Vertical Differentiation and Credence Goods: Harmonized 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 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.

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1. 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). In practice one method for addressing the credence good problem is the use of labeling. Credence good labeling in a particular market, however, requires a series of practical regulatory decisions concerning implementation. First, there is the choice between discrete and continuous labeling; second, there is a choice between certification and labeling under the authority of either a government agency or a private firm; and, third, if government labeling is mandated, a choice has to be made between whether or not to allow private certifiers to further communicate quality differences. Beyond domestic regulation, labeling rules are also an important issue in trading relations among developed and developing 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.[1]

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 to harmonize their credence good labeling regulations. Specifically, we examine two cases of economic integration: the first involves two developed countries with similar distributions of income, which we denote as North-North integration; the second involves a developed and a developing country which have overlapping distributions of income, which we denote as North-South integration. Using these two cases we are able to show under what institutional circumstances welfare gains will be maximized

[1] Harmonization implies that when two countries integrate economically, an agreed 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 (Lutz, 2000).

as economies integrate and harmonize labeling and certification policies. Specifically, we show that harmonized mandatory, exclusive discrete labeling will not maximize the gains from 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.

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 credence good labeling regimes that are harmonized. Then in section 5, we conduct the same analysis with respect to North-South integration. Finally in section 6 we end with some concluding remarks and discussion of possible results under mutual recognition of labeling regimes.

2. 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, $\underline{u} > 0$ is the minimum possible quality of the good, y is income, and p is the price of the differentiated good, where $(y - p)$ is

expenditure on a Hicksian composite commodity.[2,3] 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. Income is uniformly distributed on the interval [a, b] with the simplifying assumption that $s = (b - a)$ equals the population of the representative country under consideration.[4]

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.[5,6] 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 $\varepsilon > 0$ 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.

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[2] Alternatively, $\underline{u}$ could be thought of as a minimum-quality standard enforced by government.
[3] See Roe and Sheldon (2007) for a discussion of the multiplicative form of utility.
[4] See Shaked and Sutton (1983) for a discussion concerning relaxation of the assumption on the shape of the income distribution.
[5] The assumption of zero variable production costs can also be relaxed without altering the main results of the paper.
[6] Many goods can be characterized by a vertical quality that is dominated by fixed costs.

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.

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 $q = 1,\ldots,n$ 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:

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

which defines a point in the income distribution:

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

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 $x_n = (b\text{-}y_n)$, 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 $(b\text{-}a)$, 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. The proof of this result is as follows: for firms selling goods n and n-1, it can be stated that their market shares will be $(b - y_n) > y_n$ and $(y_n - y_{n-1}) > y_{n-1}$, 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):

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

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

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:

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

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.[7] 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):

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

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:

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

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

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

The quality pairs of $u_1^* = \underline{u}$ and (16) represent a Nash equilibrium.[8] This is equivalent to Boom's (1995) equation (24).

Aggregate consumer welfare in equilibrium is:

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

Following this we can state the following proposition, drawing on Roe and Sheldon (2007)[9]:

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[7] 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.

[8] 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.

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

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:

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

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

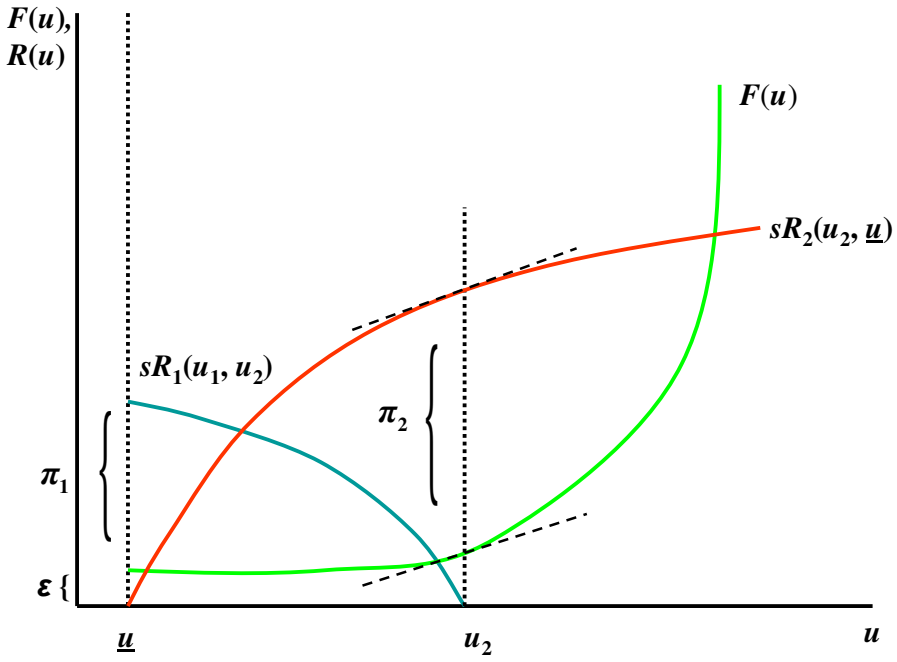
Suppose the low-quality firm chooses $\underline{u}$. If the other firm set its quality at this level, price competition drives firms' revenue to zero, given the assumption of zero variable production costs. In addition, due to sunk costs ε both firms would incur a loss. Consequently, the optimal choice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

Figure 1: Autarky Equilibrium with Perfect Information



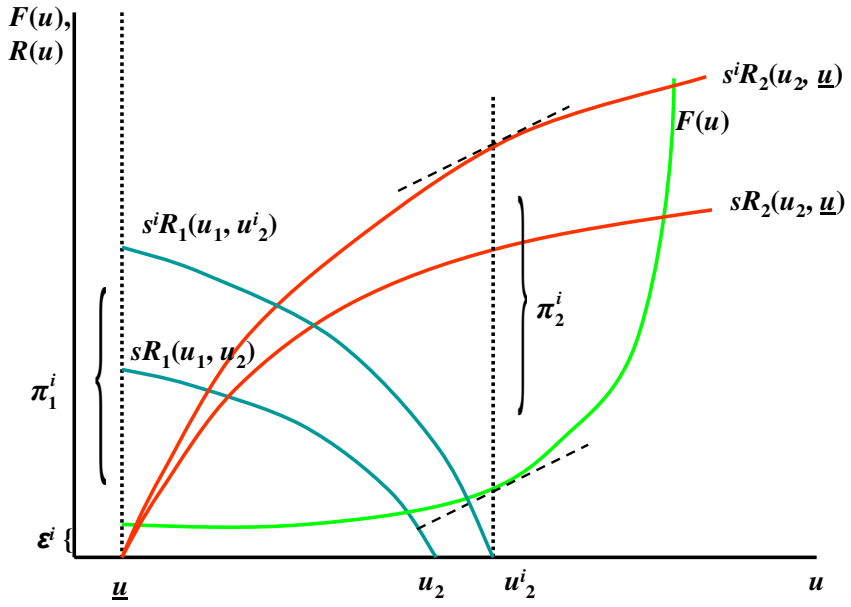
4. North-North Integrated Equilibrium

Perfect information

Suppose two North-North economies with the same uniform distribution of income integrate, where $a_1 = a_2$, and $b_1 = b_2$, 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.

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 the pattern of trade in the integrated equilibrium.

Figure 2: North-North Trade Equilibrium with Perfect Information



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^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 $\underline{u}$. 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.

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 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.[10] 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 equal to the minimum quality 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 lowest 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, $I^t(u) \geq I^d(u) \; \forall \; u > \underline{u}$.[11] Then finally, we assume that there are no variable costs of labeling.[12]

[10] 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.

[11] 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.

In stage 2 of the game, the two firms simultaneously choose quality levels, and whether or not to choose private certification. This certification choice is dependent upon any prevailing governmental labeling policy in effect. Public labeling regimes are distinguished along several fronts: compulsoriness (mandated or voluntary), explicitness (discrete or continuous), and exclusiveness (only government labeling is available or private firms may also certify).[13] Also, in the integrated economy, it is important to distinguish between, the case where the two governments harmonize their autarkic labeling regimes and the case where they mutually recognize each other's autarkic labeling regimes.

In this paper voluntary labeling means the authorities can certify and label goods but it is up to the firm whether it utilizes these services; it may instead choose a private certifier or no certification. Mandatory labeling means the authorities require any firm claiming greater than the lowest possible quality to undergo certification and labeling and pay its associated cost. Unless the government is the exclusive provider of such services, either by decree or by default, the firm may also hire a private firm to certify and label quality. Continuous labels communicate the exact quality level, while discrete labels communicate only that good has quality greater than an established labeling standard.

Given these dimensions of labeling, we now consider five cases where quality information is unverifiable by consumers in the integrated economy, i.e., credence good scenarios: (*NL*) no labeling is possible; (*MNC*) harmonized mandatory, nonexclusive continuous labeling; (*VND*) harmonized voluntary, nonexclusive discrete labeling; (*MED*) harmonized mandatory, exclusive discrete labeling; (*MND*) harmonized mandatory, nonexclusive discrete labeling. By harmonized,

[12] Allowing for variable costs of labeling would be similar to allowing for variable costs of production. As discussed in note 3, such an expansion of the model would not alter our fundamental results.
[13] See Teisl and Roe (1998) for a complete typology of labeling regimes. Examples of each labeling type are listed in our earlier paper (Roe and Sheldon, 2007).

we assume the governments of each country agree upon a single labeling regime for the integrated economy.

(i) Case *NL* - 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 ($\underline{u}$), charges $p^{NL} = b/2$ and earns profits $\pi^{NL} = b^2/4 - \varepsilon^j$, (b) at least some consumers purchase no goods, (c) there are no gains from integration.

The sunk cost of entry, ε^j, 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 lowest quality $\underline{u}$. 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.[14] On the consumer side, because $p^{NL} = b/2$ 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 *MNC* – harmonized mandatory, nonexclusive, 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 harmonized continuous labeling program, but firms are allowed to pay for additional private certification if desired.

Firm profit functions under the relevant labeling regime *l* become:

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

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

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

where the only change from profit functions (12) and (13) under perfect information is the addition of the cost of 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^j, of entering the larger integrated market.

A first, trivial result for this case is that, under our assumptions, firms have no incentive to hire an additional private certifier, as they can already communicate their desired quality level perfectly via the mandated continuous label. This results in the following propositions.

Proposition 5: For the case of North-North harmonized MNC, if $I^t \leq I_{\max}^{MNC} \equiv \pi_2^i(u_1^{MNC}*, u_2^{MNC}*)$ *then two quality levels will be produced; otherwise, case MNC results are identical to case NL results.*

Proposition 6: For the case of North-North harmonized MNC, if $I^t \leq I_{\max}^{MNC}$, *then* $u_1^{MNC}* = u_1^i* = \underline{u}$, $u_2^{MNC}* = u_2^i*$, $p_1^{MNC}* = p_1^i*$, $p_2^{MNC}* = p_2^i*$, $\pi_1^{MNC} = \pi_1^i$, and $\pi_2^{MNC} = \pi_2^i - I^t$.

Proposition 5 outlines a labeling cost threshold, $I_{\max}^{MNC}$. 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 *NL* 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 must now incur 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 harmonized *MNC* labeling.

(iii) Case *VND* – harmonized voluntary, nonexclusive, discrete labeling

In the case of harmonized voluntary, nonexclusive, discrete labeling, we assume that a voluntary labeling program, featuring a single, discrete standard, u_2^g is available to firms in the integrated market. This harmonized level of quality, however, may not coincide with the level of quality that would be chosen by the firm(s). This may occur for several reasons, including that the governments of the integrated market have their own preferences over the quality standard. For the remainder of the section, we assume $u_2^g \neq u_2^i*$, i.e., the harmonized standard does not equal the firm's preferred level of quality.

Because the harmonized standard does not maximize the high-quality firm's profits, and because harmonized labeling is voluntary, the high-quality firm has no incentive to use the harmonized label. Instead, the high-quality firm hires a private firm to certify and label its preferred quality level, which is equal to *MNC*. Furthermore, the firm will choose a discrete rather than a continuous label because, by assumption, it is cheaper.

Proposition 7: For the case of North-North harmonized VND, if $I^d \leq I_{\max}^{VND} \equiv \pi_2^i(u_1^{VND}*, u_2^{VND}*)$ *then two quality levels will be produced; otherwise, case VND results are identical to case NL results.*

Proposition 8: For the case of North-North harmonized VND, if $I^d \leq I_{\max}^{VND}$, $u_1^{VND}* = u_1^i* = \underline{u}$, $u_2^{VND}* = u_2^i*$, $p_1^{VND}* = p_1^i*$, $p_2^{VND}* = p_2^i*$, $\pi_1^{VND} = \pi_1^i$, and $\pi_2^{VND} = \pi_2^i - I^d$.

As for the case of harmonized *MNC*, so long as the high-quality firm is allowed to choose its preferred quality level, the equilibrium price and qualities are no different than the perfect information case. Because the firm incurs fewer costs to implement discrete labeling, it prefers

the harmonized labeling regime of case *VND* to that of case *MNC*. The results for consumer welfare are unchanged from case *MNC* the gains from North-North economic integration still being realized under harmonized *VND*.

(iv) Case *MED* – 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 , and firms are forbidden from certifying and communicating any other standard.

Proposition 9: For the case of North-North harmonized MED, 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* $\gamma(I_{\max}^{VND}) = \delta(I_{\max}^{VND}) = 0$. *Otherwise MED results are identical to NL results.*

Proposition 9 outlines an interval in which the harmonized discrete 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 9 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 next proposition outlines the distributional implications of harmonized standards set higher and lower than firm-preferred standards:

Proposition 10: For North-North harmonized MED 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) decreases (increases) the profits of the low-quality firm, and (d) 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.

(v) Case *MND* – harmonized mandatory, non-exclusive, discrete labeling

This case is very similar to the case of harmonized *MED* in that any firm claiming quality higher than the minimum must pay for the certification and labeling of a chosen, harmonized quality

standard. The key difference between case *MND* and *MED* is that the high-quality firm may also pay a private certification firm to certify and label another quality level. That is, if the harmonized standard is deemed too low by the firm, it may hire a private certifier to verify and communicate a higher quality. If the harmonized standard is deemed too high, the firm may hire a private certifier to verify and communicate a lower quality, u_2^p (though the authorities in the integrated market 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 11: For the case of North-North harmonized MND and $u_2^g \in [u_2^i - \gamma(I^d),\ u_2^0 + \delta(I^d)]$, *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* $u_2^p = u_2^i$*.

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. In other words, the authorities have only a limited sphere of influence on the quality standard in the integrated market when they are not the exclusive provider of certification.

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. 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 $\overline{u}_N = \underline{u} + \sigma$ with $\sigma > 0$, and $\overline{u}_S = \underline{u}$. 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):

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

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

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, $y_n < \frac{b_N}{2}; y_{n\text{-}1} < a_N; y_{n\text{-}2} \leq a_s$, 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-quality good in the South will be eliminated due to economic integration.

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.[15] Consequently, we can write the following proposition:

Proposition 12: 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.

This is an interesting result in that even though North and South 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.[16]

Imperfect information

(i) Cases *NL*, *MNC*, and *VND*

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 harmonize their labeling regulations. In the *NL* case, Proposition 4 still holds, other than the upper end of the

[15] See Beath and Katsoulacos (1991) for further discussion of this result.

[16] 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. 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 should still be driven from the market.

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 harmonized *MNC* (*VND*) cases, the only difference from Proposition 6 (Proposition 8) is that if harmonized public (private) labeling is not too costly, the market will support three goods with qualities, $u_3 > u_2 > \overline{u}_N$, the firms supplying them earning lower profits compared to the perfect information case due to labeling costs, while consumer welfare remains the same.

(ii) Case *MED*

In the North-South harmonized *MED* case, we assume that in the integrated economy, only one harmonized labeling standard u^g, is set, its impact depending on its location relative to what would be optimal for the firms choosing qualities u_3, and u_2. If the harmonized standard is set such that $u^g \leq u_2^i$, 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 results in the following propositions:

Proposition 13: For the case of North-South harmonized MED, if $u^g \leq u_2^i$, *(a) the highest-quality good will be driven from the market, and (b) the integrated market will only support two qualities,* $u_2, \overline{u}_N$, *if the harmonized standard,* $u^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$, *where both* $\gamma(.)$ *and* $\delta(.)$ *are non-negative, decreasing functions* of I^d *and* $\gamma(I_{\max}^{VND}) = \delta(I_{\max}^{VND}) = 0$.

Proposition 14: For the case of North-South harmonized MED and $u^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$, if $u^g \leq u_2^i$ *(a) aggregate consumer welfare decreases, and (b) the welfare of consumers purchasing the minimum and medium-quality goods increases, while the welfare of those purchasing the high-quality good falls, and (c) the profits of the medium and low-quality firms decrease.*

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 $\overline{u}_N \leq u_2^i \leq u^g \leq u_3^i$. This generates two further propositions:

Proposition 15: For the case of North-South harmonized MED, if $u_2^i \leq u^g \leq u_3^i$, *(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* $u_3, \overline{u}_N$ *, if the harmonized standard is either,* $u^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$ *or* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$.

Proposition 16: For the case of North-South harmonized MED where either $u_2^g \in [u_2^i - \gamma(I^d),\ u_2^i + \delta(I^d)]$ *or* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, *if* $u_2^i \leq u^g \leq u_3^i$, *(a) aggregate consumer welfare decreases, (b) the welfare of consumers purchasing the minimum-quality good decreases, while the welfare of consumers purchasing either the medium or high-quality good decreases, and (c) the profits of either the medium or the high-quality firm increase, and the profits of the low-quality firm increase.*

Finally, in the North-South harmonized *MED* case, if the standard is set such that $u_3^i \leq u^g$, this will force the medium-quality good from the market. This results in the following propositions:

Proposition 17: For the case of North-South harmonized MED, if $u_3^i \leq u^g$, *(a) the medium-quality good will be driven from the market, and (b) the integrated market will only support two qualities,* $u_3, \overline{u}_N$, *if the harmonized standard,* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$.

Proposition 18: For the case of North-South harmonized MED and $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, if $u_3^i \leq u^g$ *(a) aggregate consumer welfare decreases, and (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 (c) the profits of the low-quality firm increase while those of the high-quality firm fall.*

As with Proposition 10, the latter follows from the fact that when the standard u_2^g is set higher than u_2^i, price competition is relaxed. This harms consumers of the low-quality good, who

now pay higher prices, while former consumers of the medium-quality good are hurt as it disappears from the market. Consumers of the high-quality good are better off, 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 drives the high-quality firm's profits down.

(iii) Case *MND*

Finally, we consider the North-South harmonized *MND* case. As with the harmonized North-North *MND* case, both the medium and high-quality firms have the opportunity to pay a private firm to certify and label, another quality level if the authorities choose a harmonized standard that is either too high or too low relative to what the two firms would optimally choose. Again, the authorities will communicate to the public if either firm chooses a private standard less than the harmonized public standard, i.e., $u^p < u^g$. The key here is that either one or both firms may choose a private certifier to verify their own standard, depending on how far away the harmonized standard is from their desired quality level. This allows straightforward adaption of previous Proposition 11:

Proposition 19: For the case of North-South harmonized MND, either the medium-quality firm will not hire a private certifier if $u_2^g \in [u_2^0 - \underline{\gamma}(I^d),\ u_2^0 + \underline{\delta}(I^d)]$ *or the high-quality firm will not hire a private certifier if* $u^g \in [u_3^i - \gamma(I^d),\ u_3^i + \delta(I^d)]$, *where* $\underline{\gamma}(I^d) < \gamma(I^d)$ *and* $\underline{\delta}(I^d) < \delta(I^d)\ \forall\ I^d > 0$; *otherwise the medium or/and the high-quality firm will hire a private certifier to verify their private standards* $u_q^p = u_q^i$.

Specifically, there are three possibilities: (i) when $u^g \leq u_2^i$, if the harmonized standard is reasonably close to what is optimal for the medium-quality firm, it will not hire a private certifier, while the high-quality firm will have to hire a private certifier if it wants to remain in

the market. Otherwise both firms will choose private certification, where $u_2^p < u^g < u_3^p$; (ii) when $u_2^i \le u^g \le u_3^i$, if the standard is reasonably close to what is optimal for either the medium or the high-quality firm, either one will hire a private certifier, while the other firm will have to hire a private certifier if it wants to remain in the market; (iii) when $u_3^i \le u^g$, if the standard is reasonably close to what is optimal for the high-quality firm, it will not hire a private certifier, while the medium-quality firm will have to hire a private certifier if it wants to remain in the market. Otherwise both firms will choose private certification, where $u_2^p < u_3^p < u^g$.

The key here is that once the authorities allow for private certification, then either or both firms will necessarily choose and certify their optimal levels of quality if the harmonized standard is too low or too high, and the welfare gains of the perfect information, North-South integrated market will again be realized. This suggests that any attempt by the authorities to choose an exclusive, harmonized standard to benefit the poorest consumers in the integrated market, may actually backfire if it pushes all but the minimum-quality good out of the market.

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 integration of two economies where they agree to harmonize 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 previous sections hold some important implications for harmonized 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 consumer welfare.

When there is harmonized, mandated continuous labeling or when harmonized labeling is voluntary, 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., these harmonized labeling regimes are non-distorting, and the gains from economic integration are realized. In contrast, if the authorities use harmonized discrete labeling, 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 claim 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 both the medium and high-quality goods out of the market. When the authorities do not have exclusive authority to label the credence quality, the harmonized label will be disregarded if it is a voluntary program. Voluntary continuous labels will be eschewed by firms in favor of cheaper, discrete labels certified by private firms. Harmonized voluntary discrete government labels will also be ignored by firms unless the

authorities happen to choose exactly the standard desired by the high-quality firm in the North-North case, and either the medium and/or the high-quality firm in the North-South case.

When the authorities mandate a harmonized discrete label, but do not have the ability to exclude firms from hiring additional private certifiers to verify firm-preferred quality standards, they have a limited sphere on influencing the level of quality that appears in the market. If the government standard deviates by too much from the quality level preferred by the high-quality firm in the North-North case, and either the medium-quality, and/or the high-quality firm in the North-South case, the firms will pay redundant labeling costs to private certifiers to produce and communicate their preferred level of quality and no firm produces at the harmonized quality standard. However, if the government is somewhat close to the firms' preferred quality levels, the high-quality firm in the North-North case, and either the medium-quality and/or the high-quality firm in the North-South case will settle for the harmonized standard rather than pay additional costs to produce a second certification. Hence, the authorities can 'tweak' the market's resulting choice of quality for the credence attribute, but cannot implement large shifts.

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 potentially 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.

In terms of the present paper, this may not matter in the *MNC*, *VND* and *MND* cases. In the former case, there is no divergence between countries' standards, i.e., no standards are set as labeling is continuous. In the latter two cases, even if there is divergence between the standards

set by the two countries, it has no impact as long as firms are able to privately certify their own qualities. However, mutual recognition of standards may affect the results from the *MED* case. 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* 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.

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