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Vertical product differentiation and credence goods: Mandatory labeling and gains from international integration

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- **Abstract:** Using a model of vertical product differentiation, we show under what institutional circumstances welfare gains will be maximized as economies integrate and harmonize (mutually recognize) their (each other's) labeling and certification policies for credence goods. Specifically, we show that harmonized mandatory, exclusive discrete labeling will not maximize the gains from economic integration, i.e., the choice of 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, with mandatory, exclusive discrete labeling, there is a higher probability that the gains from integration will be maximized where countries mutually recognize each other's labeling standards.

- **Resumen:** A través de un modelo vertical de diferenciación de productos se muestra el marco institucional que maximiza el bienestar cuando dos economías se integran comercialmente y coordinan sus políticas de etiquetado y certificación. En particular, se muestra que el etiquetado discreto, armonizado y obligatorio no maximiza ganancias. Por ejemplo, la elección del tipo de etiquetado puede tener un efecto negativo sobre la estructura de mercado si las empresas deciden salirse, reduciendo así el rango y la calidad de los bienes. Pero con reconocimiento mutuo de estándares de etiquetado existe una probabilidad más alta de ganancia.

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

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■ *Introduction*

While goods are often differentiated by process attributes, consumers may be unable to verify such claims, i.e., credence goods (Darby and Karni, 1973). Labeling is one method for addressing the credence good problem, requiring a number of regulatory choices concerning the labeling regime: compulsoriness (mandated or voluntary), explicitness (discrete or continuous), and exclusiveness (only government labeling is available or private firms may also certify). Beyond domestic regulation, labeling rules are also an important issue in trading relations among countries. As countries become more integrated economically, they typically have to agree on either harmonizing or mutually recognizing their rules concerning labeling and certification of credence goods. 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 an earlier paper, we used a model of vertical product differentiation to analyze the efficiency and distributional implications of different approaches to the 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 integration of two economies where they agree either to harmonize or mutually recognize their credence good labeling regulations. Specifically, we examine two cases of economic integration: the first involves two countries with identical distributions of income, which we denote as North-North integration; the second involves countries which have overlapping distributions of income, which we denote as North-South integration.[2]

Using these two cases we show under what institutional circumstances welfare gains will be maximized, as economies integrate, assuming specific rules on credence good labeling are set exogenously by each country's regulatory authorities.[3] For North-North and North-South

2 This classification is designed to capture integration of similar advanced economies (North-North), and integration of advanced and developing economies (North-South).

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.

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, the probability of lower welfare gains depends on whether countries harmonize or mutually recognize their labeling standards. If a harmonized standard is set too high or too low, higher quality good(s) are pushed out of the market for both North-North and North-South integration, thereby lowering welfare. In contrast, mutual recognition of labeling regimes increases the probability that welfare gains from North-North and North-South integration will be achieved.

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 different possible creden a 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.

■ *Basic Model*

In this section, which draws heavily on our previous paper (Roe and Sheldon, 2007), 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. 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-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.[4,5] If the consumer decides not to buy the differentiated-good, u=0; hence,

4 A separate literature already exists focusing specifically on minimum-quality standards, e.g., Ronnen (1991), Boom (1995), Scarpa (1998), and Lutz (2000).

5 See Roe and Sheldon (2007) for a discussion of the multiplicative form of utility.

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:

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

$s(b - a)$ being a measure of the size of the representative economy under consideration.[6]

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. [7,8] We assume:

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

where ε and α are strictly positive constants. Sunk costs are convex and strictly increasing in quality. Also note that a sunk cost of $\in > 0$ must be expended to achieve even the lowest quality good; hence, the sunk cost of producing the minimum-quality good, is equal to ε. 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).

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 ε 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 concepts of sub-game perfect equilibrium and Bertrand-Nash competition for the price- and quality-setting stages.

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6 See Shaked and Sutton (1983) on relaxation of the assumption on the shape of the income distribution.

7 The assumption of zero variable production costs can also be relaxed without altering the main results of the paper.

8 Many goods can be characterized by a vertical quality that is dominated by fixed costs.

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:

$$4a > b > 2a \rightarrow b/4 < a < b/2, \tag{3}$$

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 $q = 1,...,n$ are labeled in increasing order of quality, $0 < u_1 < ... < u_n$, 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, $(b\text{-}a)$ 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 $x_n = (b - y_n)$ 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 $b < 4/a$ 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 $y_n > 2y_{n-1}$, *ie*., $b > 4y_{n-1.}$ 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:

$$y' = (1-r)p_1 + rp_2, \tag{6}$$

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

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.*

- *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):

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

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

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:

$$(14)\quad \frac{\partial\pi_1}{\partial u_1}(u_1,u_2)=-\frac{2s(b-2a)^2}{9}\frac{u_2}{(u_1)^2}-F'(u_1)<0$$

$$\text{for}\quad u_1>\hat{u}_1(u_2).$$

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.[9] 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):

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

where the second derivative is

$$\frac{\partial^2\pi_2}{\partial(u_2)^2}=-\frac{2s}{9}\left[\frac{2b-a}{u_2}\right]^2\frac{u_1}{u_2}-\frac{\partial^2F(u_2)}{\partial(u_2)^2}<0.$$

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:

9 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.

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

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.[10] 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):[11]

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:

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

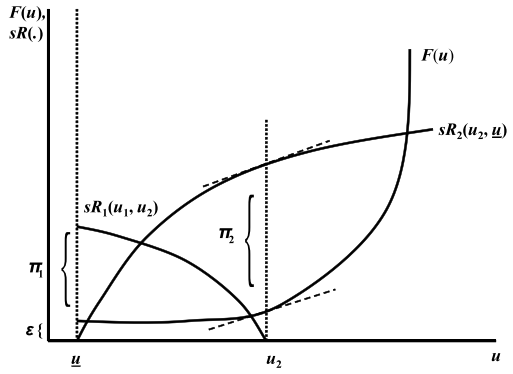
$$R_2(u_1;u_2) = \frac{s(2b-a)^2(u_2-u_1)}{9u_2}. \tag{19}$$

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

10 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.

11 See Roe and Sheldon (2007) for a detailed discussion of Proposition 1.

Figure 1
Autarky equilibrium with perfect information



to sunk costs ε both firms would incur a loss. Consequently, the optimal choice of the other firm is to increase quality to u_2 in order to maximize profits π_2. At the same time, this reduces the degree of price competition with the low-quality firm allowing it to maximize its profits π_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.

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 ε 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.*

■ *North-North Integrated Equilibrium*

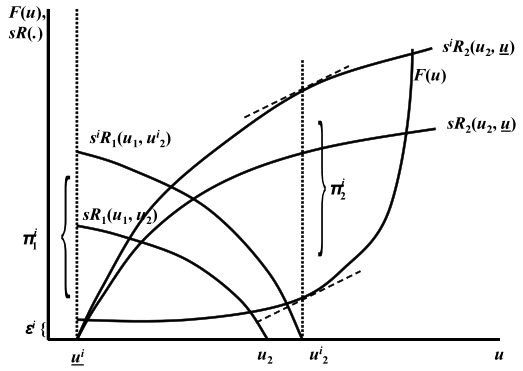
Perfect information

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 ε^i in order to enter the integrated market, and that each country has the same minimum-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 $\in^i > 0$. However, given that we cannot predict the location of the remaining two firms, we are unable to predict the direction of trade in the integrated equilibrium.

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 quality of good 2 to u_2. Given u_2, the low-quality firm's revenue function shifts out and rotates upwards, the quality of good 1 remaining the same at the minimum 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:

Figure 2
North-North trade equilibrium with perfect information



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.*

Imperfect information

We now assume consumers in the integrated North-North economy do not believe any firm-based communication concerning quality due to the unverifiable nature of process attributes. All communication of quality occurs through a mandatory label that is administered and verified exclusively by a public agency. We assume the public certifier perfectly monitors and communicates the quality of individual firms *ex ante* for a fee paid by the firms.[12] The fixed cost of certifying and labeling the good is given as:

$$I^j(u) = I^j \text{ for } u > \underline{u} \tag{20}$$
$$= 0 \text{ otherwise,}$$

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- 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 there are no economies of size in the costs of public certification, and that such costs are the same throughout the integrated economy. We also assume discrete certification is less costly, $I^t(u) \geq I^d(u) \; \forall \; u > \underline{u}$. [13] Then finally, we assume that there are no variable costs of labeling.[14]

We now consider four cases where quality information is unverifiable by consumers in the integrated North-North economy: (*XL*) no labeling is possible; (*MEC*) mandatory, exclusive continuous labeling; (MED^h)

12 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.

13 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.

14 Allowing for variable costs of labeling would be similar to allowing for variable costs of production. As discussed in note 5, such an expansion of the model would not alter our fundamental results.

harmonized mandatory, exclusive discrete labeling; (MED^{mr}) mandatory, exclusive discrete labeling with mutual recognition.[15]

(i) Case XL - no labeling

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

Proposition 4: *In the presence of credence attributes and the absence of labeling, (a) a single firm in the integrated North-North economy supplies the lowest quality level ($\underline{u}^i$), charges $p^{NL} = b/2$ 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, ε^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 labeling leads to production of the minimum-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.[16] 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 – mandatory, exclusive, continuous labeling

Next consider the case where, in the integrated economy, any firm that claims quality higher than the minimum has to participate in a continuous labeling program. Firm profit functions under this labeling regime become:

$$(12') \qquad \pi_1(u_1;u_2) = \frac{s^i(b-2a)^2(u_2-u_1)}{9u_1} - F^i(u_1) - I^t(u_1)$$

$$\text{for} \quad u_1 > \hat{u}_1(u_2)$$

$$(13') \qquad \pi_2(u_1;u_2) = \frac{s^i(2b-a)^2(u_2-u_1)}{9u_2} - F^i(u_2) - I^t(u_2)$$

$$\text{for} \quad u_2 < \hat{u}_2(u_1),$$

15 In the case of continuous labeling, the issue of harmonization versus mutual recognition simply does not arise.

16 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 quality higher than the minimum, plus firms have to incur the additional sunk costs, ε^i, of entering the larger integrated North-North market.

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

Proposition 5: *For North-North MEC, if*

$I^t \leq I_{\max}^{MEC} \equiv \pi_2^i(u_1^{MEC}*, u_2^{MEC}*)$ *then two quality levels will be produced; otherwise, case MEC results are identical to case NL results.*

Proposition 6: *For North-North MEC, if* $I^t \leq I_{\max}^{MEC}$,

then $u_1^{MEC}* = u_1^i* = \underline{u}^i$, $u_2^{MEC}* = u_2^i*, p_1^{MEC}* = p_1^i*$,

$p_2^{MEC}* = p_2^i*, \pi_1^{MEC} = \pi_1^i,$ and $\pi_2^{MEC} = \pi_2^i - I^t$.

Proposition 5 outlines a labeling cost threshold, $I_{\max}^{MEC}$. 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.

(iv) Case MED^h – harmonized, mandatory, exclusive, discrete labeling
In the case of harmonized mandatory, exclusive, discrete labeling, we assume that in the integrated market, firms claiming higher than minimal quality have to implement a single harmonized, discrete standard,

$u_2^g = u_2^g$, 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 mandatory 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 *NL*. 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 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. 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.

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. 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 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. 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. The high-quality firm suffers regardless of the direction of the harmonized labeling standard's deviation from the perfect-information quality choice.

(iv) Case MED^{mr} – mandatory, exclusive, discrete labeling with mutual recognition

In the case of mandatory, exclusive, discrete labeling with mutual recognition, we assume that in the integrated market, firms claiming higher than minimum-quality have to implement either one of two discrete standards, u_2^l or u_2^h. If each country sets the same standard, $u_2^l \cong u_2^h$ Proposition 7 applies, but if $u_2^l \neq u_2^h$, the following proposition can be stated:

Proposition 9: *For North-North MED^{mr}, and $u_2^l \neq u_2^h$, the integrated market will support two qualities if at least one of the standards,* u_2^l or $u_2^h \in [u_2^i - \gamma(I^d), u_2^i + \delta(I^d)]$ *where both* $\gamma(.)$ *and* $\delta(.)$ *are non-negative, decreasing functions* of I^d *and* $\gamma(I_{\max}^{MED^{mr}}) = \delta(I_{\max}^{MED^{mr}}) = 0$. *Otherwise MED^{mr} results are identical to XL results.*

Proposition 9 outlines an interval in which *at least one* of the discrete labeling standards must fall in order for two qualities to be produced, the interval shrinking as labeling costs rise. Obviously if both countries' labeling standards fall in the required interval, with mutual recognition, the standard chosen will be that closest to the firm-preferred standard. In either case, the distributional implications of the chosen standard are the same as stated in Proposition 8. If both countries set a labeling standard outside this interval, one or both firms earn negative profits and will not enter the integrated market. As a result, only one firm enters and the market collapses to the monopoly outcome of case *XL*.

The key to the *MED*^{mr} case is that, because the firm choosing high-quality has two standards to choose from through the principle of mutual recognition, there is a higher probability that the gains from economic integration will be realized due to one of the standards being close to the high-quality firm's preferred standard.

■ *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. 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-quality standard than the South, such that $\bar{u}_N = \underline{u} + \sigma$ with $\sigma > 0$, and $= \underline{u}_S = \underline{u}$. Consequently, in the North, given the higher minimum-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):

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

resulting in the low and high-quality goods in the North under autarky being of higher quality than their counterparts in the South.

We now allow North and South to integrate, assuming as before that firms must incur some additional sunk costs ε^i in order to enter the integrated market. In addition, assume that North and South mutually recognize each other's minimum-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, $y_n < \frac{b_N}{2}; y_{n-1} < a_N; y_{n-2} \leq a_s$, 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-quality good in the South will be eliminated due to economic integration. There will 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.

The benefit to consumers of economic integration follows from the reduction in prices of the remaining three goods, q_n, $q_{n\text{-}1}$, and $q_{n\text{-}2}$. In other words, for the lowest-quality good $q_{n\text{-}3}$ to be eliminated there must be a reduction in the price of $q_{n\text{-}2}$ 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 $p_{q\text{-}1}$ 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 that of the medium-quality good $q_{n\text{-}1}$ extends below a_N, while that of the minimum-quality good $q_{n\text{-}2}$ 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, $(s_N b_N + s_s b_s)/\left[2(s_N + s_s)\right] > y_n$, 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 $q_{n\text{-}1}$ extends beyond a_N. Suppose instead $y_{n-1} \geq a_N$ that, from Lemma 1 we know for $q_{n\text{-}1}$ 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 $q_{n\text{-}2}$ extends below a_S. Suppose instead that $y_{n-2} \geq a_S$, from Lemma 1 we know for $q_{n\text{-}2}$ 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 mutually recognize each other's minimum-quality standard, price competition ensures that while the lowest-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. Of course, North and South could harmonize their minimum quality standard to that of the North, in which case, the South's minimum-quality standard would be driven from the market by fiat. However, there will still be intensified price competition between the three remaining goods.[17]

Imperfect information

Based on the 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 either harmonize or mutually recognize their labeling regulations.

(i) Cases XL and MEC

In the *XL* case, Proposition 4 still holds, other than the upper end of the income distribution in the 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-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 $u_3 > u_2 > \bar{u}_N$, the firms supplying the high and medium-quality goods earning lower profits due to labeling costs, while consumer welfare remains the same.

(ii) Case MED^h

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 $k = N, S$.

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

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

(iii) Case MED^{mr}

In the case of mandatory, exclusive, discrete labeling with mutual recognition, we assume that in the integrated market, firms claiming higher than minimum-quality have to implement either one of two discrete standards, u^S or u^N , for which the following proposition can be stated:

Proposition 13: *For North-North MED^{mr}:*
(i) if $u^S \equiv u^N$ and one of u^S or $u^N \in [u_2^i - \gamma(I^d), u_2^i + \delta(I^d)]$, and one of u^S or $u^N \in [u_3^i - \gamma(I^d), u_3^i + \delta(I^d)]$, the integrated market will support three

qualities, where $\gamma(.)$ *and* $\delta(.)$ *are non-negative, decreasing functions* of I^{d} *and* $\gamma(I_{\max}^{MED^{mr}}) = \delta(I_{\max}^{MED^{mr}}) = 0$;
(ii) if $u^S \cong u^N$, MED^{mr} *results are identical to* MED^{h} *results.*

Otherwise MED^{mr} *results are identical to XL results.*

Proposition 13 outlines intervals in which the discrete labeling standards must fall in order for three qualities to be produced, the intervals shrinking as labeling costs rise, assuming $u^S \neq u^N$. In terms of welfare effects, compared to the perfect information case, the firms supplying the high and medium-quality goods will earn lower profits, while consumer welfare remains the same. If, however, $u^S \cong u^N$, and the labeling standards fall in one of the required intervals, the standard chosen will be that closest to the firm-preferred standard, either the medium or high-quality good being offered, the welfare effects being the same as those outlined in Proposition 12. Finally, if both countries set a labeling standard outside the required intervals, firms wishing to sell above the minimum-quality earn negative profits and will not enter the integrated market. As a result, only one firm enters and the market collapses to the monopoly outcome of case *XL*.

The key to the MED^{mr} case is that, because the firms choosing medium and high-quality have two standards to choose from through the principle of mutual recognition, there is a higher probability that the gains from economic integration will be realized due to one of the standards being close to the medium and high-quality firms' preferred standards.

■ *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 integration of two economies where they agree to either harmonize or mutually recognize their credence good labeling regulations. With perfect information about qualities, we show that integration of two North-North economies with identical income distributions, results in increased quality in equilibrium, while North-South integration, which allows more goods to be viable in equilibrium, results in lower prices in equilibrium.

The propositions derived in the paper hold some important implications for labeling programs when economies integrate in the

presence of credence goods. In our framework, the market structure is fundamentally altered in that two firms in the North-North case and three firms in the North-South case, rather than one, may enter when labeling is present and labeling costs are not too high. Consumers are given greater choice, and competition between firms helps push down prices and, hence, improves welfare.

When there is mandated, 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 realized. In contrast, if the authorities use harmonized mandated, exclusive, and discrete labeling (MED^h), quality distortion may occur. Quality distortion has distributional implications, with lower standards preferred by lower income consumers and higher standards preferred by higher income consumers and by the low-quality producing firm. Hence, discrete labeling offers the authorities a means to influence the distribution of welfare in the integrated economy.

If the authorities have exclusive authority to certify and label a quality dimension, 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.

In our earlier paper, we discussed in some detail the extent to which the assumptions of the underlying model affect the results of using this type of vertical differentiation model (Roe and Sheldon, 2007). We do not repeat that discussion here, instead we conclude by noting that the results of the current paper are sensitive to the assumption that on integration, economies harmonize their labeling regulations, when in fact they may mutually recognize each other's existing labeling regimes.

This does not matter in the case of mandatory, exclusive continuous labeling (*MEC*), because there is no divergence between countries' standards, i.e., no standards are set as labeling is continuous. However, mutual recognition of standards can affect the results in the case of mandatory, exclusive, discrete labeling (MED^{mr}). Specifically, in the North-North case, if one standard is closer than the other to what is optimal for the high-quality firm, mutual recognition of standards may ensure that a high-quality firm enters the integrated market. Likewise, in the North-South case, if one standard is closer to what is optimal for the medium-quality firm, and one is closer to what is optimal for the high-

quality firm, then under mutual recognition, either one or both firms will have an incentive to enter the integrated market. However, if there is little divergence between the standards of the integrating countries, then the previous results for the MED^h case will hold even with mutual recognition, i.e., the high-quality firm may be driven out in the North-North case if the standards are set too low, while either the medium-quality and/or the high-quality firm may be driven out in the North-South case if the standards are either set too low, or too high. The key point is that compared to harmonization of standards, mutual recognition by countries of each other's labeling regimes actually increases the probability that the benefits of integration will be achieved.

Finally, it should be noted that if private certification is permitted, there are two implications for the 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 label. Second, with mandatory discrete labeling (MED), the welfare gains from integration may be greater if regulators permit either private certification of a standard different to the harmonized standard, or private certification where there is minimal divergence between mutually recognized standards - 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.[18]

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