# Public vs. Private Eco-Labeling of Environmental Credence Goods: Maximizing the Gains from International Integration[1]

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**July 2009**

[1] This is a revised version of a paper prepared for the 2nd International Workshop, "Quality Promotion through Eco-labeling: Theoretical and Empirical Advances on the Feasibility of Developing Social and Environmental Claims", The Laboratory of Forest Economics, Nancy, France, June 29-30, 2009. We would like to thank Workshop participants for their helpful comments on the earlier version of the paper.

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**Abstract:** Using a model of vertical product differentiation, we compare the welfare gains from economic integration when countries harmonize their eco-labeling and certification policies for environmental credence goods. Specifically, we show that harmonized mandatory, exclusive discrete labeling will not maximize the gains from economic integration, i.e., the choice of eco-labeling regime can have a negative effect on market structure if firms choose to exit, reducing the range and quality of goods in the integrated market. In contrast, under a harmonized mandatory, non-exclusive discrete labeling regime, private certification increases the likelihood of maximizing the gains from international economic integration.

JEL Classification: F12, F21, L13

Keywords: Vertical differentiation, credence goods, eco-labeling, economic integration

## 1. Introduction

While goods are often differentiated by their environmental attributes, e.g., dolphin-safe tuna, sustainable forest management, low-emissions electricity, etc., consumers may be unable to verify such claims. Goods that suffer such *ex post* information asymmetries are a simplified version of *credence goods* (Darby and Karni, 1973; Dulleck and Kerschbamer, 2006). Eco-labeling is one method for addressing the environmental credence good problem, requiring a number of regulatory choices concerning the labeling regime: compulsoriness (*mandatory* or *voluntary*), explicitness (*discrete* or *continuous*), and exclusiveness (only government labeling is available {*exclusive*}, or private firms may also certify {*non-exclusive*}). In Roe and Sheldon (2007), we used a model of vertical product differentiation to analyze the efficiency and distributional implications of these regulatory choices in an economy under autarky. Sheldon and Roe (forthcoming) extend the institutional setting to allow for the international economic integration of two economies who agree either to *harmonize* or *mutually recognize* their credence good labeling regulations.[1]

In the latter paper, the regulatory authorities are assumed to have exclusive authority to certify and label a quality dimension, private certification being explicitly ruled out. For international trade settings, provision of industry standards has typically been regarded as a public good and the domain, therefore, of national regulatory authorities. However, while governments are typically involved in the process of setting standards, the certification process may be undertaken by coalitions of private firms (Casella, 2001). Since establishment of the Forest Stewardship Council (FSC) in 1993, several private certification programs have evolved

[1] Harmonization implies that when two countries integrate economically, an agreed upon standard applies in both countries. In contrast, mutual recognition implies a country-of-origin principle is applied, i.e., a standard applied in one country is recognized in the other country. Likewise, any standard set in the latter country is recognized in the former country (Leebron, 1996; Lutz, 2000).

in the US and Canada, the programs being designed to recognize companies and landowners practicing sustainable forest management (Gulbrandsen, 2005; Cashore, Auls and Newsom, 2003).[2] Such private certification programs have also become common in the marine fisheries sector (Gulbrandsen). For example, the Marine Stewardship Council (MSC) was formed in 1996 as a partnership between the World Wildlife Fund (WWF) and Unilever, a corporation with significant market share in the boxed frozen fish sector, its objective being to provide a mechanism for labeling seafood products harvested from a sustainable force (Wessells, Johnston and Donath, 1999). Elsewhere, electricity providers in 23 US states must disclose information concerning the environmental profile of energy sources, but they may also seek private certifications such as the Center for Resource Solution's Green-E® renewable electricity certification (Roe *et al*., 2001).

In the current paper, which focuses on the case of harmonized standards for environmental credence good labeling, we compare the gains from economic integration under a regulatory regime of mandatory exclusive eco-labeling to those under a regime of mandatory non-exclusive eco-labeling.[3] As in Sheldon and Roe, we examine two canonical cases of economic integration: first, two countries with identical distributions of income, which we denote as North-North integration; second countries which have overlapping distributions of income, which we denote as North-South integration.[4] For both North-North and North-South integration, mandatory, exclusive, and continuous labeling delivers the same prices and qualities as would occur under perfect information. Alternatively, if there is mandatory, exclusive, and discrete labeling, if the harmonized standard is set too high or too low, higher quality good(s) are pushed out of the

[2] The FSC was established at the initiative of the World Wildlife Fund, several NGOs, as well as other stakeholders.
[3] By assuming rules on credence good labeling are set exogenously, we ignore the possibility of regulatory capture. Consequently, no explicit political-economic framework is included in our analysis.
[4] This classification is designed to capture integration of similar advanced economies (North-North), and integration of advanced and developing economies (North-South).

market for both North-North and North-South integration, thereby lowering economic welfare. In contrast, harmonized mandatory, non-exclusive, and discrete labeling increases the likelihood of maximizing the gains from North-North and North-South integration, i.e., private certification and eco-labeling of credence goods can be economically beneficial. This result also has implications for the debate about whether there will be a "race to the bottom" in environmental standards with international economic integration.

The remainder of the paper is structured as follows. We introduce the structure of the basic model in section 2, followed in section 3 by derivation of equilibrium under autarky with perfect information about quality. In section 4, we examine the case of North-North integration with perfect information, followed by an analysis of publicly vs. privately certified credence good labeling regimes. Then in section 5, we conduct the same analysis with respect to North-South integration. Finally in section 6 we summarize and end with some concluding remarks.

## 2. Basic Model

In this section, which draws heavily on our two previous papers (Roe and Sheldon, 2007; Sheldon and Roe), we outline the basic structure of a model of vertical differentiation with perfect information, first introduced by Gabszewicz and Thisse (1979, 1980) and Shaked and Sutton (1982, 1983), and later extended by Boom (1995).

***Consumers, firms and quality***

We assume that consumers in a representative country have a unit demand for a quality-differentiated good, where higher quality is associated with goods that are less harmful to the environment. Consumer utility is:

$$U = u(y - p), \tag{1}$$

where $u \in [\underline{u}, \infty]$ is the quality level of the differentiated good, the lower bound $\underline{u} > 0$ meets a minimum environmental quality standard, perfectly enforced by government, $y$ is income, and $p$ is the price of the differentiated good, where $(y - p)$ is expenditure on a Hicksian composite commodity.[5,6] If the consumer decides not to buy the differentiated-good, $u$=0; hence, the good is always purchased unless price exceeds income. Consumers derive the same surplus from a good of a particular quality, but differ in their ability to pay. Incomes are uniformly distributed on the interval $[a, b]$, $a > 0$, so that the density function of income $y$ is:

$$g(y) = \begin{cases} s & a \le y \le b \\ 0 & \text{otherwise} \end{cases},$$

$s(b - a)$ being a measure of the size of the representative economy under consideration.[7]

Firms produce a single differentiated good and all firms share the same production technology characterized by zero production costs and a fixed, quality-dependent cost, $F(u)$, which is sunk by the firm after entry into the market.[8,9] We assume:

$$F(u) = \varepsilon + \alpha(u - \underline{u})^2 , \tag{2}$$

where $\varepsilon$ and $\alpha$ are strictly positive constants. Sunk costs are convex and strictly increasing in quality. Also note that a sunk cost of $\varepsilon > 0$ must be expended to achieve even the lowest quality good; hence, the sunk cost of producing the minimum environmental quality good, is equal to $\varepsilon$. Finally, note that if goods of differing qualities were all priced at marginal cost, all consumers would choose the same (highest) quality, which is the standard definition of vertical differentiation (Tirole, 1988).

[5] A separate literature already exists focusing specifically on minimum-quality standards, e.g., Ronnen (1991), Boom (1995), Scarpa (1988), and Lutz (2000).
[6] See Roe and Sheldon (2007) for a discussion of the multiplicative form of utility.
[7] See Shaked and Sutton (1983) on relaxation of the assumption on the shape of the income distribution.
[8] The assumption of zero variable production costs can also be relaxed without altering the main results of the paper.
[9] Many goods can be characterized by a vertical quality that is dominated by fixed costs.

***Game structure***

Firms maximize profit in the following one-shot, three-stage game. At stage 1, each firm decides to enter or not enter the market, incurring sunk costs $\varepsilon$ upon entry. At stage 2, firms that have entered simultaneously choose their good's quality level, incurring the additional fixed costs for producing the chosen quality. At stage 3, firms simultaneously set good prices.

Firms are perfectly informed about consumer preferences, the income distribution, existing labeling institutions and all firms' technologies. We invoke the definitions of sub-game perfect equilibrium and Bertrand-Nash competition for the price- and quality-setting stages.

***Entry and number of firms***

Though solutions to multi-stage games typically begin with analysis of the final stage, and then proceed by backwards induction, we draw upon previous results in the literature on vertical product differentiation to make some initial remarks about the number of firms that will enter this market in the game's first stage. First, we assume the following:

(3) $$4a > b > 2\text{a} \rightarrow b/4 < a < b/2\,,$$

limiting the dispersion of income across the population, i.e., the difference in income between the richest and poorest member of the population. When all quality levels are communicable via labeling, this ensures that exactly two firms will enter this market, so long as fixed costs plus labeling costs are not prohibitively high, and that each entrant experiences a positive market share in equilibrium, i.e., a natural duopoly. Also, this restriction on income dispersion ensures that each consumer either purchases one unit of the differentiated good or is indifferent between purchasing the lowest quality and purchasing none. When a market is structured this way, i.e., such that all consumers always buy a differentiated good, or are at least indifferent to such a purchase, it is called a 'covered' market.

This result, the so-called "finiteness property" (Shaked and Sutton, 1982, 1983), ensures that equilibrium market structure is endogenous. A proof of this result is sketched out as follows, drawing on Gabscewicz *et al*. (1981), and Shaked and Sutton (1984). If goods $q = 1,\ldots,n$ are labeled in increasing order of quality, $0 < u_1 < \ldots < u_n$, given (1), a consumer is indifferent between good $q$ at price $p_q$ and good $q$-1 at price $p_{q-1}$, when:

$$u_q(y - p_q) = u_{q-1}(y - p_{q-1}), \tag{4}$$

which defines a point in the income distribution:

$$y_q = (1 - r_q)p_{q-1} + r_q p_q, \tag{5}$$

where $r_q = u_q/(u_q - u_{q-1})$. Therefore, consumers with $y > y_q$ will strictly prefer good $q$ to good $q$-1, and the distribution of income, ($b$-$a$) can be split up into the market shares of successive firms, i.e., the market share of the firm selling the highest quality good will be $x_n = (b\text{-}y_n)$, the market share of the firm selling the next highest quality good will be $x_{n-1} = (y_n - y_{n-1})$, and so on.

Suppose that a firm offering a good of quality $u_n$ competes with a firm offering a good of quality $u_{n-1}$ offered at price $p_{n-1} = 0$. The choke price for good $n$ is determined by the upper end of the income distribution $b$. As $p_n$ falls, more consumers are willing to purchase good $n$ compared to good $n$-1 at a zero price, and if $p_n$ falls enough, even consumers at the lower end of the income distribution $a$ are willing to pay for good $n$, i.e., the total demand for good $n$ being ($b$-$a$), good $n$ covering the market. Note that if $p_n = 0$, even consumers with zero income prefer good $n$ over good $n$-1.

If the firm offering good $n$ maximizes its profits, and given that its marginal costs of production are zero, it will end up setting a price such that its market share is equal to $b/2$. From this it follows that if $(b - a) < b/2$, or equivalently $a > b/2$, the firm offering good $n$ captures the whole market, a natural monopoly, good $n$-1 having zero market share. If $(b - a) > b/2$, or

equivalently $a < b/2$, good $n$ will no longer cover the market, and if $b < 4a$, only two goods will have a positive market share. Drawing on Gabscewicz *et al*. (1981), proof of the latter result draws on the following lemma:

Lemma 1: *For any density function f(y), the necessary condition for an equilibrium in which goods 1 to n have a positive market share is*,

$$\int_{y_n}^{b} f(y)dy > f(y_n).y_n$$

$$\int_{y_q}^{y_{q+1}} f(y)dy > f(y_q).y_q \qquad 1 < q < n.$$

Applying this to the density function $g(y)$, and for firms selling goods $n$ and $n$-1, it can be stated that their market shares will be $s(b - y_n) > sy_n$ and $s(y_n - y_{n-1}) > sy_{n-1}$, or $b > 2y_n$ and $y_n > 2y_{n-1}$, i.e., $b > 4y_{n-1}$. Since by (3), $a > b/4$, then $a > y_{n-1}$, so that goods $n$-2, $n$-3,…,1, will have a zero market share.

***Price equilibrium***

We now solve the final stage of the game under the assumption that two firms have entered and chosen distinct quality levels ($0 < \underline{u} \leq u_1 < u_2$). Higher income consumers will choose the higher quality-good. From (5), define $y'$ as the income level of a consumer that is indifferent to buying either the high or low-quality good:

(6) $$y' = (1 - r)p_1 + rp_2,$$

where $r = u_2/(u_2 - u_1)$ and $p_q$ is the price of the good with quality level $q$ =1,2. Also note that, given these prices, a consumer is indifferent between a good of quality $u_1$ and no good when $p_1 = y$. Given (6), and assuming a covered market, where $p_1 < a$, profits of the two firms are:

(7) $$\pi_1 = sp_1(y' - a) - F(u_1)$$

(8) $$\pi_2 = sp_2(b - y') - F(u_2).$$

By differentiating (7) and (8) with respect to $p_1$ and $p_2$, respectively, setting the two resulting expressions equal to zero and solving the two equations for equilibrium prices, we derive,

(9) $$p_1 = \frac{b-2a}{3(r-1)}$$

(10) $$p_2 = \frac{2b-a}{3r}.$$

Substituting the definition of $r$ into equation (9) we can derive a restriction on the ratio of quality levels in a covered market:

(11) $$u_1 \geq \hat{u}_1(u_2) = \frac{u_2(b-2a)}{b+a} \text{ , and, } u_2 \leq \hat{u}_2(u_1) = \frac{u_1(b+a)}{b-2a}.$$

These are equivalent to $u_2/u_1 \geq (b + a)/(b - 2a)$, or that the ratio of high to low quality in a covered market is limited by aspects of the income dispersion.

So long as quality can be chosen from the continuum of possible qualities and (3) holds all consumers will have a choice between two distinct qualities offered by the two firms and will always choose a differentiated good. Analysis of the equations (9) and (10) leads to a first remark concerning market behavior.

Remark 1: *In a covered market, equilibrium prices for the low and high-quality good increase (decrease) as the difference in quality levels between the goods ($u_2 - u_1$) increases (decreases), i.e., increasing (decreasing) quality differentiation increases (decreases) all prices.*

## 3. Autarky Equilibrium with Perfect Information

Express the two firms' profit functions as a function of qualities by utilizing the definition of $r$ and by using equilibrium price expressions from (9) and (10):

(12) $$\pi_1(u_1;u_2) = \frac{s(b-2a)^2(u_2-u_1)}{9u_1} - F(u_1) \text{ for } u_1 > \hat{u}_1(u_2)$$

(13) $$\pi_2(u_1;u_2) = \frac{s(2b-a)^2(u_2-u_1)}{9u_2} - F(u_2) \text{ for } u_2 < \hat{u}_2(u_1),$$

where $\hat{u}_1$ and $\hat{u}_2$ are defined in (11).

Remark 2: *The low-quality firm chooses the lowest possible quality in equilibrium, i.e.,* $u_1^* = \underline{u}$.

Consider the quality choice of the low-quality firm. First-order conditions yield:

(14) $$\frac{\partial \pi_1}{\partial u_1}(u_1,u_2) = -\frac{2s(b-2a)^2}{9}\frac{u_2}{(u_1)^2} - F'(u_1) < 0 \text{ for } u_1 > \hat{u}_1(u_2).$$

The profits of the low-quality firm decrease as it raises quality. Increasing quality increases sunk quality costs and increases price competition with the higher quality firm as discussed in Remark 1. Further, a result of the covered-market model is that all consumers buy a differentiated good; hence raising quality never pulls more customers into the market.[10] This finding concerning the quality level produced by the low-quality firm corresponds with Boom's (1995) equation (21).

The high-quality firm's optimal quality decision follows from differentiating (13):

(15) $$\frac{\partial \pi_2}{\partial u_2}(u_1;u_2) = \frac{s(2b-a)^2}{9}\frac{u_1}{(u_2)^2} - F'(u_2) \text{ for } u_2 < \hat{u}_2(u_1),$$

where the second derivative is $\frac{\partial^2 \pi_2}{\partial (u_2)^2} = -\frac{2s}{9}\left[\frac{2b-a}{u_2}\right]^2 \frac{u_1}{u_2} - \frac{\partial^2 F(u_2)}{\partial (u_2)^2} < 0$. Given the low-quality firm always chooses $u_1^* = \underline{u}$, firm 2's optimal choice of quality is such that $u_2$ induces a covered- market price equilibrium:

$$\frac{\partial \pi_2}{\partial u_2}(u_2;\underline{u}) = 0 \text{ for } u_2 < \hat{u}_2(\underline{u}).$$

[10] If the income distribution were broader such that the market was uncovered, increasing quality could draw more consumers into the market and may cause firm one's optimal quality to be interior.

The equilibrium quality in a covered market is implicitly defined by:

$$u_2^* = \left\{ u_2 \left| \frac{s(2b - a)^2}{9} \frac{u_1}{(u_2)^2} - \frac{\partial F(u_2)}{\partial u_2} = 0 \right. \right\}. \tag{16}$$

The quality pairs of $u_1^* = \underline{u}$ and (16) represent a Nash equilibrium.[11] This is equivalent to Boom's (1995) equation (24).

Aggregate consumer welfare in equilibrium is:

$$W = \int_a^{y'} u_1 \, ^*(\psi - p_1^*) d\psi + \int_{y'}^b u_2 \, ^*(\psi - p_2^*) d\psi . \tag{17}$$

Following this we can state the following proposition, drawing on Roe and Sheldon (2007):[12]

Proposition 1: *As $u_2$ increases (decreases), (a) the welfare of consumers, purchasing the low-quality good decreases (increases), (b) the proportion of consumers purchasing the low-quality good declines (increases), and (c) aggregate consumer welfare increases (decreases).*

Autarky equilibrium is described in figure 1. Firms' fixed costs $F(u)$ and revenue $sR(.)$ are plotted on the vertical axis against quality $u$, where the low and high-quality firm's revenue functions can be derived from (12) and (13) respectively:

$$R_1(u_1; u_2) = \frac{s(b - 2a)^2 (u_2 - u_1)}{9u_1} \tag{18}$$

$$R_2(u_1; u_2) = \frac{s(2b - a)^2 (u_2 - u_1)}{9u_2} . \tag{19}$$

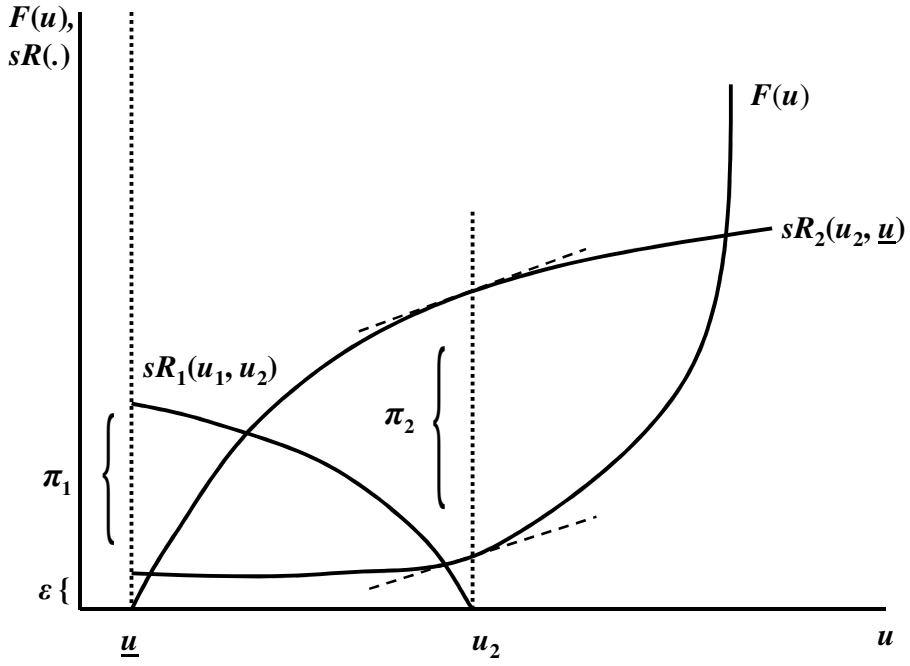
Suppose the low-quality firm chooses $\underline{u}$. If the other firm set its quality at this level, price competition drives firms' revenue to zero, given the assumption of zero variable production costs. In addition, due to sunk costs $\varepsilon$ both firms would incur a loss. Consequently, the optimal choice of

[11] More technically, this represents a Nash equilibrium only if the low-quality firm has no incentive to leapfrog the high-quality firm, and, hence become the high-quality provider given that the high-quality firm has already chosen (16). Boom (1995) has shown that such an incentive never exists if (16) holds; hence, a unique Nash equilibrium exists.

[12] See Roe and Sheldon (2007) for a detailed discussion of Proposition 1.

the other firm is to increase quality to $u_2$ in order to maximize profits $\pi_2$. At the same time, this reduces price competition with the low-quality firm, allowing the latter to maximize its profits $\pi_1$. If the low-quality firm were to increase its quality from the minimum $\underline{u}$ to $u_1 = u_2$, price competition again results in both firms incurring a loss. Hence, the equilibrium choice of qualities is $\underline{u}, u_2$.

**Figure 1: Autarky Equilibrium with Perfect Information**




It is important to note here that the only perfect equilibrium that can exist is for two firms to enter the market and survive in equilibrium with positive prices and positive market shares. If more than two firms enter, given the assumption of zero variable production costs, price competition ensures that all firms will produce the top-quality at a zero price, thereby making zero profits. If any firm produces below the top-quality, it will have a zero market share, as consumers will only purchase

the high-quality good at a zero price. Consequently, given sunk costs $\varepsilon$ only two firms can enter and make a profit in equilibrium. Following Shaked and Sutton (1982), we state the following proposition:

*Proposition 2: Given the income distribution* $4a > b > 2a$, *for any* $\varepsilon > 0$, *and a number of potential entrant firms* $n > 2$, *(a) there exists a perfect equilibrium where only two firms enter, producing the distinct qualities, and earning positive profits, and (b) no perfect equilibrium exists where* $q > 2$ *firms enter.*

## 4. North-North Integrated Equilibrium

### *Perfect information*

Suppose two North-North economies, $N = 1, 2$, with the same uniform distribution of income integrate, where $a = a_1 = a_2$, and $b = b_1 = b_2$, although they may have different sizes of population, i.e., the population of the integrated economy is $s^i = s_1 + s_2$, where either $s_1 = s_2$ or $s_1 \neq s_2$. We also assume that firms must incur some additional sunk costs $\varepsilon^i$ in order to enter the integrated market, and that each country has the same minimum environmental quality standard $\underline{u}$ prior to integration, such that $\underline{u} = \underline{u}^i$.

Due to the fact that each economy supports only two firms under autarky, the integrated equilibrium will also support only two firms, i.e., two firms will exit. This follows from Proposition 2, with $\varepsilon^i > 0$. However, given that we cannot predict the location of the remaining two firms, we are unable to predict either the direction or structure of trade in the integrated equilibrium.[13]

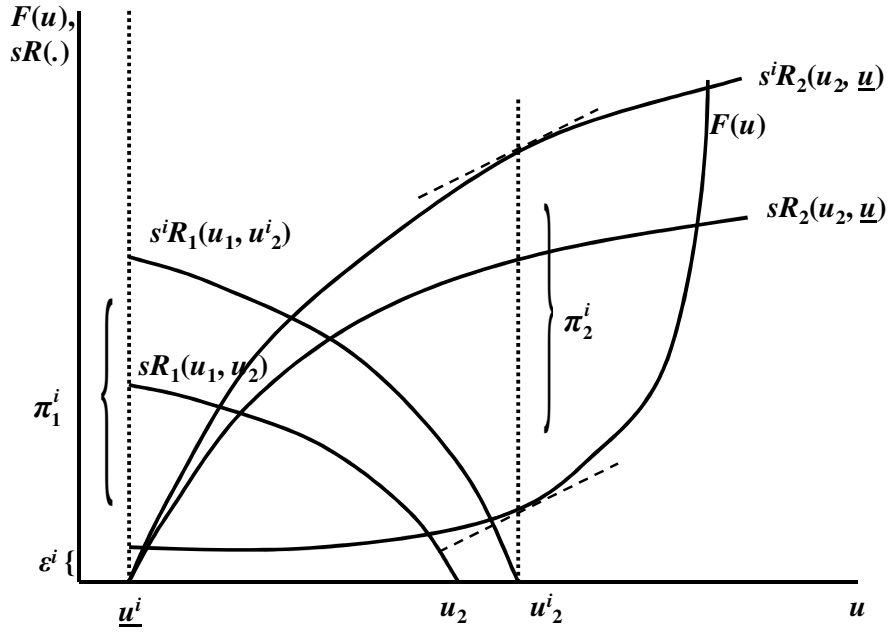
The integrated equilibrium is described in figure 2. With the increase in the population size from $s$ to $s^i$, the high-quality firm's revenue function rotates upwards, resulting in an increase in the

[13] This is not uncommon in models such as ours where firms are essentially "footloose", i.e., firms can produce anywhere in the integrated market. To pin down which country trades which good, we would need additional structure; for example, in a Ricardian-type setting, differences in unit production costs would ensure a firm in one country has a comparative advantage in producing the high-quality good, the firm located in the other country having a comparative advantage in producing the minimum-quality good, i.e., intra-industry trade in vertically differentiated products.

quality of good 2 to $u_2^i$. Given $u_2^i$, the low-quality firm's revenue function shifts out and rotates upwards, the quality of good 1 remaining the same at the minimum $\underline{u}^i$. As a result, in the integrated equilibrium, while the prices and profits of both firms increase, from Proposition 1, aggregate consumer welfare increases, i.e., the gains from integration come from increased quality. This results in the following proposition:

Proposition 3: *In the North-North integrated economy with perfect information, (a) high-quality increases to $u_2^i$, (b) the equilibrium prices and profits of the low and high-quality firm increase, and (c) aggregate consumer welfare increases due to increased quality.*

**Figure 2: North-North Trade Equilibrium with Perfect Information**




***Imperfect information***

We now assume consumers in the integrated North-North economy do not believe any firm-based communication concerning environmental quality due to the unverifiable nature of such attributes. All communication of quality occurs through an eco-label that is administered and verified by a separate certifier, who could be either a private firm or a public agency or both. We

assume private and public certifiers perfectly monitor and communicate the quality of individual firms *ex ante* for a fee paid by the firms.[14] The fixed cost of certifying and labeling the good is given as:

(20) $$I^j(u) = I^j \text{ for } u > \underline{u}$$

$$= 0 \text{ otherwise,}$$

where $j \in \{t, d\}$ and $t$ and $d$ stand for continuous and discrete labeling, respectively. Continuous labels communicate the exact level of quality while discrete labels merely communicate if quality meets or exceeds a particular quality threshold. Firms claiming quality meeting the minimum environmental quality standard are never charged a fee, $I^j(\underline{u}) = 0$, because a firm has no incentive to produce a higher-quality good and market it as the minimum quality. We assume both private and public certifiers provide labeling at the same cost and that there exist no economies of size, and that such costs are the same throughout the integrated economy. We also assume discrete certification is less costly, $I^t(u) \geq I^d(u) \; \forall \; u > \underline{u}$.[15] Then finally, we assume that there are no variable costs of labeling.[16]

We now consider three cases where environmental quality information is unverifiable by consumers in the integrated North-North economy: (i) no eco-labeling is possible (*XL*); (ii) mandatory, exclusive vs. non-exclusive, continuous eco-labeling (*MEC* vs. *MNC*); (iii) harmonized mandatory, exclusive vs. non-exclusive, discrete eco-labeling ($MED^h$ vs. $MND^h$).[17]

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[14] The assumption of perfect monitoring, while strict, allows the market to be converted from one of credence goods to one of search goods. If monitoring were noisy, deduction of equilibrium would require a repeated game structure as in McCluskey (2000). Because monitoring is assumed to be perfect, repeating the current game would not change the resulting equilibrium.

[15] Monitoring a discrete standard is likely to be cheaper as it merely requires checking that processes meet or exceed a given threshold, i.e., going over a check list, while continuous labeling may require additional monitoring equipment to calibrate and report exact performance.

[16] Allowing for variable costs of labeling would be similar to allowing for variable costs of production. As discussed in note 8, such an expansion of the model would not alter our fundamental results.

[17] In the case of continuous labeling, the issue of harmonization of standards simply does not arise.

(i) Case *XL*

First, suppose quality is opaque to the consumer and that no eco-labeling program exists in the integrated economy.

Proposition 4: *In the presence of credence attributes and the absence of eco-labeling, (a) a single firm in the integrated North-North economy supplies the lowest environmental quality level ($\underline{u}^i$), charges $p^{XL} = b/2$ and earns profits $\pi^{XL} = b^2/4 - \varepsilon^i$, (b) at least some consumers purchase no goods, (c) there are no gains from integration.*

The sunk cost of entry, $\varepsilon^i$, combined with the three-stage game supports the entry of a single firm into the integrated market, while the opaqueness of quality and lack of eco-labeling leads to production of the minimum environmental quality standard $\underline{u}$. The resulting price and profit levels are simple monopoly outcomes given the linear demand structure that emerges from a uniform distribution of consumers within the given income interval.[18] On the consumer side, because $p^{XL} = b/2$ and, by the restriction (3) on income distribution, the poorest consumer has an income smaller than this, $a < b/2$. Therefore, some consumers will not consume the good under monopoly.

(ii) Case *MEC* vs. *MNC*

(a) Next, consider the case where in the integrated economy, any firm that claims environmental quality higher than the minimum has to participate in an exclusive, continuous eco-labeling program (*MEC*). Firm profit functions under this labeling regime become:

$$(12') \qquad \pi_1(u_1;u_2) = \frac{s^i(b-2a)^2(u_2-u_1)}{9u_1} - F^i(u_1) - I^t(u_1) \quad \text{for } u_1 > \hat{u}_1(u_2)$$

$$(13') \qquad \pi_2(u_1;u_2) = \frac{s^i(2b-a)^2(u_2-u_1)}{9u_2} - F^i(u_2) - I^t(u_2) \quad \text{for } u_2 < \hat{u}_2(u_1),$$

[18] The only circumstance under which multiple firms selling the low-quality good enter is when $\varepsilon^i = 0$, i.e., a perfectly contestable market (Sutton, 1991).

where the only change from profit functions (12) and (13) under perfect information is the addition of the cost of continuous labeling, which is a step function triggered by the sale of a good with environmental quality higher than the minimum, plus firms have to incur the additional sunk costs, $\varepsilon^i$, of entering the larger integrated North-North market.

Under our assumptions, firms are able to communicate their desired quality level perfectly via the mandatory, exclusive continuous eco-label. This results in the following propositions.

Proposition 5: *For North-North MEC, if* $I^t \leq I^{MEC}_{\max} \equiv \pi^i_2(u^{MEC}_1 *, u^{MEC}_2 *)$ *then two quality levels will be produced; otherwise, case MEC results are identical to case XL results.*

Proposition 6: *For North-North MEC, if* $I^t \leq I^{MEC}_{\max}$, *then* $u^{MEC}_1 * = u^i_1 * = \underline{u}^i$, $u^{MEC}_2 * = u^i_2 *$, $p^{MEC}_1 * = p^i_1 *$, $p^{MEC}_2 * = p^i_2 *$, $\pi^{MEC}_1 = \pi^i_1$, and $\pi^{MEC}_2 = \pi^i_2 - I^t$.

Proposition 5 outlines a labeling cost threshold, $I^{MEC}_{\max}$. Costs above the threshold, which is the entirety of profits less labeling costs earned by the high-quality firm, cause the market to collapse to the monopoly analyzed in case *XL* because no high-quality firm would enter. Otherwise, two firms enter and produce distinct qualities.

Proposition 6 points out that, as long as two firms enter, the labeled market is identical to the perfect information market with respect to prices, qualities and profits for the low-quality firm. Only the profit of the high-quality firm is different because it incurs labeling costs. Hence, continuous labeling does not distort firm choices so long as it is not too expensive. Consumers experience no change in welfare compared to the perfect information case so long as two qualities are produced, as labeling leaves price and quality unchanged in equilibrium, i.e., the gains from North-North economic integration are still realized under *MEC* labeling.

(b) If the mandatory and continuous eco-labeling program is non-exclusive (*MNC*), under our assumptions firms will have no incentive to hire an additional private certifier, the results contained in Propositions 5 and 6 also holding for the case of *MNC*. This follows from the fact

that firms are already able to communicate their desired quality level perfectly via the mandated continuous eco-label hence communications by private certifiers would be redundant and only entail additional costs.

(iii) Case $MED^h$ vs. $MND^h$

(a) In the case of harmonized mandatory, exclusive, discrete labeling ($MED^h$), we assume that in the integrated market, firms claiming higher than minimum environmental quality have to implement a single harmonized, discrete standard, $u_2^g = u_2^N$, for North-North countries, $N = 1, 2$, and firms are forbidden from certifying and communicating any other standard.

Proposition 7: *For North-North $MED^h$, the integrated market will support two qualities if the harmonized standard,* $u_2^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$ *where both* $\gamma(.)$ *and* $\delta(.)$ *are non-negative, decreasing functions* of $I^d$ *and* $\gamma(I_{\max}^{MED^h}) = \delta(I_{\max}^{MED^h}) = 0$. *Otherwise $MED^h$ results are identical to XL results.*

Proposition 7 outlines an interval in which the harmonized discrete exclusive mandatory eco-labeling standard must fall in order for two qualities to be produced. If the authorities choose a standard outside this interval, one or both firms earn negative profits and will not enter the integrated market. Hence, for a standard outside this interval, only one firm enters and the market collapses to the monopoly outcome of case *XL*. Proposition 7 also points out that, as labeling costs rise, the interval the harmonized standard must fall within shrinks. In other words, as the cost of eco-labeling increases, the authorities in the integrated economy have less room for 'error' (in the eyes of the high-quality firm) in setting the harmonized standard because the high-quality firm will have less residual profit remaining to entice its entry.

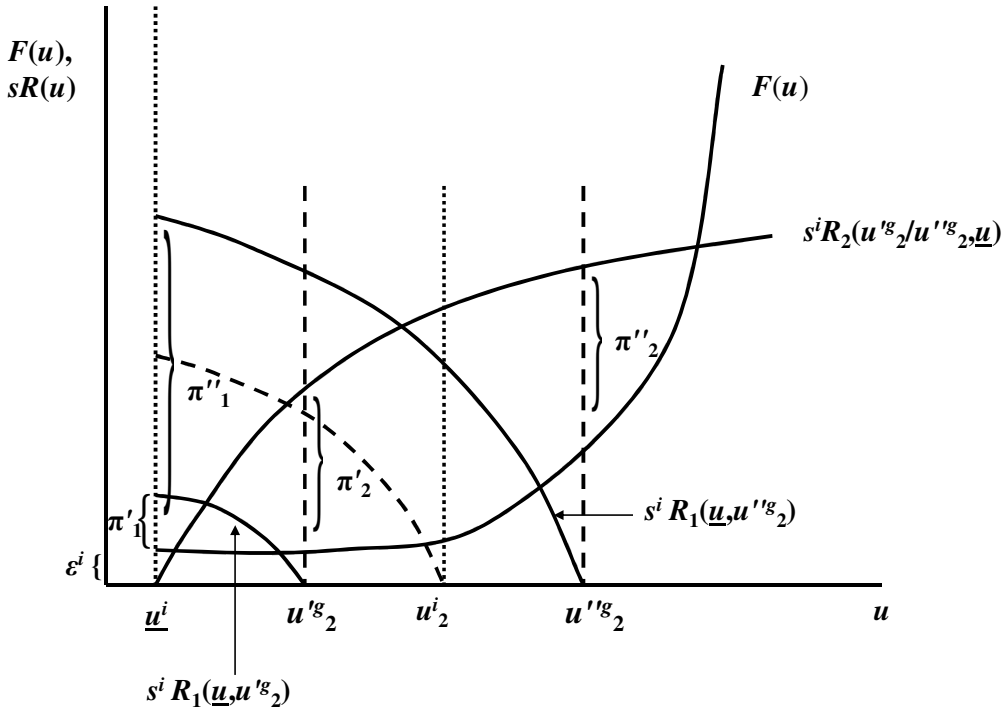
The welfare implications of harmonized standards set lower (higher) than firm-preferred standards are stated in the following proposition:

Proposition 8: *For North-North MED*$^h$ *and* $u_2^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$, $u_2^g < (>)\ u_2^i$ *(a) decreases (increases) aggregate consumer welfare, (b) improves (diminishes) the welfare of consumers purchasing the low-quality good, (c) diminishes (improves) the welfare of consumers purchasing the high-quality good, (d) decreases (increases) the profits of the low-quality firm, and (e) decreases the profits of the high-quality firm.*

If the harmonized standard $u_2^g$ is lower than $u_2^i$, then the two qualities are closer together and, as we point out in Remark 1, price competition becomes more intense between the two firms - $u_2'^g$ in figure 3. This bodes well for consumers who purchase the low-quality good, who now pay a lower price. Consumers of the high-quality good also pay a lower price, but as was shown in Proposition 1, these consumers would rather have the higher quality and pay the higher price. In aggregate, consumers lose due to the lowering of quality. The more intense price competition harms both firms - profits falling to $\pi_1'$ and $\pi_2'$ respectively in figure 3. This is obvious for the high-quality firm because the harmonized standard deviates from its preferred (profit-maximizing) choice of quality. For the low-quality firm, the loss of profits from a decrease in $u_2$ is obvious after differentiation of (12´) with respect to $u_2$.

If the standard $u_2^g$ is higher than $u_2^i$, price competition is relaxed - $u_2''^g$ in figure 3. This harms consumers of the low-quality good, who now pay higher prices. Consumers of the high-quality good welcome the increase, as they value the environmental quality increase more than they are harmed by the price increase. The relaxed price competition inflates the low-quality firm's profits as they gain a higher price with no increase in production costs - $\pi_1''$ in figure 3. The high-quality firm does charge a higher price, but the convex, fixed cost of producing quality comes to dominate and drive the high-quality firm's profits down - $\pi_2''$ in figure 3. Therefore, the high-quality firm suffers regardless of the direction of the harmonized labeling standard's deviation from the perfect-information quality choice.

**Figure 3: North-North Trade – $MED^h$ case**




(b) The case of harmonized mandatory, non-exclusive, discrete labeling ($MND^h$) is very similar to the case $MED^h$ in that any firm claiming environmental quality higher than the minimum must pay for certification and labeling of a regulator-chosen quality standard. The key difference between case $MND^h$ and $MED^h$ is that the high-quality firm may also pay a private certifier to certify and label another quality level. That is, if the regulatory authorities choose a harmonized standard the firm deems too low, the firm may hire a private certifier to verify and communicate a higher quality. Alternatively, if the regulatory authorities choose a harmonized standard the firm deems too high, the firm may hire a private certifier to verify and communicate a lower quality, $u_2^p$ (though the regulatory authorities will communicate to the public that the firm fails the harmonized standard).

In general, a firm does not like to have to pay twice to communicate its quality level. Hence, the firm compares the profits it gains from selling a good at its preferred level of quality to the additional labeling costs it pays the private certifier.

Proposition 9: *For North-North MND$^h$ and* $u_2^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$, *the high-quality firm will not hire a private certifier if* $u_2^g \in [u_2^i - \underline{\gamma}(I^d),\ u_2^i + \underline{\delta}(I^d)]$, *where* $\underline{\gamma}(I^d) < \gamma(I^d)$ *and* $\underline{\delta}(I^d) < \delta(I^d)\ \forall\ I^d > 0$; *otherwise the high-quality firm hires a private certifier to verify a standard* $u_2^p = u_2^*$.

If the harmonized standard is 'close enough' to the high-quality firm's desired quality level, the firm will not pay the additional cost of a second, private certification. However, if the harmonized standard deviates too far from firm-preferred quality levels, the harmonized standard is disregarded and replaced by a standard chosen by the high-quality firm. Consequently, once the regulatory authorities allow private certification and eco-labeling of environmental credence goods, the benefits of North-North economic integration are more likely to be achieved, even if the harmonized standard does not coincide with the high-quality firm's optimal choice.

## 5. North-South Integrated Equilibrium

### *Perfect information*

Suppose two economies, North and South, each have incomes uniformly distributed over the range $[a_k, b_k]$, and $4a_k > b_k > 2a_k$, where subscript $k$ refers to either North ($N$) or South ($S$). In addition, assume that $a_N > a_S$, $b_N > b_S$, and $b_N < 2b_S$, $a_N < 2a_S$, and that the same technology is available in North and South.[19] Under autarky, both North and South will be able to sustain two firms in equilibrium selling distinct qualities. Also assume that the North sets and enforces a higher minimum environmental quality standard than the South, such that $\overline{u}_N = \underline{u} + \sigma$ with $\sigma > 0$,

[19] The existence of footloose firms in this model is sufficient to ensure technology available in the North will also be available in the South.

and $\overline{u}_S = \underline{u}$. Consequently, in the North, given the higher minimum environmental quality standard, the high-quality firm, in order to escape the pressure of price competition, will also produce and sell a higher-quality good in equilibrium, which follows from differentiation of (16):

$$\frac{\partial u_2^*}{\partial \overline{u}_N} = \frac{2(2b - a)^2 u_2^*}{4(2b - a)^2 \overline{u}_N + 9(u_2^*)^3 \frac{\partial^2 F}{\partial u^2}(u_2^*)} > 0, \tag{21}$$

resulting in the low and high-quality goods in the North under autarky being of higher quality than their counterparts in the South. This result is consistent with the observation that demand for higher environmental quality is income elastic, and hence correlated with the level of economic development (Copeland and Taylor, 1994).

We now allow North and South to integrate, assuming as before that firms must incur some additional sunk costs $\varepsilon^i$ in order to enter the integrated market. In addition, assume that North and South accept each other's minimum environmental quality standard. Following Gabscewicz *et al*. (1981), the conditions postulated on the income distribution imply:

$$\frac{a_N}{2} < a_S < a_N < \frac{b_N}{2} < b_S < b_N, \tag{22}$$

such that in the integrated equilibrium, the following inequalities must hold, $y_n < \frac{b_N}{2}; y_{n\text{-}1} < a_N; y_{n\text{-}2} \leq a_S$, where $y_n$ is the income of the consumer indifferent between a good of quality $q$ offered at $p_q$, and a good of quality $q$-1 offered at $p_{q\text{-}1}$, $q$=1,…,$n$. Since the income of the consumer who is indifferent between consuming the minimum-quality good from the North and the minimum-quality good from the South, $y_{n\text{-}2}$, is less than or equal to the lowest income in the integrated economy, $a_S$, the integrated economy can only support three goods in equilibrium. In other words, the minimum environmental quality good in the South will be eliminated due to economic integration. There may also be intra-industry trade, if the medium-

quality good is produced in the South, and the minimum and high-quality goods are produced in the North, although this is not guaranteed with footloose firms.

The benefit to consumers of economic integration follows from the reduction in prices of the remaining three goods, $q_n$, $q_{n-1}$, and $q_{n-2}$. In other words, for the lowest-quality good $q_{n-3}$ to be eliminated there must be a reduction in the price of $q_{n-2}$ that makes even consumers of income $a_S$ better off than before. In addition, as consumers with income $y > a_S$ can do at least as well as those with $a_S$, all consumers with income above $a_S$ must also gain due to the fact that $p_q$ and $p_{q-1}$ are also reduced. Consequently, we can write the following proposition:

Proposition 10: *If North-South have incomes uniformly distributed over the range $[a_k, b_k]$, and $4a_k > b_k > 2a_k$, where each economy supports two goods under autarky, then if $a_N > a_S$, $b_N > b_S$, and $b_N < 2b_S$, $a_N < 2a_S$, the integrated economy supports only three goods in equilibrium, with qualities, $u_3^i > u_2^i > \overline{u}_N$. Aggregate consumer welfare increases due to lower prices in the integrated market.*

Following Gabscewicz *et al*. (1981), the proof of this result proceeds in stages showing that the market share of the highest-quality good $q_n$ extends beyond $b_N / 2$, that of the medium-quality good $q_{n-1}$ extends below $a_N$, while that of the minimum-quality good $q_{n-2}$ extends below $a_S$. (i) $y_n < b_S$, i.e., the market share of the highest-quality good extends below $b_S$. Suppose $y_n \geq b_S$, from Lemma 1, we know $\int_{y_n}^{b_N} s_N dy > s_N y_n$, i.e., $b_N - y_n > y_n$ or $b_N / 2 > y_n$. By assumption $b_S > b_N / 2$, therefore, $b_S > y_n$, which is a contradiction, hence, $y_n < b_S$. (ii) $y_n < b_N / 2$, i.e., the market share of the highest-quality good extends beyond $b_N / 2$. Suppose that $a_N \leq y_n < b_S$. From Lemma 1 we know that $\int_{y_n}^{b_S} (s_N + s_S) dy + \int_{b_S}^{b_N} s_N dy > (s_N + s_S) y_n$, hence, $(s_N b_N + s_S b_S) / [2(s_N + s_S)] > y_n$, but by assumption $b_N > b_S$, so that $y_n < b_N / 2$. If $y_n < a_N$, which is a contradiction, and by assumption $a_N < b_N / 2$, then $y_n < b_N / 2$ as required.

(iii) $y_{n-1} < a_N$, i.e., the market share of medium-quality good $q_{n-1}$ extends beyond $a_N$. Suppose instead that $y_{n-1} \geq a_N$, from Lemma 1 we know for $q_{n-1}$ that $y_{n-1} < y_n / 2$, and that $y_n / 2 < b_N / 4 < a_N$, so $y_{n-1} < a_N$, which is a contradiction, hence $y_{n-1} < a_N$. (iv) $y_{n-2} \leq a_S$, i.e., the market share of the minimum-quality good $q_{n-2}$ extends below $a_S$. Suppose instead that $y_{n-2} \geq a_S$, from Lemma 1 we know for $q_{n-2}$ that $y_{n-2} < y_{n-1} / 2$, and that $y_{n-1} / 2 < a_N / 2 < a_S$, so $y_{n-2} < a_S$ which is a contradiction, hence $y_{n-2} \leq a_S$.

This is an interesting result in that even though North and South accept each other's minimum environmental quality standard, price competition ensures that while the lowest environmental quality good is driven from the integrated market the poorest consumers in the South, are now able to purchase the minimum-quality good produced in the North, i.e., the South will not be a *pollution haven* with greater economic integration.[20] Of course North and South could harmonize their minimum environmental quality standard to that of the North, in which case, the South's minimum-quality good would be driven from the market by executive fiat. However, there will still be intensified price competition between the three remaining goods.[21]

***Imperfect information***

Based on the environmental credence good labeling scenarios laid out in the North-North case, we can also draw some conclusions about the gains from economic integration where North and South harmonize their eco-labeling regulations.

(i) Cases *XL* and *MEC* vs. *MNC*

In the *XL* case, Proposition 4 still holds, other than the upper end of the income distribution in the

[20] This would occur if the lower minimum environmental quality standard survived in the South after economic integration, and hence the lowest environmental quality good would be produced in the South. See Copeland and Taylor (2004) for a discussion of pollution havens.

[21] Alternatively, if the North and South harmonize to the minimum environmental quality standard of the South, as long as the cost of labeling the higher minimum environmental quality is not too high, the lower minimum quality good is still likely to be driven from the market.

integrated economy is now $b_N$ not $b$, i.e., with no labeling, there are no gains from integration, market structure being characterized by a monopoly selling the minimum environmental quality good in North and South. For the North-South *MEC* case, the only difference from the perfect information case of Proposition 10 is that if mandatory continuous labeling is not too costly, the market will support three goods with qualities $u_3 > u_2 > \overline{u}_N$, the firms supplying the high and medium-quality goods earning lower profits due to labeling costs, while consumer welfare remains the same. In addition, even if mandatory continuous labeling is non-exclusive (*MNC*), private certification will be redundant as firms are already able to perfectly communicate their desired quality level, and they will therefore have no incentive to incur any additional labeling costs.

(ii) Case *MED*$^h$ vs. *MND*$^h$

(a) In the case of North-South *MED*$^h$, we assume that in the integrated economy, one harmonized labeling standard is set, $u^g = u^k$, where $k = N, S$. The impact of the labeling standard depends on its location relative to what would be optimal for the firms choosing qualities $u_2^i$, and $u_3^i$:

- if $u^g \leq u_2^i$, this will force the highest-quality good from the market, and it may force the medium-quality good out of the market as well if $u^g$ is set too low, thereby intensifying price competition too much between the medium and minimum-quality goods. This bodes well for consumers who purchase the low-quality good, who now pay a lower price. Consumers of the medium-quality good may also pay a lower price, but they would rather have "higher" medium-quality and pay a higher price, while consumers of the high-quality good clearly suffer a loss of welfare. In aggregate, consumers lose due to the lowering of quality;

- if $u_2^i \leq u^g \leq u_3^i$, either the medium or the highest-quality good will be driven from the market, depending on the location of the harmonized public standard between the medium-quality and the

high-quality goods. Essentially, if the standard is set not too far from the optimal level of quality, $u_2^i(u_3^i)$, the high-quality (medium-quality) good will be driven from the market, as only one good can survive at that level of quality. This will of course diminish competition between the remaining goods, because whether the medium or high-quality good survives, it is the case that $\overline{u}_N \leq u_2^i \leq u^g \leq u_3^i$. Consumers of the low-quality good will lose from paying a higher price, while consumers of either medium or high-quality goods will lose if their preferred good is forced out of the market. Consumers of the medium-quality good will benefit if the standard results in a quality increase, while consumers of the high-quality good lose if the standard results in a quality decrease;

- if $u_3^i \leq u^g$, the medium-quality good will be forced from the market as it will be unprofitable for two firms to compete at a standard set higher than that preferred by the high-quality firm. This harms consumers of the low-quality good, who now pay higher prices, and also consumers of the medium-quality good who are unable to purchase the high-quality good. Consumers of the high-quality good benefit as they value the quality increase more than they are harmed by the price increase.

These results are summarized in the following propositions:

Proposition 11: *For North-South MED$^h$:*

*(i)* *if* $u^g \leq u_2^i$ *and* $u^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$, *(a) the highest-quality good will be driven from the market, and (b) the integrated market will only support two qualities,* $u_2, \overline{u}_N$ *;*

*(ii)* *if* $u_2^i \leq u^g \leq u_3^i$ *and either,* $u^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$ *or* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, *(a) either the highest-quality or medium-quality good will be driven from the market, and (b) the integrated market will only support two qualities,* $u_2, \overline{u}_N$ *or* $u_3, \overline{u}_N$ *;*

*(iii)* *if* $u_3^i \leq u^g$ *and* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, *(a) the medium-quality good will be driven from the market, and (b) the integrated market will only support two qualities.*

*Otherwise MED$^h$ results are identical to XL results. In all cases,* $\gamma(.)$ *and* $\delta(.)$ *are non-negative, decreasing functions* of $I^d$ *and* $\gamma(I_{\max}^{MED^h}) = \delta(I_{\max}^{MED^h}) = 0$.

Proposition 12: *For North-South MED$^h$:*

*(i)* *if* $u^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$, and $u^g \leq u_2^i$, *(a) aggregate consumer welfare decreases, (b) the welfare of consumers purchasing the minimum-quality-good increases, while the welfare of those who purchase the medium-quality good falls,(c) the welfare of those who prefer the high-quality good falls, and (d) the profits of the medium and low-quality firms decrease;*

*(ii)* *if either* $u_2^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$ *or* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, *and* $u_2^i \leq u^g \leq u_3^i$, *(a) aggregate consumer welfare decreases, (b) the welfare of consumers purchasing the minimum-quality good decreases, while the welfare of consumers who prefer the medium or high-quality good decreases if they cannot purchase that good,(c)the welfare of those who purchase the medium-quality(high-quality) good increases (falls) if the standard raises (lowers) quality, and (d) the profits of either the medium or the high-quality firm increase, and the profits of the low-quality firm increase;*

*(iii)* *if* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, and $u_3^i \leq u^g$ *(a) aggregate consumer welfare decreases, (b) the welfare of consumers purchasing the minimum and medium-quality goods decreases, (c) the welfare of consumers purchasing the high-quality good increases, and (d) the profits of the low-quality firm increase while those of the high-quality firm fall.*

(b) In the case of North-South *MND$^h$*, firms claiming environmental quality higher than the minimum must pay for certification and labeling of a regulator-chosen quality standard, however, firms may also pay a private certifier to certify and label another quality level. That is, if the regulatory authorities choose a harmonized standard these firms deem too low (too high), they may hire a private certifier to verify and communicate a higher (lower) quality. Similar to North-North integration, firms will compare the profits they gain from selling a good at their preferred level of quality to the additional labeling costs they pay the private certifier. This is summarized in the following proposition:

Proposition 13: *For North-South MND$^h$,* $u_2^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$ *and/or* $u_3^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, *the medium-quality firm and/or the high-quality firm will not hire a private certifier if* $u_2^g \in [u_2^i - \underline{\gamma}(I^d),\ u_2^i + \underline{\delta}(I^d)]$ *and/or* $u_3^g \in [u_3^i - \underline{\gamma}(I^d),\ u_3^i + \underline{\delta}(I^d)]$, *where* $\underline{\gamma}(I^d) < \gamma(I^d)$ *and* $\underline{\delta}(I^d) < \delta(I^d)\ \forall\ I^d > 0$; *otherwise the medium and/or the high-quality firm will hire a private certifier to verify their standard(s)* $u_2^p = u_2^*$ *and/or* $u_3^p = u_3^*$.

If the harmonized standard is 'close enough' to the medium-quality and/or the high-quality firm's desired quality levels, neither firm will pay the additional cost of a second, private

certification. However, if the harmonized standard deviates too far from firm-preferred quality levels, the harmonized standard is disregarded and replaced by a standard chosen by the medium-quality and/or the high-quality firm(s). Therefore, if the regulatory authorities allow private certification and eco-labeling of environmental credence goods, the benefits of North-South economic integration are more likely to be achieved, even if the harmonized standard does not coincide with the medium-quality firm's and/or the high-quality firm's optimal choice.

Of course, it might be questioned whether firms based in the South will be in a position to hire private certifiers.[22] In the case of forest management, however, there is some evidence for certification in developing countries (Cashore *et al*., 2006). For example, there is strong support in South Africa for forest certification under the FSC from large, privately-owned plantations producing for the European Union (EU) and US markets, while large Russian firms exporting timber to the EU have also endorsed FSC certification under pressure from Scandinavian firms.

## 6. Summary and Conclusions

In an earlier paper, we used a model of vertical product differentiation to analyze the efficiency and distributional implications of different approaches to labeling of credence goods in an economy under autarky (Roe and Sheldon, 2007). In this paper we extend the institutional setting by allowing for the international integration of two economies that agree to harmonize their mandatory environmental credence good labeling regulations. As a base case we start with perfect information about environmental qualities, showing that integration of two North-North economies with identical income distributions, results in increased quality in equilibrium, while North-South integration allows more goods to be viable in equilibrium, resulting in lower prices.

[22] If firms are footloose, it is always possible that a firm from the North will produce in the South and utilize private certification.

We then compare harmonized labeling regimes when there is economic integration. Under mandatory, exclusive, and continuous labeling (*MEC*), the labeling regime in both the North-North and North-South cases delivers the same prices and qualities as would be delivered under perfect information in the integrated economy, i.e., the labeling regime is non-distorting, and the gains from economic integration are maximized. In contrast, if the authorities have exclusive authority to certify and label an environmental quality dimension ($MED^h$), in the North-North case, they risk pushing out the high-quality good if the harmonized standard is too high or too low to yield positive profits for the high-quality producing firm, while in the North-South case, they run the risk of pushing either one of or both the medium and high-quality goods out of the market.

If private certification is permitted, there are two key results: first, with mandatory continuous labeling (*MEC*), the welfare gains from integration are unaffected as there will be no incentive for firms to hire a private certifier. This follows from the fact that firms are already able to communicate their desired quality level perfectly via the mandated continuous eco-label; second, with harmonized mandatory discrete labeling ($MED^h$), the welfare gains from integration will be maximized if regulators permit private certification of a standard different to the harmonized standard - private certification lowers the risk that higher-quality goods are pushed out of the market if standard(s) are set too low or too high.

Finally, the results presented in this paper have implications for the debate about increased economic integration and its impact on the environment, especially the so-called "race to the bottom" in environmental standards (Bagwell and Staiger, 2001; Copeland and Taylor, 2004). In the absence of any environmental credence good regulations, only the minimum-quality good is produced in equilibrium, and *de facto*, standards never leave the bottom. In contrast, once there

is mandatory eco-labeling, as long as it is either continuous or private certification of discrete eco-labeling is permitted there will be no race to the bottom as firms have a private incentive to produce higher than minimum environmental quality goods in equilibrium, i.e., even if the regulatory authorities "harmonize-down" environmental standards in a race to the bottom, private certification ensures that the full gains of economic integration can be realized.[23]

[23] Interestingly, Cashore, Auld and Newsom (2003) argue that, efforts to develop private certification of sustainable forest management have been a response to the "…'downward' effects of globalization on environmental standards…"

## References


Bagwell, Kyle and Robert W. Staiger (2001). "The WTO as a mechanism for securing market access property rights: Implications for global labor and environmental issues", *Journal of Economic Perspectives*, 15(3): 69-88.

Boom, Anette (1995). "Asymmetric international minimum quality standards and vertical differentiation", *Journal of Industrial Economics*, 43(1): 101-119.

Casella, Alessandra (2001). "Product standards and international trade: Harmonization through private coalitions?" *Kyklos*, 54(2/3): 243-264.

Cashore, Benjamin, Graeme Auld, and Deanna Newsom (2003). "Forest certification (eco-labeling) programs and their policy-making authority: Explaining divergence among North American and European case studies", *Forest Policy and Economics*, 5(3): 225-247.

Cashore, Benjamin, Fred Gale, Errol Meidinger, and Deanna Newsom, eds. (2006). *Confronting Sustainability: Forest Certification in Developing Countries and Transitioning Countries*. Report No.8. Yale, CT: Yale School of Forestry and Environmental Studies.

Copeland, Brian R. and M. Scott Taylor (1994). "North-South trade and the environment", *Quarterly Journal of Economics*, 109(3): 755-787.

Copeland, Brian R. and M. Scott Taylor (2004). "Trade, growth, and the environment", *Journal of Economic Literature*, XLII(1): 7-71.

Darby, Michael R. and Edi Karni (1973). "Free competition and the optimal amount of fraud", *Journal of Law and Economics*, 16(1): 67-88.

Dulleck, Uwe and Rudolf Kerschbamer (2006). "On doctors, mechanics and computer specialists: The economics of credence goods", *Journal of Economic Literature*, XLIV(1): 5-42.

Gabszewicz, John J. and Jacques F. Thisse (1979). "Price competition, quality and income disparities", *Journal of Economic Theory*, 20(3): 340-359.

Gabszewicz, John J. and Jacques F. Thisse (1980). "Entry (and exit) in a differentiated industry", *Journal of Economic Theory* 22(2): 327-338.

Gabszewicz, John J., Avner Shaked, John Sutton, and Jacques F. Thisse (1981). "International trade in differentiated products", *International Economic Review* 22(3): 527-534.

Gulbrandsen, Lars. H. (2005). "Mark of sustainability? Challenges for fishery and forestry eco-labeling", Environment, 47(5): 10-23.

Leebron, David W. (1996). "Lying down with Procrustes: An analysis of harmonization claims", in Jagdish N. Bhagwati and Robert E. Hudec eds., *Fair Trade and Harmonization: Prerequisites for Free Trade?* Massachusetts, MA: MIT Press, pp.41-117.

Lutz, Stefan. H. (2000). "Trade effects of minimum quality standards with and without deterred entry", *Journal of Economic Integration*, 15(2): 314-344.

McCluskey, Jill J. (2000). "A game theoretic approach to organic foods: An analysis of asymmetric information and policy", *Agricultural and Resource Economics Review*, 29(1): 1-9.

Roe, Brian and Ian Sheldon (2007). "Credence good labeling: The efficiency and distributional implications of several policy approaches", *American Journal of Agricultural Economics*, 89(4): 1020-1033.

Roe, Brian, Mario F. Teisl, A.S. Levy, and M. Russell (2001). "Consumer preferences for residential electricity services with different generation sources and air emission profiles", *Energy Policy*, 29(11): 917-925.

Ronnen, Uri (1991). "Minimum quality standards, fixed costs, and competition", *The Rand Journal of Economics*, 22(4): 490-504.

Scarpa, Carlo (1998). "Minimum quality standards with more than two firms", *International Journal of Industrial Organization*, 16(5): 665-676.

Shaked, Avner and John Sutton (1982). "Relaxing price competition through product differentiation", *Review of Economic Studies* 49(1): 3-13.

Shaked, Avner and John Sutton (1983). "Natural oligopolies", *Econometrica*, 51(5): 1469-1483.

Shaked, Avner and John Sutton (1984). "Natural oligopolies and international trade", in Henryk Kierzkowski ed., *Monopolistic Competition and International Trade*. Oxford: Oxford University Press, pp.34-49.

Sheldon, Ian and Brian Roe. "Vertical product differentiation and credence goods: Mandatory labeling and gains from international integration", *EconoQuantum*, forthcoming.

Sutton, John (1991). *Sunk Costs and Market Structure*. Cambridge, MA: MIT Press.

Tirole, Jean (1988). *The Theory of Industrial Organization*. Cambridge, MA: MIT Press.

Wessels, Cathy R., Robert J. Johnston, and Holger Donath (1999). "Assessing consumer preferences for ecolabeled seafood: The influence of species, certifier, and household attributes", *American Journal of Agricultural Economics*, 81(5): 1084-1089.