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

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* Draws on Roe and Sheldon (2006), "Credence Good Labeling: The Efficiency And Distributional Implications of Several Policy Approaches"

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) $\qquad U = u(y - p),$

where $u \in [\underline{u}, \infty]$ and $\underline{u} > 0$

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:

$$F(u) = \varepsilon + \alpha(u - \underline{u})^2 , \; \varepsilon \text{ and } \alpha > 0$$

■ *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:

$$l^j(u) = l^j \text{ for } u > \underline{u}, \quad j \in \{t, d\}, \text{ and } l^t \geq l^d$$

where *t* = continuous, and *d* = discrete labeling

■ *Entry and number of firms*

Assume:

(2) $\qquad$ $4a > b > 2a.$

ensuring *covered* market of 2 firms with quality levels $0 < \underline{u} \leq u_1 < u_2$

■ *Price equilibrium*

y' is income at which consumer is indifferent to buying either high or low-quality good:

(3) $\qquad$ $y' = (1 - r)p_1 + rp_2,$

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

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

Bertrand-Nash equilibrium prices being:

(6) $\quad\quad p_1 = \dfrac{b - 2a}{3(r - 1)}$

(7) $\quad\quad p_2 = \dfrac{2b - a}{3r}$

(6) and (7) holding if $p_1 < a$, so that $u_1 > \hat{u}_1(u_2) = \dfrac{u_2(b - 2a)}{b + a}$

- *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:

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

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

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

● *Low-quality firm chooses $u_1^0 * = \underline{u}$ in equilibrium*

Follows from differentiating (9):

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

High-quality firm's optimal quality decision follows from (10):

$$(12) \qquad \frac{\partial \pi_2^0}{\partial u_2^0}(u_1^0; u_2^0) = \frac{s(2b-a)^2}{9} \frac{u_1^0}{(u_2^0)^2} - F'(u_2^0) \text{ for } u_2 < \hat{u}_2(u_1^0)$$

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

Given $u_1^0 = \underline{u}$, firm 2's choice of quality induces a covered market:

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

Equilibrium quality in a covered market is implicitly defined by:

$$(13) \qquad u_2^0 * = \left\{ u_2^0 \left| \frac{s(2b-a)^2}{9} \frac{u_1^0}{(u_2^0)^2} - F'(u_2^0) = 0 \right. \right\}$$

$u_1^0 * = \underline{u}$ 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:

$$(14) \qquad W = \int_a^{y'} u_1^0{}^*(\psi - p_1^0{}^*)d\psi + \int_{y'}^{b} u_2^0{}^*(\psi - p_2^0{}^*)d\psi$$

- *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, $\quad \dfrac{\partial y'}{\partial u_2^0} = -\dfrac{2u_1^0 u_2^0(2b-a)}{3(u_2^0 - u_1^0)^3} < 0$

(iii) In aggregate, consumers value quality over price increases

Equilibrium with perfect information
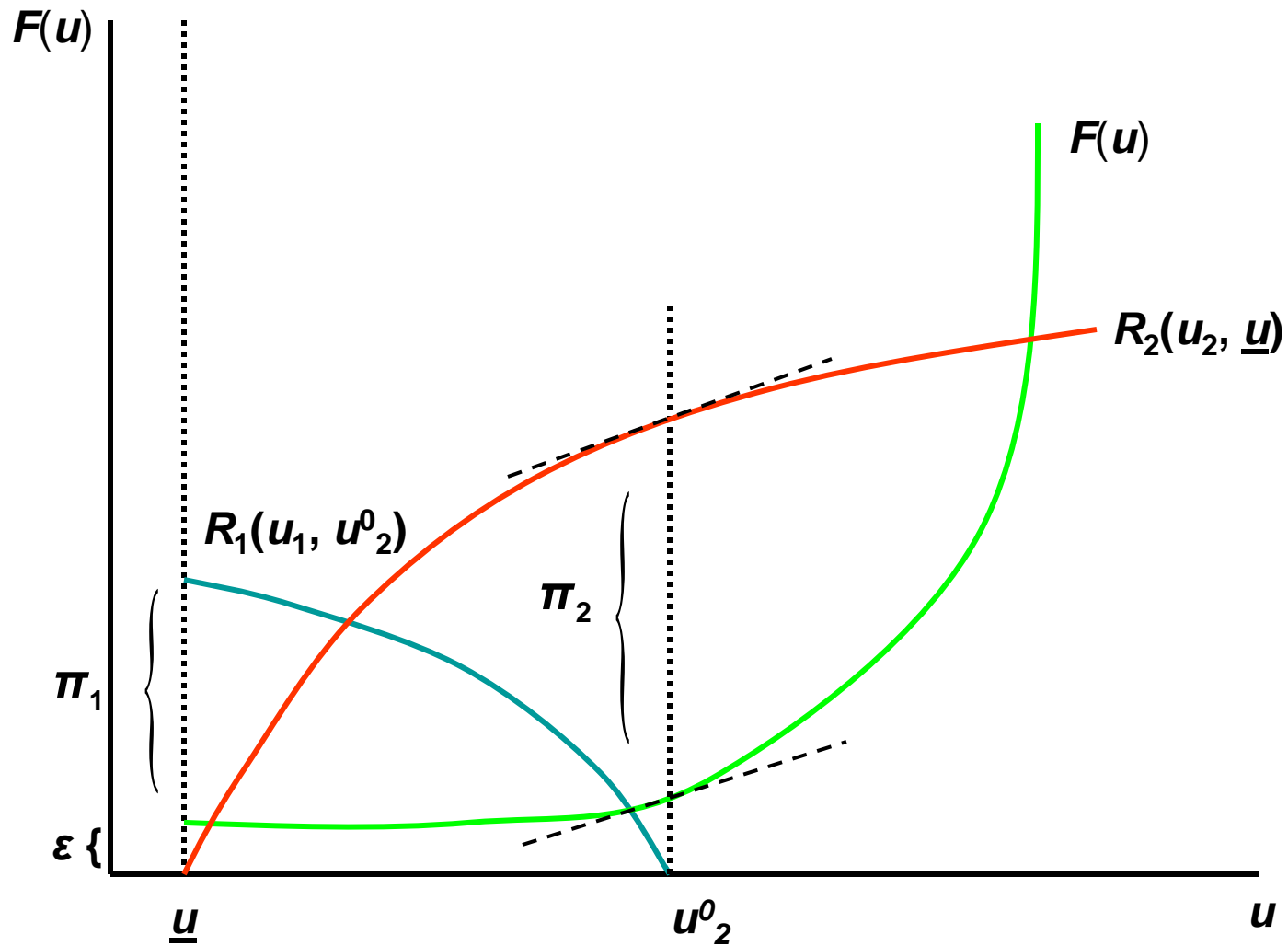
■ *(i) No Labeling*

● *In presence of credence attributes and no labeling, (a) single firm supplies lowest quality level ($\underline{u}$), 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 $I^t \leq I^{ii}_{\max} \equiv \pi^0_2(u^{ii}_1{}^*, u^{ii}_2{}^*)$, *two quality levels produced; otherwise, (i) results***

- **$I^t \leq I^{ii}_{\max}$, $u^{ii}_1{}^* = u^0_1{}^* = \underline{u}$, $u^{ii}_2{}^* = u^0_2{}^*$, $p^{ii}_1{}^* = p^0_1{}^*$, $p^{ii}_2{}^* = p^0_2{}^*$, $\pi^{ii}_1 = \pi^0_1$, and $\pi^{ii}_2 = \pi^0_2 - I^t$**

- 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

- ### *(iii) Voluntary, Nonexclusive, Discrete Labeling*

Government offers voluntary labeling program based on discrete standard, u^g_2, 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 $I^d \leq I_{max}^{iii} \equiv \pi_2^0(u_1^{iii}*, u_2^{iii}*)$, two quality levels produced; otherwise, (iii) identical to (i)*

- *If $I^d \leq I_{max}^{iii}$, $u_1^{iii}* = u_1^o* = \underline{u}$, $u_2^{iii}* = u_2^0*$, $p_1^{iii}* = p_1^0*$, $p_2^{iii}* = p_2^o*$, $\pi_1^{iii} = \pi_1^0$, and $\pi_2^{iii} = \pi_2^0 - I^d > \pi_2^{ii}$*

- 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** $u_2^g \in [u_2^0 - \gamma(I^d), u_2^0 + \delta(I^d)]$ **where** $\gamma(.)$ *and* $\delta(.)$ *are non-negative, decreasing functions of* I^d *and* $\gamma(I_{max}^{iii}) = \delta(I_{max}^{iii}) = 0$, *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

- $u_2^g < (>) u_2^0$ *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

$F(u)$

$F(u)$

$R_2(u^g_2, \underline{u})$

$R_1(\underline{u}, u^g_2)$

ε {

$\underline{u}$ u^g_2 u^0_2 u^g_2 u
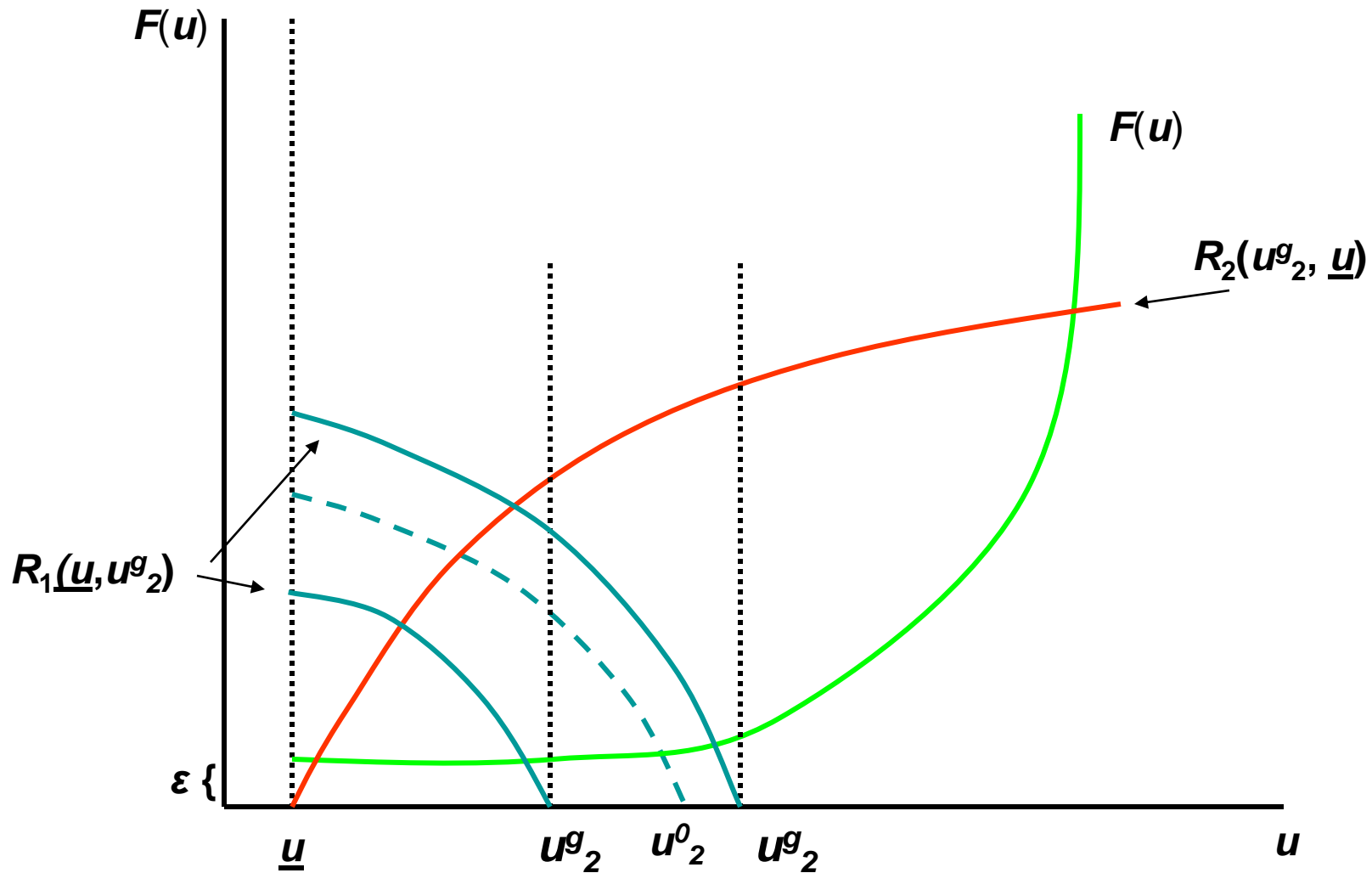
■ *(v) Mandatory, Non-exclusive, Discrete Labeling*

- if government chooses too low (high) a standard, firm may hire private certifier to verify and communicate higher (lower) quality, u_2^p, but government will communicate to public if $u_2^p < u_2^g$

● *If $u_2^g \in [u_2^0 - \gamma(I^d), u_2^0 + \delta(I^d)]$, high-quality firm will not hire private certifier if $u_2^g \in [u_2^0 - \gamma'(I^d), u_2^0 + \delta'(I^d)]$, 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 $u_2^p = u_2^0$ ***

- 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**