

“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)
- Eco-labeling key to resolving information asymmetry associated with environmental *credence* goods
- Rapid growth of eco-labeling relating to food and agricultural products since 1970s (Gruère, 2013)
- Trade often expected to generate negative externalities (Copeland and Taylor, 2004)
- However, if production generates environmental benefits, eco-labeling beneficial (Swinnen, 2015)

Outline

- **Develop Ricardian-type model drawing on Eaton and Kortum (2002), and others including, *inter alia*, Chor (2010), Waugh (2010), Fieler (2011)**
- **Class of model already applied to agricultural trade by Reimer and Li (2010), Reimer (2015), 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**

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 Fréchet:

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

- Prices offered by exporter i in n :

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

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 :

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

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

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

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 around world 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 :

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

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

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

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

Model

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

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

- 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

Comparative Statics: Labeling

■ Labeling increases *EF* trade flows:

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

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

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

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

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:

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

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 (p_i^{EF} / p_i^{LC})

Comparative Statics: Land and *EF*

- Optimal land allocation implies:

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

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 labeling in n implies:

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

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

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 input 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} , ζ_{ni} , σ , and ω_i
- Standard approach: log-linearize (1) and estimate gravity-like equation to get, T_i , and τ_{ni} , use values of θ and σ from literature, and solve for ζ_{ni} and ω_i

Model: Solution and parameterization

Table 1: Key Parameters

α	Land's value-added share in organic production (1-average labor share of value-added)	0.65 (OECD, 2009)
w_i	Solve out assuming $H_i=1$ for all countries	Calibrate
r_i	Country's agricultural output/hectare of arable land	World Bank (2012)
T_i	Mean parameter for productivity distribution	Estimate
θ	Dispersion parameter for productivity distribution	2.83 (Reimer and Li, 2010)
τ_{ni}	Bilateral trade costs	Estimate
ζ_{ni}	Organic labeling costs in market n in excess of exporter i 's labeling costs	Calibrate
σ	Elasticity of substitution	1.5 (Ruhl, 2008)
ω_i	Consumer love of sustainability	Calibrate

Model: Solution and parameterization

- Following Reimer and Li (2010), define:

$$S_i = \ln(T_i) - \theta \ln(r_i)$$

- Average productivity and trade cost parameters from gravity-like structural relationship in *LC*:

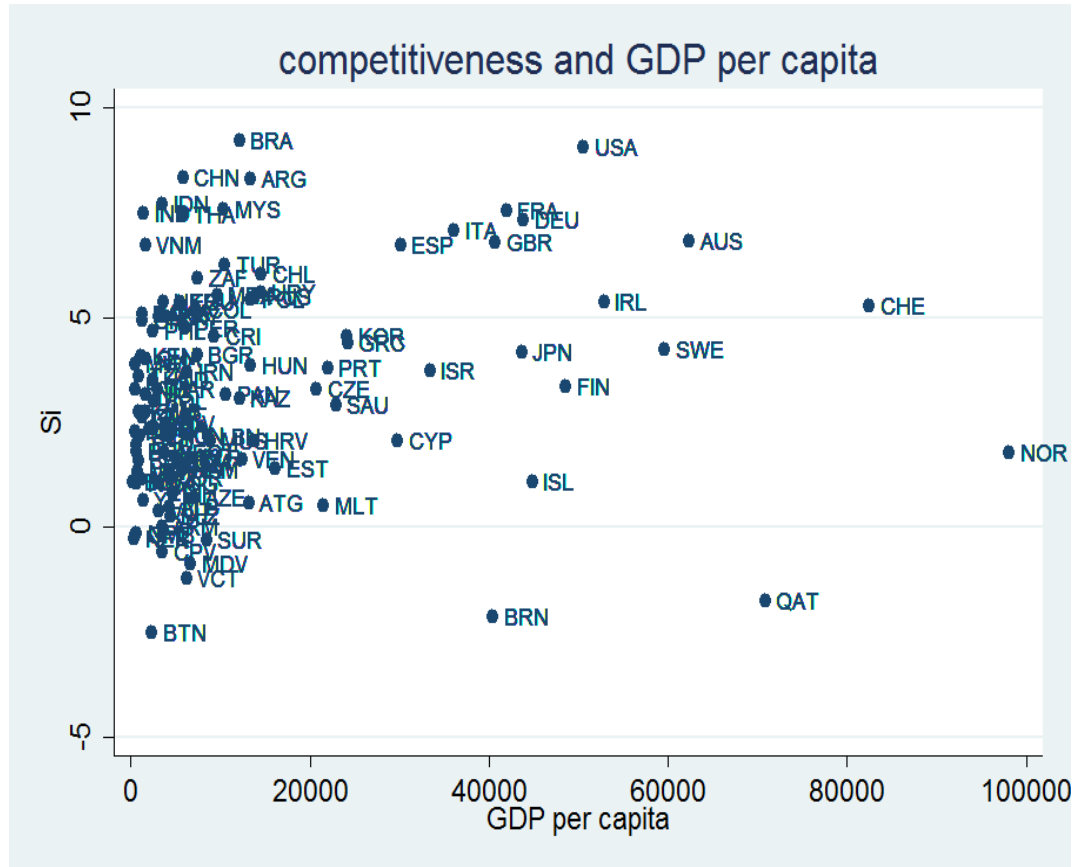
$$\ln\left(\frac{\pi_{ni}^{LC}}{\pi_{nn}^{LC}}\right) = S_i - \theta \left(b_{ni} + l_{ni} + RTA_{ni} + \sum_m d_{mni} + ex_i \right) - S_n$$

$$\ln(\tau_{ni}) = b_{ni} + l_{ni} + RTA_{ni} + \sum_m d_{mni} + ex_i + \xi_{ni}$$

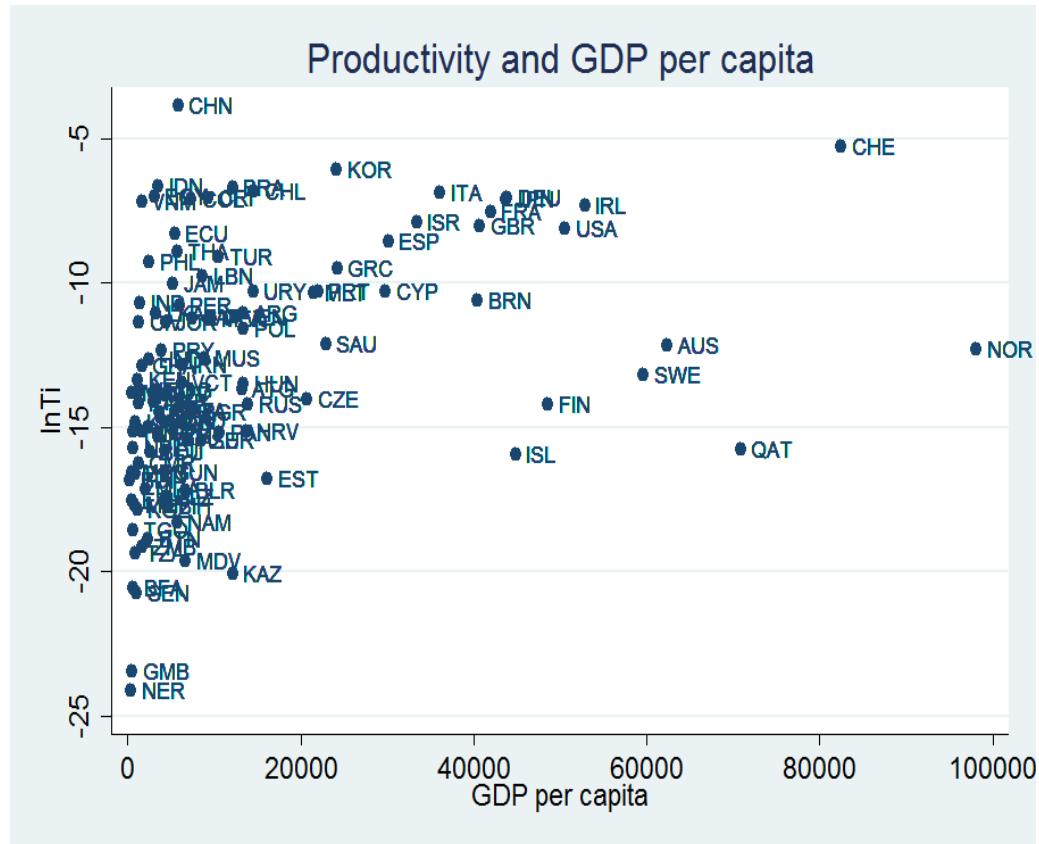
Gravity Equation - 2011

Variable	Estimate
D1 (0,375)	-9.468 (0.501)
D2 (375,750)	-10.583 (0.473)
D3 (750, 1500)	-11.610 (0.463)
D4 (1500, 3000)	-12.112 (0.460)
D5 (3000, 6000)	-13.055 (0.465)
D6 (6000, max)	-13.509 (0.467)
Border	0.588 (0.165)
Language	1.144 (0.096)
RTA	1.024 (0.088)
R ²	0.95
Sample-size	6,202

Average S_i (2010-13)



Average $\ln T_i$ (2010-13)



Next Steps

- **Use parameterized model to explore impact of alternative eco-labelling policies:**
 - **Mutual recognition**
 - **Regulatory harmonization**
- **Allow for non-homothetic preferences to explore impact of income differences across i (Fieler, 2011)**
- **Construct index of environmentally-friendly production by country**