)^{1-\alpha}$ and W^i, to recall, denotes gross national product. Taking as given the Nash equilibrium labeling standard of country j, e^j_{NE}, country i maximizes national welfare by setting e^i, with[15]

$$\frac{dV^i(e^s,e^n)}{de^i} \geq 0$$

$$\Leftrightarrow p(1)X^i_e - \frac{N}{b^+}\int_0^{b^i_e} b\gamma(e^i_{NE})^{\gamma-1}bdb - M'(e^i_{NE}) + (X^i - \frac{\alpha W^i}{p(1)})\frac{\partial p(1)}{\partial e^i} \geq 0 \tag{28}$$

Thus, the welfare consequences of an increase in Southern labeling standard is composed of three distinct effects. First, an increase in e^s raises producer revenue by $p(1)X^i_e$ in the presence of labeling. Such gains in producer revenues are achieved at an additional resource cost of $\int_0^{b^i_e}\frac{b\gamma(e^i)^{\gamma-1}}{b^+}db$, along with an additional monitoring expense $M'(e^i_{NE})$. Of course, up till here, Southern government's evaluation of the net marginal benefits of raising e^i is exactly the same as that of the Pareto Optimal outcome, precisely since the market price $p(1)$ correctly measures the shadow value of green consumption π.

Where non-cooperative behavior and Pareto Optimality differs turns out to be a terms of trade effect $(X^i - \alpha W^i/p(1))(\partial p(1)/\partial e^i)$. In particular, since $p(1)$ is strictly decreasing in e^i from Proposition 2, the terms of trade effect is strictly negative (positive) if and only if $X^i > (\leq)\frac{\alpha W^i}{p(1)}$, or equivalently, if and only if country i is a net exporter (importer). In particular, from equation (21), we have

$$\frac{\partial p(1)}{\partial e^i} = \frac{p(1)}{2(X^s+X^n)}\frac{\partial X^i}{\partial e^i} > 0.$$

Making use of the definition of b^i_e and X^i_e and rearranging terms, we have,

$$\frac{\partial V^i(e^s,e^n)}{\partial e^i} \geq 0 \quad\Leftrightarrow\quad (1+s^i_p - s^i_c)\frac{\partial X^i}{\partial e^i} - (1+\frac{\alpha/2}{1-\alpha/2}(s^i_p - s^i_c))M'(e^i) \geq 0 \tag{29}$$

where $s^i_c \equiv W^i/(W^s+W^n)$ denotes the share of country i's consumption expenditure.

[15]See the Appendix for a proof of these results.

As asserted in the discussion of lemma 1 above, therefore, a necessary condition for country i; $i = n, s$ to set voluntary labeling standard e^i that strictly exceeds the baseline eco-unfriendly level, is that total effective green outut X^i in country i is increases with e^i.

Furthermore, equations (20) and (21) reveal that the terms of trade effect constitutes the sole source of conflict of interest between the importing North and the exporting South, and guides the two countries to deviate from the Pareto Optimal of labeling standards in opposite directions. In sum, we have

Proposition 6 *With eco-labeling,*

1. $e^s_{NE} > 1$ *and* $e^n_{NE} > 1$.

2. *The exporting South underestimates, while the importing North overestimates the benefits of raising voluntary labeling standard relative to the Pareto Optimal benchmark , with*

$$\frac{\partial V^n(e^s, e^n)}{\partial e^s}|_{e^i=e^i_{NE}} \geq 0, \tag{30}$$

$$\frac{\partial V^s(e^n, e^s)}{\partial e^n}|_{e^i=e^i_{NE}} \leq 0. \tag{31}$$

Thus, Nash equilibrium labeling standards constitute neither a race to the bottom, nor a race to the top, in the sense that the strategic incentives guiding the two countries in a Nash equilibrium are diametrically opposite to each other.

More importantly, these strategic incentives imply *an important reason as to why eco-labeling has perverse volume of trade consequences.* In particular, high voluntary labeling standards in the North shifts the relative producer market share in favor of the North, while *low* labeling standards in the South simply reinforces the market share shifting consequences of strategic interaction between the two countries. This implies, from Proposition 6, that uncoordinated competition in labeling standards yields an equilibrium trade volume that is strictly less than the Pareto Optimal benchmark.

6 An Example

As an illustration, we present in Table 2 the result of a numerical simulation based on equations (1), (2) and (11) - (22) of the model. The results show the relationship between the Nash equilibrium choice of labeling standards and the Pareto Optimal when income asymmetry is the only source of comparative advantage between the North and the South.[16] Our choice of parameter values essentially normalize the status-quo world price $p(1)$ to unity when both countries adopt eco-unfriendly production methods. The simulation results show that:

Labeling Standards: In the Pareto Optimal benchmark, the joint welfare of the two countries requires both countries to employ the same labeling standard (Corollary 2). This is in contrast to the Nash Equilibrium outcome with eco-labeling, wherein $e^s_{NE}(= 1.35) < e^n_{NE}(= 1.508)$ (Proposition 6).

Price Effects: Focussing on equilibrium labeling standards under Nash competition, note that with both the North and the South raising green production relative to the status quo, the price of eco-unfriendly products decreases (Proposition 4). Meanwhile, the price of labeled products originating from both the North and the South increases via the label-specific green premia.

Producer Profits and Market Shares: Since $e^n_{NE} > e^s_{NE}$ in the Nash equilibrium, aggregate producer profits increase in the North, and decrease in the South relative to the status quo. The result obtains even though the North has no inherent advantage in producing green output, and North-South difference in *consumer income* constitutes the only source of comparative advantage. Meanwhile, in the Pareto Optimal benchmark, symmetric labeling standards implies that the market shares of producers in the two countries do not change. However, the increase in production costs induces exit and lowers aggregate profits in both countries relative to the status quo.

[16]We take the following parameters characterizing the North and the South as given: $\gamma = 1.2$ and satisfies the conditions given in lemma 1. In addition, $N/b^+ = 1$ and the cost of monitoring is given by $.5(e-1)^3$. The consumption share α is 0.2.

National Welfare: In terms of national welfare, the simulation results show that the South unambiguously loses while the North is strictly better off if terms of trade gains can be achieved via an all out competition in labeling standards relative to the status-quo (Propositions 5 and 6).

Figure 1 illustrates these results by explicitly plotting best-response and iso-welfare functions as given by equations (30) and (31). The efficient choice of labeling standards (equation (26)) based on the Pareto Optimal benchmark are illustrated by the pair of solid lines while the pair of dotted lines are the best-response functions. The family of inverted U-shaped iso-welfare contours in dotted lines correspond to the welfare of the South successively when the pair of labeling standards are given by $(1, 1)$, (e^s_{PO}, e^n_{PO}), and (e^s_{NE}, e^n_{NE}). Note that the South is better off whenever the North lowers labeling standards. Hence, downward shifts of the iso-welfare contours indicate an increase in Southern welfare. Meanwhile, the second family of iso-welfare contours in solid lines depicts the welfare of the North successively when the pair of labeling standards are given by (e^s_{PO}, e^n_{PO}), and (e^s_{NE}, e^n_{NE}). As should be apparent, the two countries are jointly better off choosing the pair of Pareto Optimal labeling standards relative to the Nash equilibrium benchmark, although the South is better off still if both countries adopt the status-quo eco-unfriendly production methods (with $e^s = 1, e^n = 1$), as the Southern iso-welfare contour evaluated at the Pareto Optimal labeling standards lies above the point $e^s = e^n = 1$.

Volume of Trade: Table 2 also reports the trade volume consequences of Nash competition in environmental standards between the two countries with eco-labeling. Note that the volume of trade falls in the presence of eco-labeling compared to the status quo, as the asymmetric Nash labeling standards shift producer market share in favor of the North, and unambiguously lower the volume of trade. These results reiterate our conclusion in Propositions 2, and show that the perverse market access implications of eco-labeling based on North-South market share rivalry is indeed a Nash equilibrium outcome. In comparison to the Pareto Optimal benchmark, what is notable is that a deterioration in market access from the status quo is indeed not an inevitable consequence of eco-labeling. Indeed, trade volume remains strictly unaffected when the two countries choose labeling standards that maximize their joint welfare.

7 Conclusion

This paper examined has the nature of Nash competition between importing and exporting countries in the choice of environment related product labeling standard. We find that the absence of eco-labeling has a pro-trade bias, whenever high income importing countries use higher product standards. In this context, the first round trade volume impact of eco-labeling should more appropriately be viewed as a corrective device, which remedies consumer information imperfection.

By explicitly taking product labeling standards as endogenously determined by Nash competition between the two countries, however, we find that the trade volume impact of eco-labeling may be even larger, particularly when the distribution of disposable consumer income between the two countries is sufficiently unequal. These results can be attributed to the observations that eco-labeling leads to opposing incentives on the part of the two countries, so that net exporting countries of eco-unfriendly products may refrain from strict product standards in order to avoid a deterioration in terms of trade. Meanwhile, importing countries overestimate the gains from labeling as they do not internalize the terms of trade losses borne by the exporting country. Thus, eco-labeling may create new distortions unless international cooperation in labeling standards are taken seriously.

In addition, our results show that labeling may have adverse income distributional consequences that fall disproportionately on resource-poor countries. The framework set out in this paper thus sets the stage for understanding the nature of coordination failure between countries in terms of their choice of labeling standards in the presence of environmentally conscious consumption behavior, along with the income redistribution consequences of environmental policies in the absence of North-South cooperation in trade related environmental policy-making[17].

[17] See, for instance, Abrego, Perroni, Whalley and Wigle (1997) and Nordhaus and Yang (1996) study North-South bargaining when Northern consumers attach existence value to environmental assets that are not revealed in the product pricing.

Appendix A

Welfare optimal product standards in the Absence of eco-labeling

The indirect utility function of the South is given by $V^s(\bar{e}^s, \bar{e}^n) = W^s[\bar{e}^s/\bar{p}]^\alpha$, where W^s denotes Southern gross national income as defined in equation (7). We have:

$$\left.\frac{\partial \bar{V}^s}{\partial \bar{e}^s}\right|_{\bar{e}^s=1} \geq 0 \Leftrightarrow \quad \left(\frac{\alpha W^s}{\bar{e}^s} - \frac{N}{b^+}\int_0^{\bar{b}^s} \gamma(\bar{e}^s)^{\gamma-1} b db - m^s M'(\bar{e}^s) \right.$$
$$\left. + \, (\bar{p}\bar{X}^s - \frac{\alpha W^s}{\bar{p}})\frac{\partial \bar{p}}{\partial \bar{e}^s} \right) |_{\bar{e}^s=1} \geq 0$$

There are thus three effects in play. $\alpha W^s/\bar{e}^s$ denotes the direct marginal benefit of an increase in standards $\bar{e}^s$. The resource and monitoring costs of raising standards are $\frac{N}{b^+}\int_0^{\bar{b}^s}\gamma(\bar{e}^s)^{\gamma-1} b db - M'(\bar{e}^s)]$. Raising standards also implies a terms of trade *gains*. Making use of the definition of $\bar{b}^s$ and $\bar{X}^s$ and simplifying, we obtain:

$$\bar{e}^s_{NE} = 1 \Leftrightarrow \beta^s - \bar{s}^s_p \geq \frac{\bar{s}^s_p(\gamma/2 - 1)}{(1-\alpha/2)(1-\gamma\bar{s}^s_p/2)}.$$

Thus, if (i) the share of resource in the South β^s, and hence W^s, is sufficiently small, (ii) the cost of raising standard, as given by γ is large, or if (iii) the market share of the South $\bar{s}^s_p$ is large enough, the South will optimally choose to produce only eco-unfriendly products.

In a similar fashion, the indirect utility function of the North is given by $V^n(\bar{e}^s, \bar{e}^n) = W^n[(\lambda^n(\bar{e}^s)(\bar{e}^s - \bar{e}^n) + \bar{e}^n)/\bar{p}]^\alpha$, we have

$$\bar{e}^n_{>} 1 \Leftrightarrow \beta^n - \bar{s}^n_p \geq \frac{\bar{s}^n_p(\gamma/2 - 1)}{(1-al/2)(1-\gamma\bar{s}^n_p/2)}.$$

Volume of Trade Let $\bar{\Omega}^i \equiv \bar{X}^i/\bar{p}$. From the definition of $\bar{X}^s$, and W^s, the volume of trade as given by equation (10) can be as

$$\begin{aligned}
\bar{p}\bar{X}^s - \alpha W^s &= (1-\frac{\alpha}{2})\bar{p}^2\bar{\Omega}^s - \alpha(\beta^s\mathcal{L} - M(\bar{e}^s)) \\
&= \alpha(\mathcal{L} - M(\bar{e}^s) - M(\bar{e}^n))\frac{\bar{\Omega}^s}{\bar{\Omega}+\bar{\Omega}} - \alpha(\beta^s\mathcal{L} - M'(\bar{e}^s)) \\
&= \alpha(\bar{s}^s_p - \beta^s)\mathcal{L} + \alpha[\bar{s}^n_p M(\bar{e}^s) - \bar{s}^s_p M(\bar{e}^n)]
\end{aligned}$$

which gives equation (10) in the text.

Proof of Proposition 2: 1. From equation (10) in the text, we have,

$$\frac{\bar{p}\bar{X}^s - \alpha W^s}{\partial \bar{e}^n} = (\mathcal{L} - M(\bar{e}^s) - M(\bar{e}^n))\frac{\partial \bar{s}_p^s}{\partial \bar{e}^n} - \alpha \bar{s}_p^s M'(\bar{e}^n) > 0$$

if $M'(\bar{e}^n)$ is not too large, since $\bar{s}_p^s = \frac{1/(\bar{e}^s)^\gamma}{1/(\bar{e}^s)^\gamma + 1/(\bar{e}^n)^\gamma}$ is strictly increase in $\bar{e}^n$. The volume of trade impact of an increase in $\bar{e}^s$ can be similarly ascertained.

2. In addition, making use of equation (8), it can be readily verified that

$$\frac{\partial \bar{p}}{\partial \bar{e}^s} = \frac{\bar{p}}{2}\frac{\gamma \bar{s}_p^s}{\bar{e}^s} - \frac{\bar{p}^2 M'(\bar{e}^s)}{\mathcal{L} - M(\bar{e}^s) - M(\bar{e}^n)} > 0$$

if $M'(\bar{e}^n)$ is sufficiently small.

Appendix B

Let $\Omega^i \equiv X^i/p(1)$, be the aggregate green production per dollar in country i.

Proof of lemma 1:

By definition,

$$\frac{\partial X^i}{\partial e^i} = p(1)\frac{\partial \Omega^i}{\partial e^i} = p(1)\frac{N}{b^+}\frac{e^i - 1}{(e^i)^\gamma - 1}\frac{(2-\gamma)(e^i)^\gamma - 2 + \gamma(e^i)^{\gamma-1}}{(e^i)^\gamma - 1} > 0$$

if $\gamma < 2$.

Proof of Proposition 4:

1. Since X^i is increasing in e^i from lemma 1, Southern market share s_p^s is thus increasing in e^i as well. Part 1 of the proposition thus follows from routine differentiation of equation (14), provided that $M'(e^i)$ is not too large.

2. From equation (13), and the definition of Ω^i above, we have

$$\frac{\partial p(1)}{\partial e^i} = -\frac{1}{2(\Omega^n + \Omega^s)}\frac{\partial X^i}{\partial e^i} - \frac{\alpha}{2-\alpha}\frac{M'(e^i))}{\Omega^n + \Omega^s} < 0,$$

if $(\partial X^i/\partial e^i)|_{p(1)const.} > 0$, or from lemma 1, if $\gamma < 2$.

Proof of Proposition 5:

Let ϕ^y, ϕ^i and ϕ^1, respectively be the Lagrangian multipliers associated with the market clearance equations for the homogenenous numeraire, eco-friendly output produced in country i and the eco-unfriendly output respectively. Also let ϕ^u and ϕ^L be the Lagrangian multipliers

respectively associated with $U(D_x^n, d_y^n) \geq \bar{U}^n$ and the material balance equation (14).
The first order conditions for consumption allocations are given by:

$$\begin{aligned}
\alpha e^i \frac{U^s}{D_x^s} - \phi^i &= \phi^u \alpha e^i \frac{U^n}{D_x^n} - \phi^i = 0, \;\; i = n, s, \\
\alpha \frac{U^s}{D_x^s} - \phi^1 &= \phi^u \alpha \frac{U^n}{D_x^n} - \phi^1 = 0, \\
\alpha \frac{U^s}{D_x^s} - \phi^1 &= \phi^u \alpha \frac{U^n}{D_x^n} - \phi^1 = 0, \\
(1-\alpha) \frac{U^s}{d_y^s} - \phi^y &= \phi^u (1-\alpha) \frac{U^n}{d_y^n} - \phi^y = 0.
\end{aligned}$$

In addition, the first order conditions for producer allocations are:

$$\begin{aligned}
\phi^i - \phi^1 - \tilde{b}_e^i((\tilde{e}^i)^\gamma - 1)\phi^y &= 0, \;\; i = n, s, \\
\phi^1 - \tilde{b}_1^i \phi^y &= 0.
\end{aligned}$$

Finally, the Pareto Optimal labeling standard satisfies:

$$\alpha d_x^s(e^i) \frac{U^s}{D_x^s} + \phi^u \alpha d_x^n(e^i) \frac{U^n}{D_x^n} \phi^y \left(\frac{N}{b^+} \int_0^{\tilde{b}_e^i}\right) \gamma (e^i)^{\gamma - 1} b db = 0.$$

The four sets of conditions in Proposition 3 are thus obtained by recalling that $\pi^i = (\alpha / D_x^i)(d_y^i/(1-\alpha))$.

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Table 1

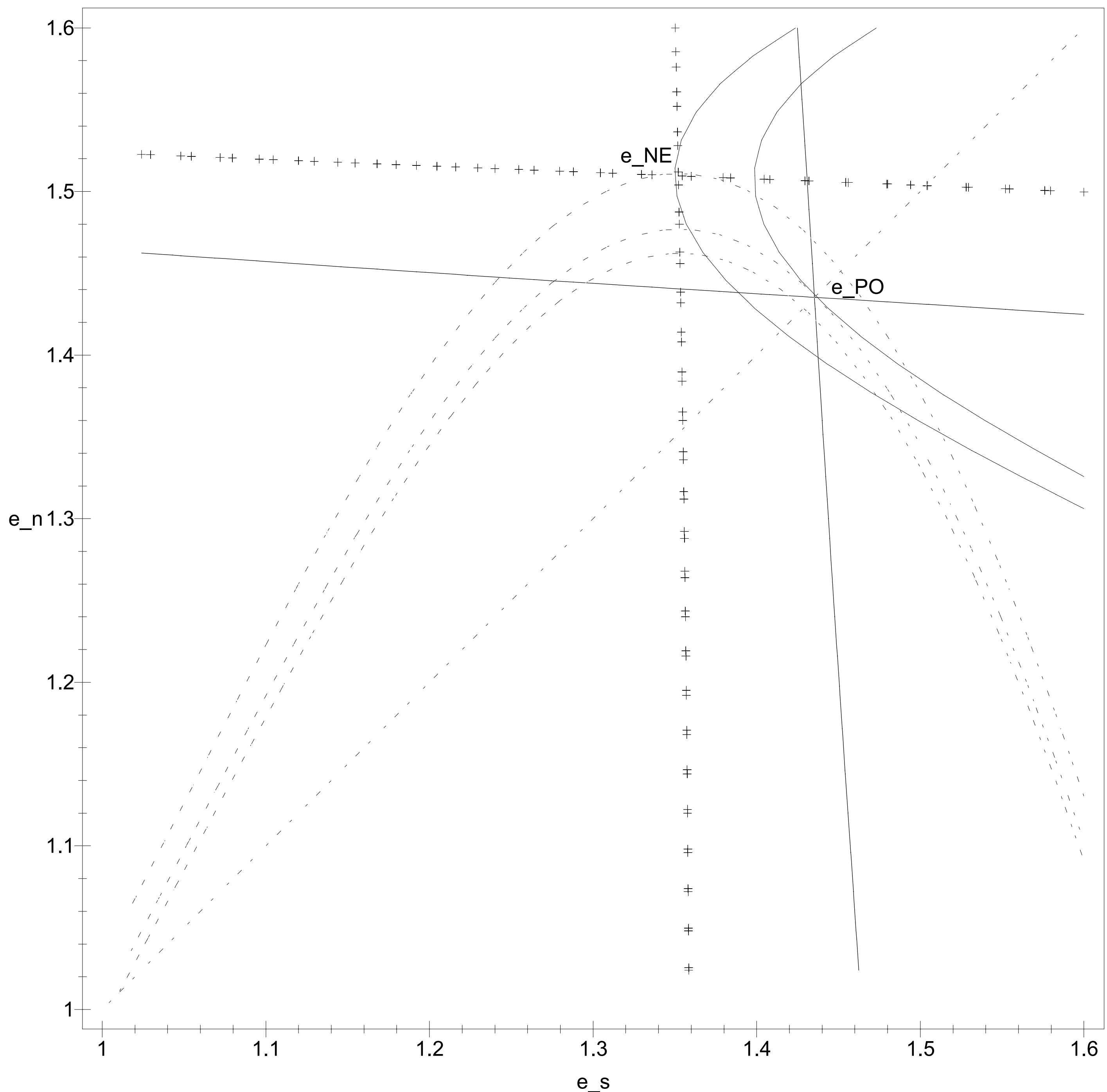
Country	Seal	Mandatory / Voluntary	Gov't / Non-Gov't	Year Founded	No. of Product Categories	Used in Retail Products
Austria	Austrian Eco-Label	Voluntary	Gov't	1991	35	Yes
Brazil	ABNT	Voluntary	Quasi	1993	2	Yes
Canada	Environmental Choice	Voluntary	Quasi	1988	49	Yes
China	Ecomark	Voluntary	Gov't	1994	12	Yes
Croatia	Croatia's Environmental Label	Voluntary	Gov't	1993	33	Yes
Czech Rep.	–	Voluntary	Gov't	1994	17	Yes
Nordic Countries	Nordic Swan	Voluntary	Quasi	1989	42	Yes
EU	European Union Ecolabel Award Scheme	Voluntary	Gov't	1992	11	Yes
France	NF-Environment	Voluntary	Gov't	1992	6	Yes
Germany	Blue Angel	Voluntary	Gov't	1977	88	Yes
Germany	Green Dot	Voluntary	Quasi	1990	7	Yes
India	Ecomark	Voluntary	Gov't	1991	16	Yes
Indonesia	BAPEDAL	Voluntary	Gov't	1995	n.a.	n.a.
Japan	Ecomark	Voluntary	Quasi	1989	69	Yes
Korea	Ecomark	Voluntary	Gov't	1992	36	Yes
Malaysia	Product Certification Program	Voluntary	Gov't	1996	1	Yes
Netherlands	Stichting Mileukeur	Voluntary	Quasi	1992	32	Yes
New Zealand	Environmental Choice	Voluntary	Quasi	1990	17	Yes
Singapore	Green Label	Voluntary	Gov't	1992	21	Yes
Thailand	Thai Green Label	Voluntary	Gov't	1993	6	Yes
U.S.	Energy Star	Voluntary	Quasi	1992	26	Yes

Source: WTO (2000).

Table 2. Simulation Results

	Status Quo	Pareto Optimal (% change from status quo)	Nash Equilibrium (% change from) status quo)
Labeling Standards			
South	1.00000	43.40000	35.00000
North	1.00000	43.40000	50.80000
Price Response Eco-unfriendly			
South	1.00000	-14.26301	-14.15364
North	1.00000	-14.26301	-14.15364
Price Response Eco-friendly			
South	1.00000	29.13699	20.84636
North	1.00000	29.13699	36.64636
Price Response Eco-friendly			
South	1.00000	29.13699	20.84636
North	1.00000	29.13699	36.64636
Price Response Eco-friendly			
South	1.00000	29.13699	20.84636
North	1.00000	29.13699	36.64636
Trade Volume			
South	0.70000	0.00000	-6.43219
North	0.70000	0.00000	-6.43219
Producer Profits			
South	0.50000	-0.90831	-5.47921
North	0.50000	-0.90831	3.54619
National Welfare			
South	1.50000	0.00329	-0.25719
North	8.50000	2.57458	2.51929
Joint	10.0000	2.18889	2.10282

Figure 1. Nash Equilibrium and Pareto Optimal Labeling Standards



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