“Eco-labeling and the gains from agricultural and food trade: A Ricardian approach”

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Motivation

- Analysis of agricultural system should recognize extent of vertical product differentiation, e.g., environmental claims (Sexton, 2013)
- Rapid growth of eco-labeling relating to food and agricultural products since 1970s (Gruére, 2013)
- Trade often expected to generate negative externalities (Copeland and Taylor, 2004)
- However, if production generates environmental benefits, eco-labeling beneficial (Swinnen, 2015)

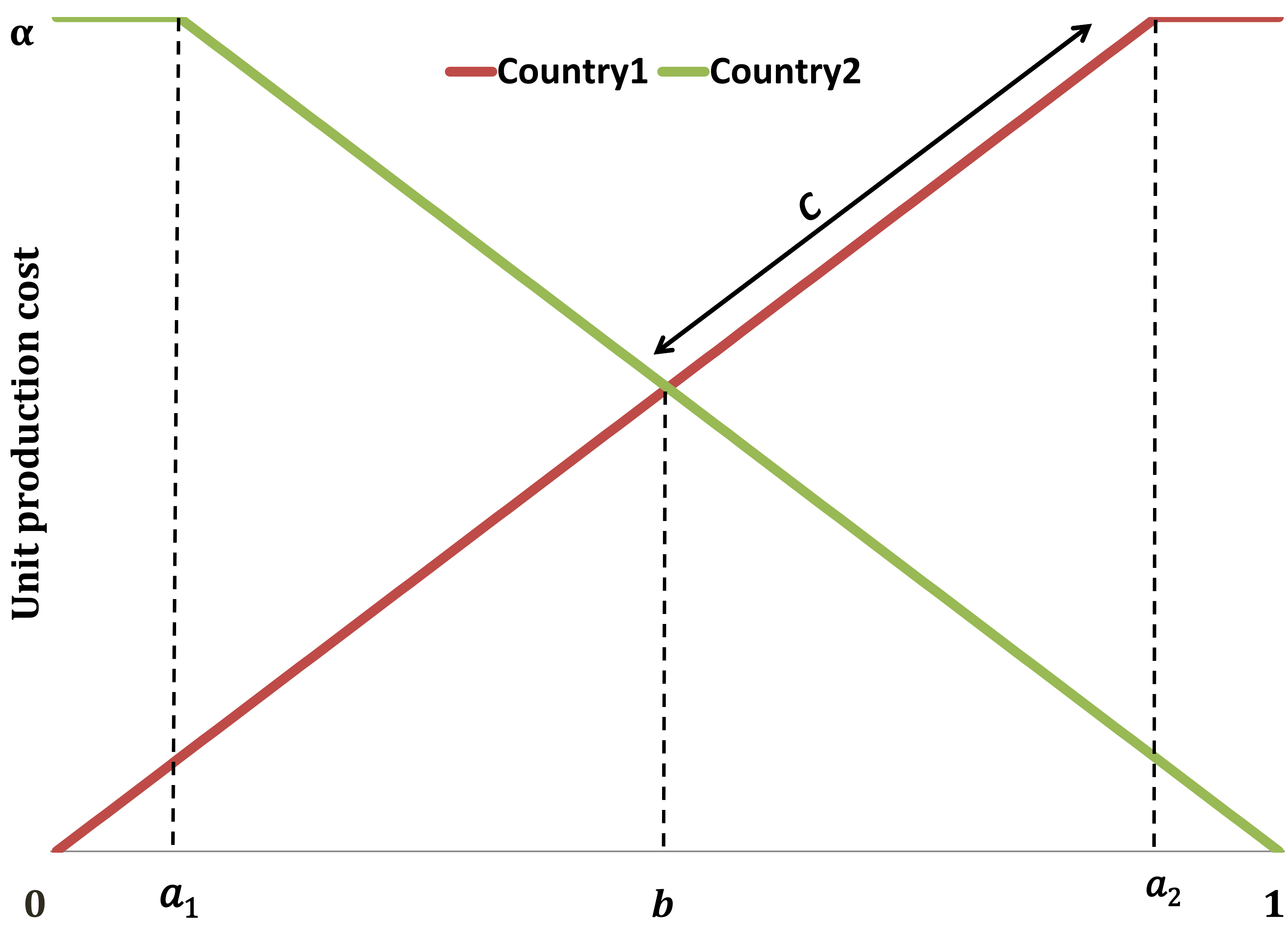
Outline

- **Provide simple illustrative model**
- **Extend to Ricardian-type model drawing on Eaton and Kortum (2002), and others including, *inter alia*, Chor (2010)**
- **Class of model already applied to agricultural trade by Reimer and Li (2010), and Heerman *et al*. (2015)**
- **Use to derive comparative statics concerning impact of labeling of and trade in eco-friendly products**
- **Lay out “recipe” for calibrating model**

Illustrative Model

- Assume two countries, with many buyers, and continuum of agricultural products
- Each country has unique technology for producing each product, markets assumed competitive
- Products ordered by increasing (decreasing) unit costs for countries 1 (2) respectively (Figure 1)
- In autarky, both countries produce all goods with less-than-infinite costs of production

Figure 1: Comparative advantage along the continuum



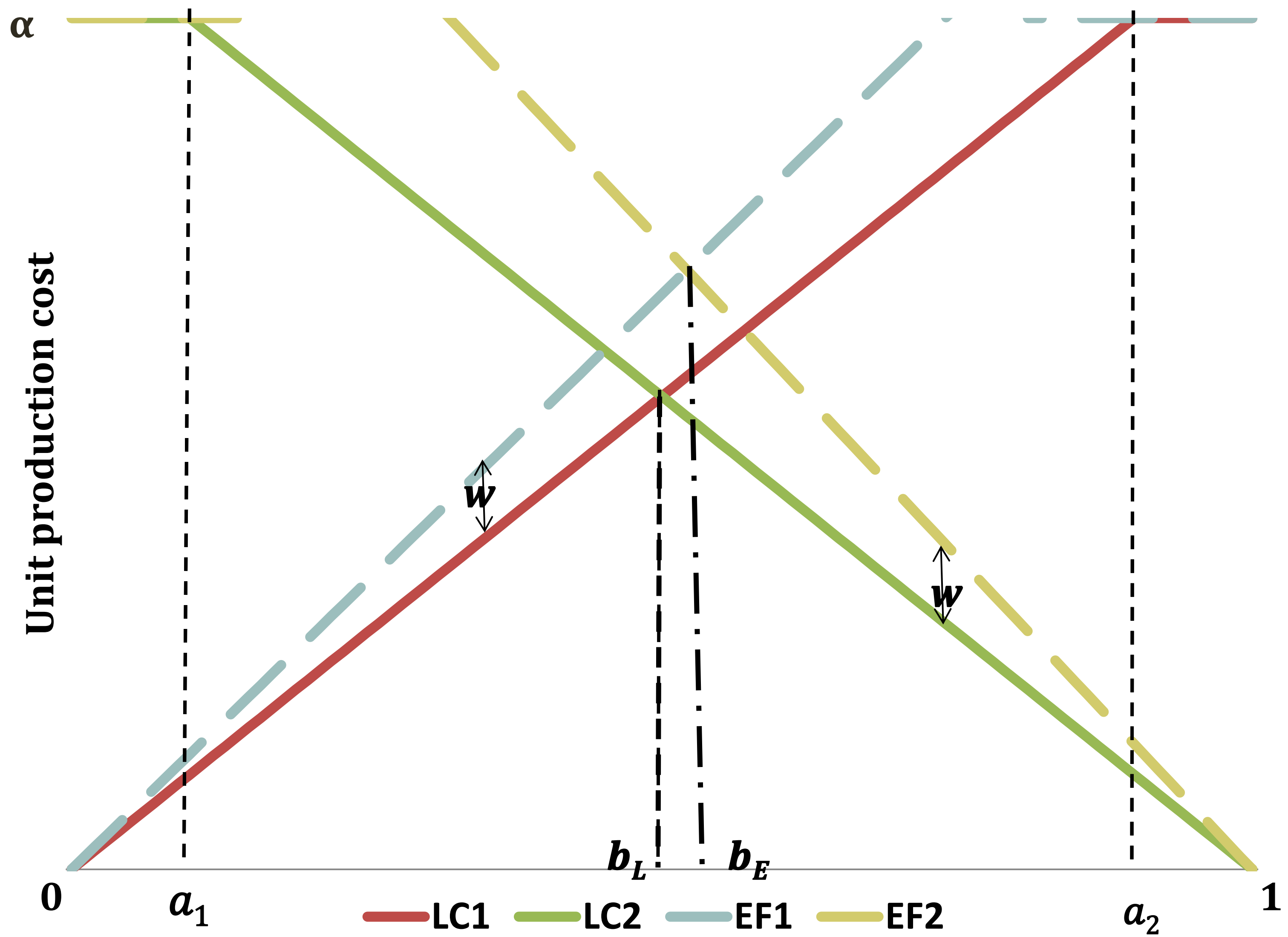
Illustrative Model - I

- **Under autarky, consumers in Country 1(2) buy products 0 to a_2 (1 to a_1)**
- **With trade, all products consumed, Country 1(2) specializing in 0 to b (b to 1)**
- **If products in which country has comparative advantage have lower unit input requirements, and fewer inputs imply lower environmental impact**
- **Hence, environmental gain $f(C)$ when Country 1 stops producing b to a_2**

Illustrative Model - II

- **Suppose producers have access to more environmentally friendly technologies (*EF*), unit costs of production being higher**
- **Subset of consumers always willing to pay higher price for *EF* products**
- **Another subset willing to purchase *EF* as long as price compared to price of lower cost technology *LC* is less than *w***
- **Environmental gain from trade is function of share of consumers who always buy *EF*, α_E, those that buy some *EF*, α_B, and *w*, $f(\alpha_E, \alpha_B, w)$**

Figure 2: Comparative advantage along the continuum



Illustrative Model - II

- With trade, Country 1 produces 0 to b_L with *LC* technology, and specializes in *EF* products from b_L to b_E (Figure 2)
- Eco-labels allow consumers willing to pay higher price for *EF* products to identify them and producers get paid for using *EF* technology
- Eco-labeling gives Country 1 ability to capitalize on its comparative advantage
- Simple model extended to many-country world using Eaton and Kortum approach – model unit costs for each product as random variable

Model

- I countries trade products j, produced along continuum, producers having access to LC and EF:

$$q_i^{LC}(j) = z_i(j)L_i$$
$$q_i^{EF}(j) = z_i(j)L_i^{\alpha}H_i^{1-\alpha}$$

- $z_i(j)$ distributed independently as Frechet:

$$F_i(z) = \exp\{-T_i z^{-\theta}\}$$

- Prices offered by exporter i in n:

$$p_{ni}^{LC}(j) = \frac{r_i \tau_{ni}}{z_i(j)} \qquad p_{ni}^{EF}(j) = \frac{\kappa r_i^{\alpha} w_i^{1-\alpha} \tau_{ni} \zeta_{ni}}{z_i(j)}$$

Model

- Consumers in *n* buy *LC* and *EF* products at lowest price on offer:

$$p_n^k(j) = \min_i\{p_{ni}^k(j)\}$$

- Productivity distribution used to derive distributions of *EF* price offers by *i* in *n*, and prices of *EF* products offered in *n* :

$$G_{ni}^{EF}(p) = 1 - exp\left\{-T_i\left(\kappa r_i^{\alpha} w_i^{1-\alpha} \tau_{ni} \zeta_{ni}\right)^{-\theta} p^{\theta}\right\}$$

$$G_n^{EF}(p) = 1 - exp\{-\Phi_n^{EF} p^{\theta}\}$$

where: $\Phi_n^{EF} = \sum_{l=1}^{I} T_l\left(\kappa r_l^{\alpha} w_l^{1-\alpha} \tau_{nl} \zeta_{nl}\right)^{-\theta}$

Model

- **Setting $\alpha = \zeta_{ni} = 1$:**

$$G_{ni}^{LC}(p) = 1 - exp\{-T_i(r_i\tau_{ni})^{-\theta}p^{\theta}\}$$

$$G_{n}^{LC}(p) = 1 - exp\{-\Phi_n^{LC}p^{\theta}\}$$

where: $\Phi_n^{LC} = \sum_{l=1}^{I} T_l(r_l\tau_{nl})^{-\theta}$

- Φ_n^k, ***k*=*EF*,*LC*** **describe how average productivity, input costs, trade and labeling costs affect prices of each type of good in each import market**
- **Lower trade costs allow consumption with smaller environmental impact, even without reallocation of consumption to *EF* products**

Model

- Using price distributions, probability *i* offers lowest prices of *EF* and *LC* products in *n*:

$$\pi_{ni}^{EF} = \frac{T_i\left(\kappa r_i^{\alpha} w_i{}^{1-\alpha}\tau_{ni}\zeta_{ni}\right)^{-\theta}}{\Phi_n^{EF}}$$

$$\pi_{ni}^{LC} = \frac{T_l(r_l\tau_{nl})^{-\theta}}{\Phi_n^{LC}}$$

- With continuum, these are also fraction of products that consumers in *n* purchase from *i*:

$$\frac{X_{ni}^k}{X_n^k} = \frac{\pi_{ni}^k \int_0^1 Q^k(j)dj \int_0^{\infty} p dG_n^k(p)}{\int_0^1 Q^k(j)dj \int_0^{\infty} p dG_n^k(p)} \equiv \pi_{ni}^k \qquad (1)$$

Model

- Consumers have preferences over products, choosing *EF* and *LC* to maximize:

$$\frac{\sigma}{\sigma-1}\left(\int_0^1 q_i^{LC}(j)^{\frac{\sigma-1}{\sigma}}dj+\omega_i^{\frac{1}{\sigma}}\int_0^1 q^{EF}(j)^{\frac{\sigma-1}{\sigma}}dj\right)$$

- Implies total expenditure on *EF* relative to *LC*:

$$\frac{x_i^{EF}}{x_i^{LC}}=\omega_i\left(\frac{P_i^{EF}}{P_i^{LC}}\right)^{1-\sigma}$$

P_i^k is CES price index, $P_i^k=\gamma\Phi_n^{k\,\frac{1}{\theta}}, k=LC, EF$ – consumers only choose *EF* if labeled

Model: Solution and parameterization

- **Given T_i, τ_{ni}, ζ_{ni}, H_i and ω_i, equilibrium is r_i, w_i, π_{ni}^{LC}, π_{ni}^{EF}, x_i^{LC}, x_i^{EF} and L_i^{LC}, L_i^{EF}, such that labor markets clear and trade is balanced**
- **Solve for *LC*-type equilibrium variables, obtaining land rental rate r_i, and then solve for equilibrium w_i, and *EF*-type equilibrium values**
- **Parameterization/calibration requires values for T_i, θ, τ_{ni}, σ, and ω_i**
- **Standard approach : log-linearize (1) and estimate gravity-like equation to get, T_i, τ_{ni} and $\hat{\zeta}_{ni}$, use values of θ and σ from literature, and also solve for ω_i**

Model: Solution and parameterization

Table 1: Parameters, their meaning and step in which they are addressed		
α	Land's value-added share in organic production	Step 1
T_i	Mean parameter for productivity distribution	Step 3
θ	Dispersion parameter for productivity distribution	Step 1
τ_{ni}	Bilateral trade costs	Step 2
ζ_{ni}	Organic labeling costs in market n in excess of exporter i's labeling costs	Step 4
σ	Elasticity of substitution	Step 1
ω_i	Consumer love of sustainability	Step 5

Table 2: Data Requirements	
X_{ni}^{LC}, X_{ni}^{EF}	Value of bilateral trade flows in agriculture and organic agriculture (used to calculate π_{ni}^{k}, bilateral market shares)
Y_i^{LC}, Y_i^{EF}	Value of agricultural and organic agricultural production (used to calculate π_{ni}^{k}, bilateral market shares)
L_i	Total land endowment
H_i	Total skilled labor force endowment

Comparative Statics: Labeling

- **Labeling increases *EF* trade flows:**

(i) Labelling increases share of *EF* expenditure on imports:

$$\pi_{nn}^{EF} = \frac{T_n\left(\kappa r_n^{\alpha} w_n^{1-\alpha}\right)^{-\theta}}{\Phi_n^{EF}} = \frac{T_n\left(\kappa r_n^{\alpha} w_n^{1-\alpha}\right)^{-\theta}}{\sum_{l=1}^{I} T_l\left(\kappa r_l^{\alpha} w_l^{1-\alpha} \tau_{nl}\zeta_{nl}\right)^{-\theta}}$$

Without labeling $\zeta_{ni} = \infty$, consumers do not recognize imported *EF* as distinct from *LC* products, therefore:

$$\Phi_n^{EF} = T_n\left(\kappa r_n^{\alpha} w_n^{1-\alpha}\right)^{-\theta} \text{ and } \pi_{nn}^{EF} = 1$$

As labeling costs fall, Φ_n^{EF} increases and π_{nn}^{EF} falls, i.e., import share of expenditure on *EF* products rises

Comparative Statics: Labeling

(ii) Labeling increases share of total expenditure allocated to *EF* products:

By definition, $X_i = X_i^{EF} + X_i^{LC}$, therefore:

$$\frac{X_i^{EF}}{X_i} = \frac{\omega_i \left(p_i^{EF}/p_i^{LC}\right)^{1-\sigma}}{1 + \omega_i \left(p_i^{EF}/p_i^{LC}\right)^{1-\sigma}}$$

Recall $p_n^{EF} = \gamma {\Phi_n^{EF}}^{-1/\theta}$, so lower labeling costs implies lower prices for *EF* products

Therefore, since lower labeling costs have no impact on Φ_n^{LC}, introducing *EF* labels lowers $\left(p_i^{EF}/p_i^{LC}\right)$

Comparative Statics: Land and *EF*

- **Optimal land allocation implies:**

$$\frac{L_i^{EF}}{L_i^{LC}} = \frac{\sum_n \pi_{ni}^{EF} X_n^{EF}}{\sum_n \pi_{ni}^{LC}\left(X_n - X_n^{EF}\right)}$$

Already established that π_{ni}^{EF} increases with eco − labeling, as does share of expenditure allocated to *EF*

$X_n - X_n^{EF}$ is also decreasing in import markets where labeling of *i*'s *EF* products is introduced

Therefore, share of land allocated to *EF* production increases for exporter *i*

Comparative Statics: Mutual recognition

- **Recognition of *i*'s labelling in *n* implies:**

$$\pi_{ni}^{EF} = \frac{T_i\left(\kappa r_i^{\alpha} w_i^{1-\alpha}\tau_{ni}\right)^{-\theta}}{\Phi_n^{EF}}$$

$$\Phi_n^{EF} = T_n\left(\kappa r_n^{\alpha} w_n^{1-\alpha}\right)^{-\theta} + T_i\left(\kappa r_i^{\alpha} w_i^{1-\alpha}\tau_{ni}\right)^{-\theta} + \sum_{l \neq i,n} T_l\left(\kappa r_l^{\alpha} w_l^{1-\alpha}\tau_{nl}\zeta_{nl}\right)^{-\theta}$$

Φ_n^{EF} increases, and given:

$$\frac{\Phi_n^{EF}}{\Phi_n^{LC}} = \left(\frac{p_i^{EF}}{p_i^{LC}}\right)^{-\theta}$$

Relative price of *EF* products declines, *EF* trade flows increase for fixed level of expenditure