"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 (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

- **Develop Ricardian-type model drawing on Eaton and Kortum (2002), and others including, *inter alia*, Waugh (2010), Fieler (2011), Levchenko and Zhang (2014)**
- **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, and initial estimation of gravity equation**

Modern Ricardian Approach

- Difficult to adapt Dornbusch, Fischer and Samuelson (1977) to multi-country setting
- Contribution of Eaton and Kortum (2002): focus on parameters of productivity distribution
- Given country will be more productive than others at producing range of goods in continuum – generates reason for trade
- Generates gravity-like structure between share of spending on imports and trade costs (Arkolakis, Costinot and Rodriguez-Clare, 2012)

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:

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

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 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*:

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

$$\pi_{ni}^{LC} = \frac{T_i(r_i\tau_{ni})^{-\theta}}{\Phi_n^{LC}}$$

- 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:

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

- 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, $P_i^k=\gamma {\Phi_n^k}^{-1/\theta}$, $k=LC,EF$ – consumers only choose *EF* if labeled

Comparative Statics: Labeling

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

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

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

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 labeling 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

Model: Solution and parameterization

- Given T_i, τ_{ni}, ζ_{ni}, H_i and ω_i, equilibrium is r_i, w_i, $\pi_{ni}^{LC}, \pi_{ni}^{EF}, X_i^{LC}, X_i^{EF}$ 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 $T_i, \theta, \tau_{ni}, \zeta_{ni}, \sigma$, 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

- Normalize π_{ni}^{LC} by π_{nn}^{LC}:

$$\frac{\pi_{ni}^{LC}}{\pi_{nn}^{LC}} = \frac{X_{ni}^{LC}}{X_{nn}^{LC}} = \frac{T_i(r_i\tau_{ni})^{-\theta}}{T_n(r_n)^{-\theta}} = \frac{T_i}{T_n}\left(\frac{r_i}{r_n}\right)^{-\theta}\tau_{ni}^{-\theta}$$

and taking the log:

$$\ln\left(\frac{X_{ni}^{LC}}{X_{nn}^{LC}}\right) = \ln\frac{T_i}{T_n} - \theta\ln\frac{r_i}{r_n} - \theta\ln\tau_{ni}$$

- Following Reimer and Li (2010), define:

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

Model: Solution and parameterization

- Substituting S_i in for T_i:

$$\ln\left(\frac{X_{ni}^{LC}}{X_{nn}^{LC}}\right) = -\theta \ln \tau_{ni} + S_i - S_n$$

- Gravity-like structural relationship in LC:

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

where:

$$-\theta \ln(\tau_{ni}) = b_{ni} + l_{ni} + RTA_{ni} + \sum_c d_{c_{ni}} + ex_i + \xi_{ni}$$

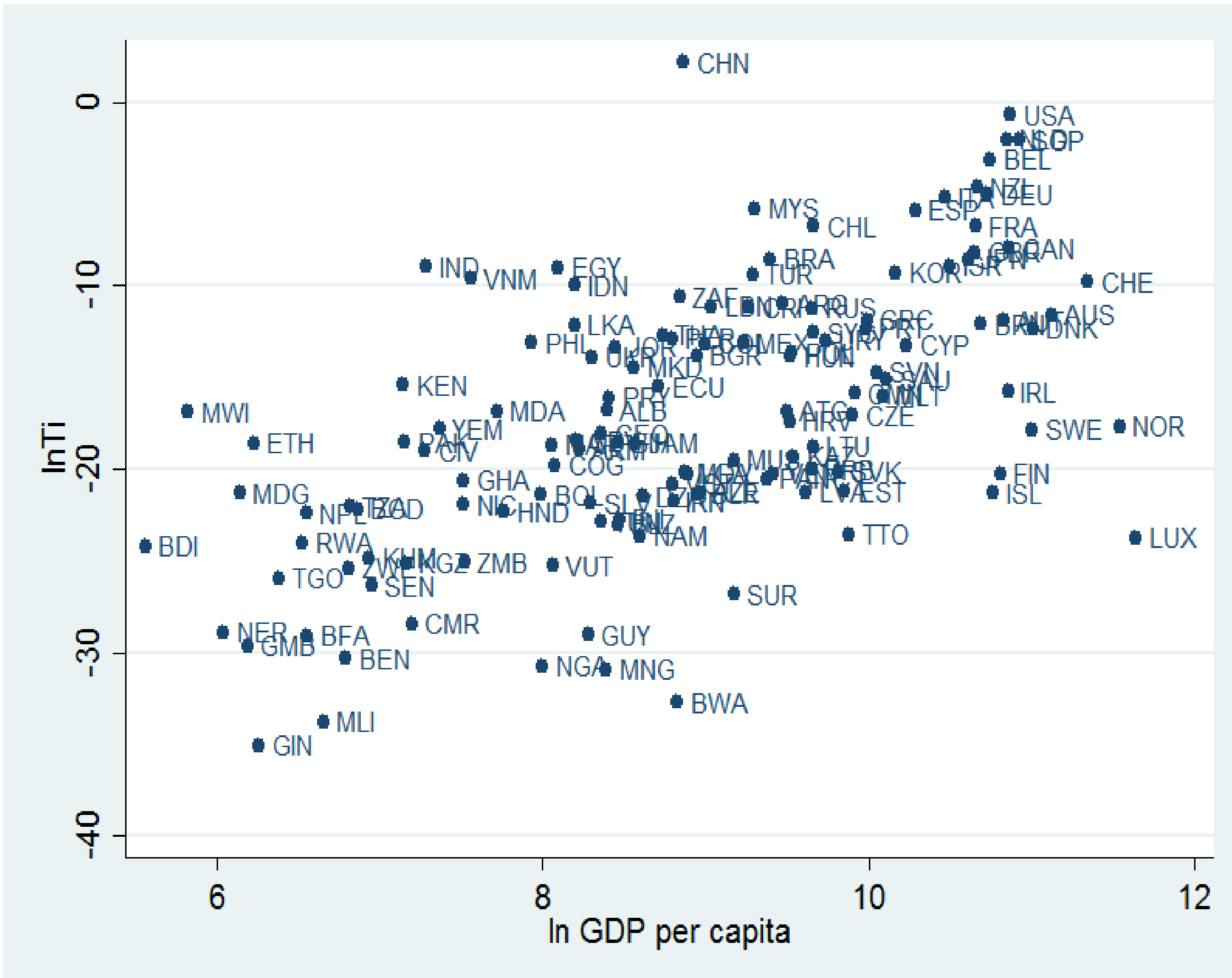
Gravity Equation Estimates

Variable	2010		2013	
D1 (0,375)	-12.71***	(0.50)	-12.92***	(0.45)
D2 (375,750)	-14.99***	(0.30)	-14.41***	(0.28)
D3 (750, 1500)	-17.92***	(0.20)	-17.34***	(0.20)
D4 (1500, 3000)	-19.75***	(0.14)	-19.28***	(0.15)
D5 (3000, 6000)	-20.92***	(0.08)	-20.82***	(0.09)
D6 (6000, max)	-21.30***	(0.17)	-21.33***	(0.12)
Border	1.30***	(0.45)	1.01***	(0.41)
Language	1.35***	(0.18)	1.30***	(0.19)
RTA	2.88***	(0.21)	3.35***	(0.21)
Adjusted R^2	0.51		0.53	
Sample-size	11,955		12,099	

*** Significant at 1 percent level

lnT_i (2010, θ=2.83)

$\ln T_i$ (2013, θ=2.83)



Next Steps

- **Use parameterized model to evaluate 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), i.e., North vs. South and differing standards**
- **Introduce explicit environmental damage function**
- **Use pesticide standards to pin down weight ω_i on consumer preferences in utility function**