On the Interaction of Eco-Labeling and Trade

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29 September, 2019

Stylized Facts

- Consumers consistently express willingness to pay a premium for environmentally friendly goods
- Firms may wish to capitalize on consumers WTP but suffer an asymmetric information problem
- Role for third party to provide information (eco-labeling)
- Concern that eco-labeling used to erect trade barriers
  - WTO case Brazil v. Holland
  - even if contrary to goal of environmentally friendly outcomes

Timber certification

- Consumers in developed countries often express interest in protecting tropical forests
  - environmentally-friendly timber harvesting techniques
    - protection of old-growth forests
    - movement away from clear-cutting
    - approaches that are less likely to adversely impact speciation
- variety of of timber certification programs
  - most focus on production methods
  - several are based in developed countries
- sellers typically bear two types of costs:
  - direct costs (associated with the certification process)
  - indirect costs (associated with converting production technology)
    - indirect costs can be substantial, particularly in tropical zones

Assumptions

1. Two countries: S (south), N (north)
2. Three types of technologies
   - type 1 (brown, present in both countries)
   - type 2 (green, present only in S)
   - type 3 (green, present only in N)
     - $c_3(q) \geq c_2(q) > c_1(q)$ for any $q > 0$
     - $c_2(q) + \beta q > c_3(q)$ for any $q > 0$
3. Consumers in N w.t.p. a premium for green goods
   - inverse D curve for green, $P_G(\cdot)$, lies above inverse D curve for brown, $P_B(\cdot)$, in N
4. Consumers in S don't care about green/brown
   - inverse D curve depends on total sales, $P_S(\cdot)$
5. label available in N
   - one-time cost C, licensing cost b per unit
   - identifies type 3 firms
   - type 2 firms (in S) can obtain label by "adapting"
     - at cost β

Equilibrium: no certification

- price in country N: $P_0 = \theta_0 P_G + (1 - \theta_0) P_B$
  - where $\theta_0 = pr(G) = \frac{Q_{G0}}{Q_{G0}+Q_{B0}}$
    - fraction of green units offered in country N
- price in country S: $P_S^0 = P_0 - \tau$
  - where τ = transport cost between S and N
    - trade equilibrium condition

Market with labeling

- certified price = $P_c = P_G(Q_{GN})$
  - where $Q_{GN} = Q_{3c} + Q_{3u} + Q_{2c}$
  - (total number of green units)
- unlabeled price = $P_u = \nu P_c + (1 - \nu) P_B$
  - where $\nu =$ pr(G | not c)
- Price in country S $= P_S(Q_S)$
  - where $Q_S = Q_{2u} + Q_{S1}$

Profits for type 3 firms

- if certify: $\pi = (P_c - b) - c_3(q_3) - C$
  - max profit at q_3^* : $c_3'(q_3^*) = P_c - b$
- if remain unlabeled: $\pi = P_u q_3 - c_3(q_3)$
  - max profit at q_3^{**} : $c_3'(q_3^{**}) = P_u$
- maximized profits:
  - $\Pi_3^* = (P_c - b)q_3^* - c_3(q_3^*) - C$
  - $\pi_3^* = P_u q_3^{**} - c_3(q_3^{**})$

Profits for type 2 firms

- if certify: $\pi = (P_c - b - \beta - \tau) - c_2(q_2) - C$
  - max profit at $q_2^* : c_2'(q_2^*) = P_c - b - \beta - \tau$
- if remain unlabeled: $\pi = P_S q_2 - c_2(q_2)$
  - max profit at $q_2^{**} : c_2'(q_2^{**}) = P_S$
- maximized profits:
  - $\Pi_2^* = (P_c - b - \beta - \tau)q_2^* - c_2(q_{2*}) - C$
  - $\pi_2^* = P_S q_2^{**} - c_2(q_2^{**})$

Should the firm obtain the eco-label?

- Let $\lambda =$ fraction type 3 that are unlabeled
- Let μ_2 = fraction type 2 units labeled (and exported)
- Let μ_1 = fraction type 1 units exported into N (unlabeled)
  - arbitrage condition: $\mu_1\left(P_S^e - P_u^e + \tau\right) = 0$
    - $Q_S^e = (1-\mu_1)Q_{S1}^e + Q_{2u}^e$
    - $Q_1^e = Q_{N1}^e + \mu_1 Q_{S1}^e$
- then gains to certification for type $k = 2, 3$ are Ω_k:

$$\Omega_3(\lambda,\mu_1,\mu_2) = [P_c^e - b]q_3^*(\lambda,\mu_1,\mu_2) - c_3\left(q_3^*(\lambda,\mu_1,\mu_2)\right) - \left[P_u^e q_3^{**}(\lambda,\mu_1,\mu_2) - c_3\left(q_3^{**}(\lambda,\mu_1,\mu_2)\right)\right]$$

$$\Omega_2(\lambda,\mu_1,\mu_2) = [P_c^e - b]q_2^*(\lambda,\mu_1,\mu_2) - c_2\left(q_2^*(\lambda,\mu_1,\mu_2)\right) - (\beta+\tau)q_2^*(\lambda,\mu_1,\mu_2) - [P_S^e q_2^{**}(\lambda,\mu_1,\mu_2) - c_2\left(q_2^{**}(\lambda,\mu_1,\mu_2)\right)]$$

- it turns out that $\Omega_3 > \Omega_2$

Existence of quilibrium

- Think of 'game' between populations of type 2 and type 3 firms
  - λ and μ_2 are like mixed strategies
- Market equilibrium is akin to mixed strategy NE in this 'game'
  - MSNE exists because $\Omega_k, k = 2, 3$ are continuous in (λ, μ_2)
- Generically, either $\lambda = 0$ or $\mu_2 = 0$
  - (if some type 2 certify then all type 3 will certify)
- let $\underline{C}_3 = \Omega_3$ when $\lambda = 0$, $\overline{C}_3 = \Omega_3$ when $\lambda = 1$
- let $\underline{C}_2 = \Omega_2$ when $\mu = 0$, $\overline{C}_2 = \Omega_2$ when $\mu = 0$

Possible equilibria

1. *class I equilibrium*: $\overline{C}_3 > C > \underline{C}_3 \Rightarrow \lambda^e \in (0,1)$
   - ▷ type 3 indifferent, type 2 prefers to stay in S
2. *class II equilibrium*: $\underline{C}_2 < C < \overline{C}_2$
   - ▷ type 3 prefers to certify, type 2 indifferent
3. If $C \geq C_3^+$ then no sellers certify
4. If $C \leq \underline{C}_2$ then all green sellers certify

Some characteristics of *class I equilibrium*

- Welfare can be higher or lower in than no-information equilibrium
- τ plays no role in outcome
  - $\Rightarrow$ ecolabel does not create trade barrier
- Type 3 sellers benefit from increase in C or b
  - either leads to $\lambda \uparrow \rightarrow$ both $P_c^e, P_u^e \uparrow$
  - hence π_{3*} increases, which implies that Π_{3*} increases
    - P_c^e rises fast enough that revenues increase more than costs

Some characteristics of *class II equilibrium*

- Type 3 sellers are worse off with increase in C or b
- Type 2 sellers are worse off with increase in C or b
- Increases in either τ or β harm type 2 sellers, benefit type 3 sellers

$\Rightarrow$ duality between τ or β

- suggests eco-labels can create a sort of trade barrier
- ambiguous welfare effects

Extension to heterogeneous costs

- suppose production costs are $c_k(q;\alpha_i)$ for a type k firm i
  - larger values of $\alpha_i \rightarrow$ higher costs, higher marginal costs
    - *e.g.*, $c_k(q;\alpha_i) = \alpha_i c_k(q)$
- pdf $f_k(\alpha_j)$and cdf $F_k(\alpha_j)$, $k = S, N$, $j = 1, 2, 3$; defined on the intervals $[\underline{\alpha}_{kj}, \overline{\alpha}_{kj}]$
- $\underline{\alpha}_{S1} < \underline{\alpha}_{S2}$; $\underline{\alpha}_{N1} \leq \underline{\alpha}_{N3}$; $\overline{\alpha}_{S2} \geq \overline{\alpha}_{S1}$; $\overline{\alpha}_{N3} \geq \overline{\alpha}_{N1}$
- produces outcomes where firms separate into different cohorts
  - provides texture for population-based "mixed strategies"
- equilibrium classes, comparative statics broadly similar to above

Timber certification redux

- if types 2 and 3 are similar in terms of sustainability and biodiversity, model suggests eco-labeling has limited ability to promote desired ecological ends
- in S (tropical timber), concern that eco-labeling indirectly yields market conditions favoring brown firms
- in N (temperate timber), eco-labeling has tendency to promote green production
- net outcome depends on relative importance of production in N, S
- to the extent that deforestation is a larger concern in tropical than temperate regions, effect in S is likely to be more important