Is trade of bioenergy good for the environment?

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Motivation

- Bioenergy and climate policies context in North
  - Market potential for bioenergy production
  - Competition with oil: need for subsidies for domestic producers
  - Problem: low environmental gains
- Opening North-South bioenergy trade
  - Low production cost and high yields in South
  - Potential for resource-based development
  - Problem: increasing pressure on land use (deforestation)

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Literature on trade and environment (Copeland and Taylor, 1994, 1995, 2003) based on

- Factor abundance and technological differences

  (Heckscher-Ohlin-Samuelson, Dornbusch-Fisher-Samuelson)

- Pollution haven

  A country with low pollution taxes has a comparative advantage in pollution-intensive sector

- But agriculture has been neglected

  2 externalities: land use competition, emissions from land use

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Framework: Copeland and Taylor (1994,1995)

- Hypotheses:

  - transboundary pollution

  - general equilibrium (continuum of industries)

  - North-South difference: labor is more productive in North

  - Nash equilibrium with endogenous policy on pollution

- Results:

  - Pollution haven in South

  - FPE: same global pollution level as in autarky
  but $\nearrow$ in South and $\searrow$ in North

  - no FPE: increase in global pollution

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2 goods, 3 factors model

- Agricultural sector: $A = K_A^{\mu} L_A^{1-\mu}$

  - 2 inputs: L_A labor and K_A natural capital available in the country

  - Substitution in output between food and bioenergy

- Industrial sector: $M = L_M^{1-\alpha}[Z^{1-e}B^{e}]^{\alpha}$

  3 inputs: labor L_M, fossil fuel E, bioenergy B

- Both sectors are responsible for GHG emissions

  either through the use of natural capital, or through the use of fossil fuel

- Bioenergy intermediate product can reduce industrial emissions but generates emissions from production

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Endogenous pollution regulation

- Each government decides to regulate pollution using two sectoral policies:

  τ tax per unit of fossil fuel emissions (affecting the industrial sector)

  τ_A tax per unit of natural capital considering its externality (chemicals, deforestation)

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Demand

- Representative consumer's utility:

$$U = b_A lnD_A + b_M lnD_M - \beta \frac{(Z^w)^\gamma}{\gamma}$$

- b_A, b_M shares of food and industrial goods in spendings

- $\beta > 0$ constant determining the welfare loss from pollution

- $\gamma \geq 1$ to ensure environmental quality is a normal good

- Income: $I = wL + \tau Z_M + \tau_A K_A$

  lump-sum redistribution of pollution taxes

  full employment

Optimal regulation

Dual approach

Whatever the region, optimal taxes are defined by

$$\tau = \beta I (Z^w)^{\gamma - 1} \tag{1}$$

$$\tau_A = \psi'(K_A)\tau \tag{2}$$

then pollution taxes increase in income and global pollution

Factor intensity hypothesis

- **H1: The industry is pollution-intensive:**

$$Z_M/L_M > Z_A/L_A$$

- Rationale: LULUCF represents almost 20 percent of global emissions in 2004, industries 29 percent (and transport 15 percent)

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Pollution supply and demand

- Equilibrium equalizes pollution demand and supply:

  Supply depends on technologies and relative share of each sector

  Demand is implicit when consumers demand consumption goods

- Inverse supply pollution function:

$$\frac{\tau}{w} = \frac{\beta L \left(Z^w\right)^{\gamma-1}}{1 - \beta[Z_M + \sigma Z_A]\left(Z^w\right)^{\gamma-1}}$$

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  But demand depends on the openness to trade

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Autarky equilibrium

- Only domestic demand
- Total pollution demand for North:

$$Z = Z_M + Z_A = \frac{\theta}{\beta(Z^w)^{\gamma-1}}$$

with $\theta \equiv (1-e)\alpha b_M + \mu(e\alpha b_M + b_A)/\sigma$.

Hence $Z = Z^*$

- Global level of pollution:

$$Z^{wa} = nZ + n^*Z^* = \left[\frac{(n+n^*)\theta}{\beta}\right]^{\frac{1}{\gamma}}$$

Autarky results

Despite different labor endowment ($L > L^*$), in autarky, North and South are characterized by

- Same national level of pollution
- Same natural capital use
- Same industrial pollution levels
- Relative factor price difference

$$\tau/\tau^* = \tau_A/\tau_A^* > 1 \text{ and } \quad w/w^* < 1.$$

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Comparative advantages

- HOS predictions: labor-abundant North should specialize in labor-intensive agriculture and pollution-abundant South in industry.
- However same pollution levels and intermediate product
- **H2: South specializes in agriculture and North in industry if**

given industrial unit-cost function $c_M(w,\tau) = \kappa_M w^{1-\alpha}\tau^{(1-e)\alpha}$,

$$c_M(w,\tau) < c_M(w^*,\tau^*) \text{ if } \mu > 1/\xi = \frac{\alpha(1-e)}{1-e\alpha} \qquad \text{H2}$$

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Diversified trade equilibrium

- Producers face international demand
- Iceberg cost approach (Samuelson, 1954):

  No friction for agricultural good

  Trade frictions for industrial good: 'shrinkage'

- If trade frictions are high, close to autarky

  Free trade corresponds to no friction

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Trade equilibrium

- No factor price equalization

  $\tau/\tau^* = I/I^*$ increases if high σ,

  τ_A/τ_A^* decreases and w/w^* increases.

- Pollution demand depends on international demand

$$Z_M + \sigma Z_A = \frac{\phi \delta_Z/\delta_I}{\beta (Z^w)^{\gamma-1}}$$

where $\phi \equiv (1-e)\alpha b_M + \mu(e\alpha b_M + b_A)$ share of taxes in income

δ_I Northern share of global revenue

δ_Z Northern share of environmental taxes.

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Trade impacts on the environment

Proposition 1: With the opening of the frontiers, compared to autarky,

- Agriculture use more natural capital in South and less in North
- Industries pollute more in North and less in South
- Northern total level of pollution increases whereas Southern one decreases
- The global level of pollution decreases

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Trade impacts on the welfare

Proposition 2: With the opening of the frontiers, compared to autarky, the revenue of Northern countries increases provided that $\sigma > \bar{\sigma}$ whereas the revenue of Southern countries decreases.

As a consequence,

- Reduction in global emissions is welfare improving
- Trade widens the North-South divide since I^N/I^S increases
- Net effect: positive for North, whereas for South it depends on β (environmental preference versus consumption)

Conclusion

- Focus on energy and natural capital as sources of emissions
- Bioenergy is the intermediate factor that allows to pollute less in industry but increases pressure on lands
- Decrease in global emissions due to a technique effect
- With optimal taxes in both sector, detrimental effect on Southern revenue

  Hence strong case against South's involvement in international agreements (stricter regulation)

  Even if bioenergy trade is seen as a compensation

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Trade equilibrium

- Income shares for environmental taxes and wages depend on global income:

$$\tau Z_M^N + \tau^* Z_M^S + \tau_A K_A^N + \tau_A^* K_A^S = \phi(I^N + I^S)$$
$$wL^N + w^* L^S = (1-\phi)(I^N + I^S)$$

  where $\phi \equiv (1-e)\alpha b_M + \mu(e\alpha b_M + b_A)$
  share of all environmental taxes in global income

- For regional shares, denote

$$\delta_Z \equiv \frac{\tau Z_M^N + \tau_A K_A^N}{\tau Z_M^N + \tau_A K_A^N + \tau^* Z_M^S + \tau_A^* K_A^S}$$
$$\delta_L \equiv wL^N/(wL^N + w^* L^S)$$
$$\delta_I \equiv I^N/(I^N + I^S)$$

- Relationship between the shares: $\delta_I = (1-\phi)\delta_L + \phi\delta_Z$

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- Inverse pollution demand function in trade:

$$\frac{\tau}{w} = \frac{\phi \delta_Z L}{(1-\phi)\delta_L [Z_M + \sigma Z_A]}$$

- At the equilibrium, supply and demand of pollution are equalized:

$$Z_M + \sigma Z_A = \frac{\phi \delta_Z / \delta_I}{\beta (Z^w)^{\gamma - 1}}$$

which is combined with $\frac{\sigma}{\mu} Z_A + \xi Z_M = 1/[\beta (Z^w)^{\gamma-1}]$ to give

- Sectoral levels of pollution:

$$Z_M^t = \frac{\mu - \phi \delta_Z / \delta_I}{(\mu \xi - 1)\beta (Z^w)^{\gamma - 1}}$$

$$Z_A^t = \frac{\mu [\xi \phi \delta_Z / \delta_I - 1]}{\sigma (\mu \xi - 1)\beta (Z^w)^{\gamma - 1}}$$

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