Credence Goods and Vertical Product Differentiation: The Impact of Labeling Policies*

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Motivation

- Goods increasingly differentiated by process attributes, e.g., organic food, dolphin-safe tuna, GM-free food

- 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

- Examine implication of these choices in context of a model of vertical product differentiation (Shaked and Sutton, 1982)

- Allows for endogeneity of entry and quality choice
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 \( u > 0 \)

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

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

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

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

Assume sub-game perfection and Bertrand-Nash competition

■ **Labeling policy**

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

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

where \( t = \) continuous, and \( d = \) discrete labeling
Entry and number of firms

Assume:

(2) \[ 4a > b > 2a. \]

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) \( \pi_1 = sp_1(y' - \max[p_1, a]) - F(u_1) - I^j(u_1) - \epsilon \)

(5) \( \pi_2 = sp_2(b - y') - F(u_2) - I^j(u_2) - \epsilon \).

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 \( p_1 < a \), so that \( u_1 > \hat{u}_1(u_2) = \frac{u_2(b - 2a)}{b + a} \)

- In covered market, equilibrium prices increase in \( b \) and \( (u_2 - u_1) \)
Base Case: Equilibrium with Perfect Information

Suppose quality is observable, firms’ profit functions are:

\[ \pi_1^0(u_1^0; u_2^0) = \frac{s(b - 2a)^2 (u_2^0 - u_1^0)}{9u_1^0} - F(u_1^0) - \epsilon \text{ for } u_1^0 > \hat{u}_1(u_2^0) \]  

\[ \pi_2^0(u_1^0; u_2^0) = \frac{s(2b - a)^2 (u_2^0 - u_1^0)}{9u_2^0} - F(u_2^0) - \epsilon \text{ for } u_2^0 < \hat{u}_2(u_1^0) \]

where \( \hat{u}_1 \) is defined in (8), and \( \hat{u}_2(u_1) = u_1(b + a)/(b - 2a) \)

- Low-quality firm chooses \( u_1^0* = u \) in equilibrium

Follows from differentiating (9):

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

\[
\frac{\partial \pi^0_2}{\partial u^0_2}(u^0_1;u^0_2) = \frac{s(2b-a)^2}{9} \frac{u^0_1}{(u^0_2)^2} - F'(u^0_2) \text{ for } u_2 < \hat{u}_2(u^0_1)
\]

where

\[
\frac{\partial^2 \pi^0_2}{\partial (u^0_2)^2} = -\frac{2s}{9} \left[ \frac{2b-a}{u^0_2} \right]^2 \frac{u^0_1}{u^0_2} - 2\alpha < 0
\]

Given \( u^0_1 = u \), firm 2’s choice of quality induces a covered market:

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

Equilibrium quality in a covered market is implicitly defined by:

\[
u^0_2* = \begin{cases} u^0_2 & \frac{s(2b-a)^2}{9} \frac{u^0_1}{(u^0_2)^2} - F'(u^0_2) = 0 \\
\end{cases}
\]

\( u^0_1* = u \) and (13) represent the Nash equilibrium in qualities
With perfect information on $u_2^0$*, profits of both firms increase with $b$ and $s$

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

Aggregate consumer welfare in equilibrium is:

(14) \[ W = \int_{u_1^{0*}}^{u_1^0} u_1^0* (\psi - p_1^0*)d\psi + \int_{u_2^{0*}}^{u_2^0} u_2^0* (\psi - p_2^0*)d\psi \]

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

(iii) In aggregate, consumers value quality over price increases
Equilibrium with perfect information

\[ F(u) \]

\[ R_1(u_1, u^0_2) \]

\[ R_2(u_2, u) \]

\[ \pi_1 \]

\[ \pi_2 \]

\[ \varepsilon \]
(i) No Labeling

- In presence of credence attributes and no labeling, (a) single firm supplies lowest quality level \( (u) \), charges \( p = b/2 \) and (b) at least some consumers purchase no goods.

  - Sunk cost of entry combined with 3-stage game supports entry of a single firm into market producing lowest quality.

  - Price is monopoly outcome given linear demand structure due to assumptions on income distribution.

  - As \( p = b/2 \) and poorest consumer has income \( a < b/2 \), some consumers do not purchase the good.

(ii) Mandatory, Nonexclusive, Continuous Labeling

- Firms have no incentive to hire a private certifier.
\* If \( l^t \leq l_{\text{max}}^\text{ii} \equiv \pi_2^0(u_1^{\text{ii}^*}, u_2^{\text{ii}^*}) \), two quality levels produced; otherwise, (i) results

\* \( l^t \leq l_{\text{max}}^\text{ii} \), \( u_1^{\text{ii}^*} = u_1^0 = u \), \( u_2^{\text{ii}^*} = u_2^0 = p_1^0 = p_2^0 \), \( \pi_1^{\text{ii}} = \pi_1^0 \), and \( \pi_2^{\text{ii}} = \pi_2^0 - l^t \)

- if two firms enter, labeled market is identical to perfect information market, except profit of high-quality firm

- no change in consumer welfare compared to perfect information case if two qualities are produced, labeling having no influence on price/quality equilibrium

\( \text{Voluntary, Nonexclusive, Discrete Labeling} \)

Government offers voluntary labeling program based on discrete standard, \( u_2^g \), which does not coincide with level of quality firm would choose
High-quality firm hires private firm to certify and label its preferred quality level, and chooses discrete label

- If $l^d \leq l^{iii}_{max} \equiv \pi_{2}^{0}(u_{1}^{iii},u_{2}^{iii})$, two quality levels produced; otherwise,

(iii) identical to (i)

- If $l^d \leq l^{iii}_{max}$, $u_{1}^{iii} *= u_{1}^{0} *= u$, $u_{2}^{iii} *= u_{2}^{0} *= p_{2}^{0} *$, $p_{1}^{iii} *= p_{1}^{0} *$, $p_{2}^{iii} *= p_{2}^{0} *$, $\pi_{1}^{iii} = \pi_{1}^{0}$, and $\pi_{2}^{iii} = \pi_{2}^{0} - l^d > \pi_{2}^{ii}$

- if high-quality firm is allowed to choose quality level, equilibrium price and qualities no different to perfect information case, and consumer welfare is unchanged

(iv) Mandatory, Exclusive, Discrete Labeling

Government requires firm(s) claiming higher than minimal quality to implement single, discrete standard, $u_{2}^{g}$, and forbids private firms from certifying and communicating any other standard
Market supports two qualities if \( u^g_2 \in [u^0_2 - \gamma(l^d), u^0_2 + \delta(l^d)] \) where \( \gamma(.) \) and \( \delta(.) \) are non-negative, decreasing functions of \( l^d \) and \( \gamma(l^{\text{max}}_{\text{iii}}) = \delta(l^{\text{max}}_{\text{iii}}) = 0 \), otherwise (i) results

- government’s discrete labeling standard must fall in an interval for two qualities to be produced, and as labeling costs rise, interval must shrink

- if government chooses standard outside interval, one or both firms earn negative profits, so only one firm enters and market collapses to monopoly outcome

\( u^g_2 < (>u^0_2 \) decreases (increases) aggregate consumer welfare, improves (diminishes) welfare of consumers purchasing low-quality good, decreases (increases) profits of low-quality firm, and decreases profits of high-quality firm in both cases
Mandatory/exclusive/discrete labeling

$F(u)$

$R_2(u^g_2, u)$

$R_1(u, u^g_2)$

$\varepsilon \{u \}$

$u^g_2, u^0_2, u^g_2$
(v) Mandatory, Non-exclusive, Discrete Labeling

- if government chooses too low (high) a standard, firm may hire private certifier to verify and communicate higher (lower) quality, $u^p_2$, but government will communicate to public if $u^p_2 < u^g_2$

- If $u^g_2 \in [u^0_2 - \gamma(I^d), u^0_2 + \delta(I^d)]$, high-quality firm will not hire private certifier if $u^g_2 \in [u^0_2 - \gamma'(I^d), u^0_2 + \delta'(I^d)]$, where $\gamma'(I^d) < \gamma(I^d)$ and $\delta'(I^d) < \delta(I^d) \forall I^d > 0$; otherwise high-quality firm hires private certifier to verify standard $u^p_2 = u^0_2$

- if government standard is close enough to firm’s preferred quality, it will not pay extra cost of certification, otherwise government standard is discarded

- therefore, government has less influence on quality standard when it is not exclusive provider of information
Model Assumptions

- Noisy certification may impact non-distortion results

- Repetition of game may affect relative attractiveness of discrete vs. continuous labeling regimes

- Results still hold if production costs are allowed for, as long as they do not rise more steeply than consumers’ willingness to pay for increases in quality (Shaked and Sutton)

- Wider income distribution allows for more qualities in equilibrium, but discrete/mandated labels still have potential to force firm(s) out, e.g., Scarpa (1998) for case of minimum-quality standards

- Allowing for horizontal vs. vertical quality differentiation – if consumers value credence attribute most, analysis of labeling still relevant, e.g., Irmen and Thisse (1998)
Conclusions

- Labeling can fundamentally affect market structure, generating lower prices and greater consumer choice.

- Government may or may not reduce welfare through its labeling/certification regimes.
  
  - Non-exclusive, mandatory/continuous, and voluntary/discrete labeling is non-distorting.
  
  - Voluntary, non-exclusive labeling may be ignored by firms, either due to cheaper private alternatives, or standard is too far from firm’s optimal quality choice.
  
  - Exclusive, mandatory/discrete labeling can be distorting.
  
  - Non-exclusive, mandatory/discrete labeling gives government limited ability to affect choice of quality.