“Sustainable Agricultural Production, Income and Eco-Labelling: What Can Be Learned from a Neo-Ricardian Approach?”

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General Remarks

- **Definition of sustainability matters, i.e., *weak* vs. *strong***
- **Economic models accounting for sustainability objectives highlight importance of interdisciplinary research – especially *ex post* evaluation**
- **Nature and resolution of information asymmetries over sustainability is critical, i.e., *diagnosis* vs. *treatment***
- **Need to account for income effects in analyzing standards**
- **Trade models need to do better job of accounting for vertical market structures**
- **With free-riding in sustainability agreements, economic/legal analysis of standards may have to address issue of appropriate border adjustments**

Motivation

- **Analysis of agricultural system should recognize extent of vertical product differentiation, e.g., environmental and sustainable production claims (Sexton, 2013)**
- **Eco-labelling key to resolving information asymmetry associated with environmental *credence* products**
- **Rapid growth of eco-labelling 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 sustainability benefits, eco-labelling beneficial (Swinnen, 2015)**

Outline

- **Develop Ricardian-type model drawing on Eaton and Kortum (2002), and others including, *inter alia*, Fieler (2011), and Levchenko and Zhang (2014)**

- **Class of model applied to agricultural trade by Reimer and Li (2010), Reimer (2015), Heerman *et al*. (2015), Costinot *et al*. (2016), Gouel and Laborde (2017), Heerman and Sheldon (2018), and Heerman (2020)**

- **Use to derive comparative statics concerning impact of eco-labelling of and trade in sustainable products, allowing for non-homothetic preferences**

- **Sustainability dimension relates to use of water**

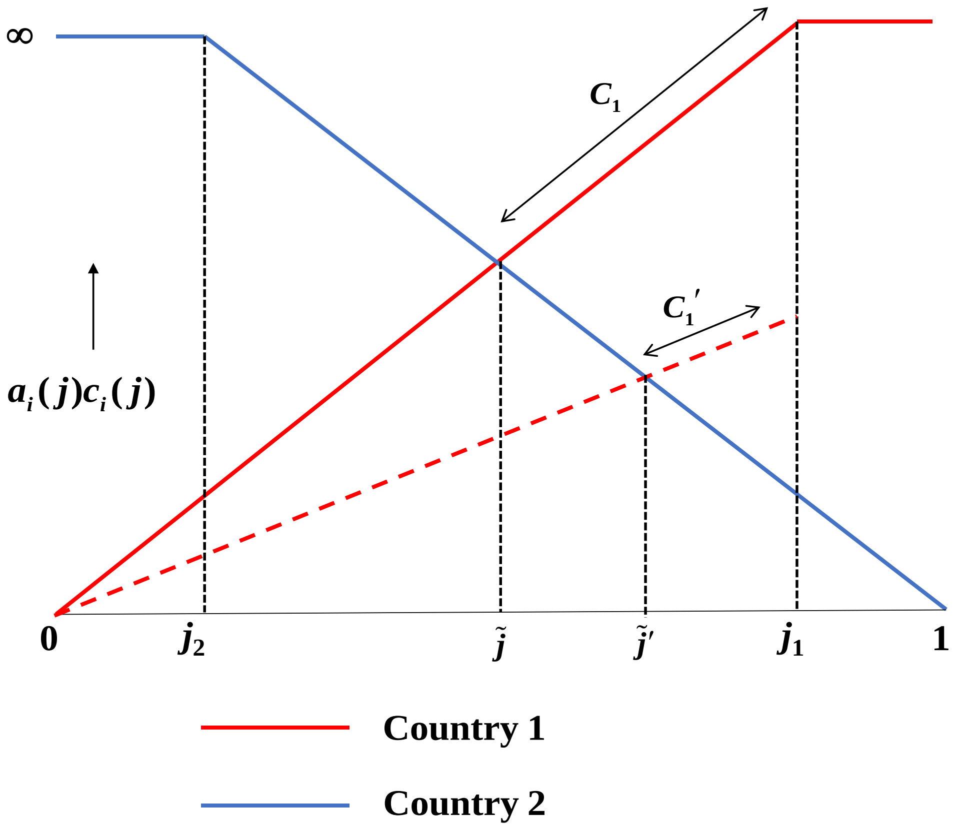
Water

- **Competition for scarce water resources has intensified in past 70 years (Molden, 2007)**
- **Although perceived by many as an abundant natural resource, fresh water is becoming limited due to over-consumption – posing threat to humans, ecosystems, and biodiversity (Weinzettel and Pfister, 2019)**
- **80% of world's population live in areas where there is significant risk to water security – notably regions of intensive agriculture (Vörösmarty *et al*., 2010)**
- **Steffen *et al*. (2015) propose boundaries on annual global water consumption**

Modern Ricardian Approach

- Dornbusch, Fischer and Samuelson (1977) two-country model gives some intuition (Figures 1)
- Difficult to adapt 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 products in continuum – generates reason for trade with implications for sustainability
- Following Heerman (2020), local agroecological characteristics also included in analysis

Figure 1: Comparative Advantage in the Continuum



Model

- I countries trade products j^k, produced along continuum, with technology $k \in U,S$:

$$q_i^U(j^U) = z_i(j^U)\left[(a_i(j^U)\Upsilon_i)\right]$$

$$q_i^S(j) = z_i(j^S)\left[(a_i(j^S)\Upsilon_i)^{\alpha} H_i^{1\text{-}\alpha}\right]$$

- $z_i(j^k)$ distributed independently as Fréchet:

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

- Prices offered by exporter i in n:

$$p_{ni}^U(j^U) = \frac{\tilde{a}_i(j^U)c_i^U(j^U)\tau_{ni}}{z_i(j^U)} \qquad p_{ni}^S(j^S) = \frac{\tilde{a}_i(j^S)c_i^S(j^S)\tau_{ni}\zeta_{ni}}{z_i(j^S)}$$

Model

- **Consumers have preferences over products, choosing *S* and *U* to maximize:**

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

- **Implies total expenditure on *S* relative to *U*:**

$$\frac{X_i^S}{X_i^U}=\lambda_i^{\sigma^U-\sigma^S}\left(\frac{\omega_i P_i^{S^{1-\sigma^S}}}{P_i^{U^{1-\sigma^U}}}\right)$$

P_i^k is CES price index – consumers choose *S* if labelled, i.e., no asymmetric information about either *diagnosis* or *treatment*

Model

- Consumers in *n* buy *U* and *S* at lowest price on offer:

$$p_n^k(j^k) = \min_i \left\{ p_{ni}^k(j^k) \right\}, \ k = U, S$$

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

$$\pi_{ni}^S = \frac{T_i \left(\tilde{a}_i(j^S) c_i^S(j^S) \tau_{ni} \zeta_{ni} \right)^{-\theta^S}}{\Phi_n^S(j^S)}$$

$$\pi_{ni}^U = \frac{T_i \left(\tilde{a}_i(j^U) c_i^U(j^U) \tau_{ni} \right)^{-\theta^U}}{\Phi_n^U(j^U)}$$

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

Comparative Statics: Labelling

- **Labelling increases S trade flows:**

(i) Labelling increases share of S expenditure on imports:

$$\pi_{nn}^{S} = \frac{T_n\left(\tilde{a}_n(j^S)c_n^S(j^S)\right)^{-\theta^S}}{\sum_{l=1}^{I} T_l\left(\tilde{a}_l(j^S)c_l^S(j^S)\tau_{nl}\zeta_{nl}\right)^{-\theta^S}} = \frac{T_n\left(\tilde{a}_n(j^S)c_n^S(j^S)\right)^{-\theta^S}}{\Phi_n^S(j^S)}$$

Without labelling $\zeta_{ni} = \infty$, therefore:

$$\Phi_n^S(j^S) = T_n\left(\tilde{a}_n(j^S)c_n^S(j^S)\right)^{-\theta^S} \text{ and } \quad \pi_{nn}^S = 1$$

As labelling costs fall, $\Phi_n^S(j^S)$ increases and π_{nn}^S falls, i.e., import share of expenditure on S products rises

Comparative Statics: Labelling

(ii) Labelling increases share of total expenditure allocated to *S* products:

By definition, $X_i = X_i^S + X_i^U$**, therefore:**

$$\frac{X_i^S}{X_i} = \lambda_i^{\sigma^U - \sigma^S} \left(\frac{\omega_i \left(P_i^S / P_i^U \right)^{1-\sigma^U}}{1 + \omega_i \left(P_i^S / P_i^U \right)^{1-\sigma^S}} \right)$$

Therefore, lower labelling costs implies lower prices for *S* products

Since lower labelling costs have no impact on $\Phi_n^U(j^U)$**, introducing *S* labels lowers** $\left(P_i^S / P_i^U\right)$

Comparative Statics: Composite Input and *S*

- **Optimal composite input allocation implies:**

$$\frac{\Upsilon_i^S}{\Upsilon_i^U} = \frac{\sum_n \pi_{ni}^S X_n^S}{\sum_n \pi_{ni}^U \left(X_n - X_n^S\right)}$$

Established that π_{ni}^S increases with eco − labelling, as does share of expenditure allocated to *S*

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

Therefore, share of composite input allocated to *S* production increases for exporter *i* – generating sustainability gains

Comparative Statics: Income and Trade

- If $\sigma^S > \sigma^U$, relative expenditure on *S* increasing in income – so for high-income country, $X_{ni} / X_{nn} \approx X^S_{ni} / X^S_{nn}$, and:

$$\frac{X^S_{ni}}{X^S_{nn}} = \frac{T_i}{T_n}\left(\frac{\tilde{a}_i(j^S)c^S_i(j^S)\tau_{ni}\zeta_{ni}}{\tilde{a}_n(j^S)c^S_n(j^S)\tau_{nn}\zeta_{nn}}\right)^{-\theta^S}$$

- Impact of eco-labelling cost becomes less critical as θ^S falls – average agricultural productivity drives imports from *i*

- Trade not necessarily dominated by high-income countries, i.e., if $\tilde{a}_i(j^S)c^S_i(j^S)$ are low, and value of θ^S is not too low, low-income country able to export *S*

- Assumes producers in low-income countries have access to *H*, and ability to certify credence products

Next Steps

- Parameterize model to evaluate impact of eco-labelling policies – not straightforward gravity-type approach
- Need tractable method of capturing non-homothetic preferences, i.e., allowing for substitution to sustainable products as per capita income increases
- Build empirical connection between agricultural production, agroecological characteristics and use of water resources
- Incorporate vertical market structure and figure out how rents from standards get shared out