Vertical Product Differentiation and Credence Goods: Mandatory Labeling and Gains from International Integration

Ian Sheldon and Brian Roe
(The Ohio State University)

“Quality Promotion through Eco-Labeling: Theoretical and Empirical Advances on the Feasibility of Developing Social and Environmental Claims”

2nd International Workshop at Laboratoire d’Economie Forestière
Nancy, France, June 29-30, 2009
Motivation

- Goods increasingly differentiated by process attributes
- Consumers unable to verify claims about attributes, i.e., a form of *credence good* (Darby and Karni, 1973)
- Labeling possible, but there are implementation issues:
  - discrete vs. continuous labels
  - voluntary vs. mandatory
  - exclusive vs. non-exclusive
  - harmonized vs. mutual recognition
- Examine trade implications of choices in context of model of *vertical* product differentiation
Model

- **Consumers, firms and quality**

Consumers have unit demand for quality-differentiated good, consumer utility is:

(1) \[ U = u(y - p), \]

where \( u \in [u, \infty) \) and \( u > 0 \) is minimum quality-standard

Income uniformly distributed on interval \([a, b]\), and size of population is \( s \)

Firms produce single differentiated good with zero production costs and a fixed, quality-dependent cost, \( F(u) \), sunk by firm after entry:

\[ F(u) = \epsilon + \alpha(u - u)^2, \epsilon \text{ and } \alpha > 0 \]
**Game structure**

3-stage game: (1) entry/no-entry; (2) choice of quality; (3) price

Invoke sub-game perfection and Bertrand-Nash competition

**Labeling policy**

Public certifiers perfectly monitor and communicate quality of individual firms *ex ante*, total cost of certifying and labeling being:

\[ I^i(u) = I^j \text{ for } u > u, \quad j \in \{t, d\}, \text{ and } I^t \geq I^d \]

where \( t = \text{continuous}, \) and \( d = \text{discrete labeling} \)

No economies of scale in public certification, and no variable costs of labeling
Entry and number of firms

Assume:

(2) \[4a > b > 2a \text{ or } b/4 < a < b/2.\]

ensuring covered market of 2 firms with quality levels \(0 < u \leq u_1 < u_2\)

Price equilibrium

\(y^{'}\) is income at which consumer is indifferent to buying either high or low-quality good:

(3) \[y^{'} = (1 - r)p_1 + rp_2,\]

where \(r = u_2 / (u_2 - u_1)\), and \(p_q\) is price of good, \(q = 1, 2\), and if \(p_1 = y\), consumer indifferent between good of quality \(u_1\) and no good
Firms’ profits are:

(4) \[ \pi_1 = sp_1(y' - a) - F(u_1) \]

(5) \[ \pi_2 = sp_2(b - y') - F(u_2) \]

Bertrand-Nash equilibrium prices being:

(6) \[ p_1 = \frac{b - 2a}{3(r - 1)} \]

(7) \[ p_2 = \frac{2b - a}{3r} \]

(6) and (7) holding if \( p_1 \leq a \), so that \( u_1 \geq \hat{u}_1(u_2) = \frac{u_2(b - 2a)}{b + a} \)

- In covered market, equilibrium prices increase in \( b \) and \( (u_2 - u_1) \)
Suppose quality is observable, firms’ profit functions are:

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

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

where \( \hat{u}_1 \) is as defined, and \( \hat{u}_2(u_1) = u_1(b + a)/(b - 2a) \)

Low-quality firm chooses \( u_1^* = \bar{u} \) in equilibrium

Follows from differentiating (9):

(11) \[ \frac{\partial \pi_1}{\partial u_1}(u_1; u_2) = -\frac{2s(b - 2a)^2}{9} \frac{u_2}{(u_1)^2} - F'(u_1) < 0 \text{ for } u_1 > \hat{u}_1(u_2) \]
High-quality firm’s optimal quality decision follows from (10):

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

where

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

Given \( u_1 = u \), firm 2’s choice of quality induces a covered market:

\[ \frac{\partial \pi_2}{\partial u_2} (u_2; u) = 0 \text{ for } u_2 < \hat{u}_2(u) \]

Equilibrium quality in a covered market is implicitly defined by:

\[ u_2^* = \left\{ u_2 \left| \frac{s(2b-a)^2}{9} \frac{u_1}{(u_2)^2} - F'(u_2) = 0 \right. \right\} \]

\( u_1^* = u \) and (13) represent the Nash equilibrium in qualities.
With perfect information on \( u_2^* \), profits of both firms increase with \( b \) and \( s \).

This follows from inspection of (9) and (10).

Aggregate consumer welfare in equilibrium is:

\[
W = \int_a^b \psi u_1^* (\psi - p_1^*) d\psi + \int_{y'}^b \psi u_2^* (\psi - p_2^*) d\psi
\]

As \( u_2 \) increases, (i) welfare of consumers purchasing low-quality good decreases, (ii) proportion of consumers purchasing low-quality good declines, and (iii) aggregate consumer welfare increases.

(i) See utility function (1)

(ii) Differentiate (3) w.r.t \( u_2 \),

\[
\frac{\partial y'}{\partial u_2} = -\frac{2u_1 u_2 (2b - a)}{3(u_2 - u_1)^3} < 0
\]

(iii) In aggregate, consumers value quality over price increases.
Figure 1: Autarky equilibrium with perfect information

\[ F(u), \quad sR(u) \]

\[ sR_1(u_1, u_2) \]

\[ sR_2(u_2, u) \]

\[ \pi_1 \]

\[ \pi_2 \]

\[ \varepsilon \]
North-North Integrated Equilibrium

- **Perfect information (PI)**
  - two economies, \( N=1,2 \), with same distribution of income integrate, \( a_1=a_2 \) and \( b_1=b_2 \), although may be of differing sizes, i.e., \( s^i = s_1 + s_2 \)
  - firms incur additional sunk costs \( \varepsilon^i \) to enter integrated market, but \( u_1 = u_2 \),
  - economy supports 2 firms, i.e., 2 firms have to exit, figure 2
  - increase in quality of good 2, quality of good 1 remaining the same

- **Trade with no labeling (XL)**
  - sunk cost of entry combined with 3-stage game supports entry of single firm into integrated market producing lowest quality
  - price is monopoly outcome given linear demand structure due to assumptions on income distribution
Figure 2: North-North trade equilibrium – PI case
<table>
<thead>
<tr>
<th></th>
<th>MEC</th>
<th>MED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harmonized</td>
<td>Replicates <em>PI</em></td>
<td>May be <em>XL</em> (Figure 3)</td>
</tr>
<tr>
<td>Mutual recognition</td>
<td>Replicates <em>PI</em></td>
<td>May replicate <em>PI</em></td>
</tr>
</tbody>
</table>

*PI* – perfect information

*X* *L* – no labeling

*MEC* – mandatory, non-exclusive, continuous

*MED* – mandatory, exclusive, discrete
Figure 3: Harmonized – MED case
North-South Integrated Equilibrium

- Trade equilibrium with overlapping income distributions
  - if two economies, \( N \) and \( S \) initially support two goods using same technology, but \( a_N > a_S \), and \( b_N > b_S \), and \( u_N > u_S \), there will be three goods in integrated equilibrium if, \( a_N/2 < a_S < a_N < b_N/2 < b_S < b_N \)
  - gains from trade occur due to lower prices in equilibrium
  - \( XL \) generates monopoly outcome
  - \( MEC \) replicates \( PI \)
  - harmonized \( MED \), one or two firms may be forced from market in equilibrium, but not necessarily with mutual recognition