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Emissions trading enhances the social desirability of environmental improvement

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Overview

- Emissions trading is a well known measure to decrease a given amount of emissions at the possible least cost.
- We look at another effect that emissions trading brings about on.
    - Country's environmentally friendliness
- We discuss how emission trading will affect the social desirability of reducing emission and also other properties from this viewpoint.

The Model

- *N* countries with population L_i
- Production of each country depends on emission z_i as

$$Y_i = f_i(z_i) \quad f_i' > 0, f_i'' < 0$$

Production

- Utility of a representative individual in country i depends on its consumption per capita and total emission

$$U(c_i, Z) = u(c_i) + v(Z)$$

Consumption

Emission

$$c_i = f_i(z_i)/L_i$$

$$Z = z_i + \sum_{j \neq i} z_j$$

$$u' > 0, u'' < 0, v' < 0$$

An Index which describes a country's environmentally-friendliness

We define the index by

$$\phi^i(\mathbf{Z}) := \underbrace{L_i \left\{ \frac{-v'(Z)}{u'(f_i(z_i)/L_i)} \right\}}_{\text{Marginal WTP in country i for reducing emission.}} - \underbrace{f_i'(z_i)}_{\text{Opportunity cost of reducing emission}}.$$

$\phi^i(\mathbf{Z}) > 0$ Country i is called *environmentally-friendly*, because the reduction of its own emissions is socially desirable.

$\phi^i(\mathbf{Z}) = 0$ Country i does not want to increase or reduce its emissions.

$\phi^i(\mathbf{Z}) < 0$ Country i is called *environmentally-unfriendly*, because the increase of its own emissions is socially desirable.

Emissions Trading Among N Countries

Initial allocation of emission permits $(\bar{z}_i)_{i=1}^N$.

Emissions allocation ET equilibrium $(z_i^*)_{i=1}^N$

Market price of emission permit Q

Equilibrium must satisfy

$$\left(\begin{array}{l} z_i^* = \bar{z}_i + \triangle z_i, \ Y_i^* = f_i(z_i^*) - Q^* \triangle z_i > f_i(\bar{z}_i), \\ Q^* = f_i'(z_i^*), \qquad \sum_{i=1}^N \triangle z_i = 0. \end{array}\right)$$

Suppose that initial allocation $(\bar{z}_i)_{i=1}^{N}$ is a Nash equilibrium as:

$$u\left(\frac{f_i(\bar{z}_i)}{L_i}\right) + v(\bar{z}_i + \sum_{j \neq i} \bar{z}_j) \geq u\left(\frac{f_i(z_i)}{L_i}\right) + v\left(z_i + \sum_{j \neq i} \bar{z}_j\right)$$

$$\forall z_i \neq \bar{z}_i, \forall i = 1, \cdots, N$$

$$\Longrightarrow \quad \boxed{\phi^i(\bar{z}) = 0, \forall i}$$

Note: This situation is implemented by introducing optimal emission tax in each country.

Question 1:

How does the sign of the index change by emissions trading, when no county wants to change its own emission at the initial allocation?

Before

$$\phi^i(\bar{z}) = 0, \forall i$$

We further assume $u(c) = \log c$ for the ease of analysis.

After

If $\phi^i(\mathbf{z}^*) > 0 \ \forall i$

we can say that emissions trading makes all the countries *environmentally-friendly*.

Result 1

Emissions trading makes all the countries *environmentally-friendly*

$$\emptyset^i(\bar{z}) = 0 \rightarrow \emptyset^i(z^*) > 0 \; \forall i$$

if and only if, $$\frac{Y_i^* - \bar{Y}_i}{\bar{Y}_i} > \frac{Q^* - \bar{Q}_i}{\bar{Q}_i}. \; \forall i$$

$\bar{Q}_i = f_i'(\bar{z}_i)$ is a domestic price of emissions in each country.

The rate of income growth is strictly greater than that of the rise of emission price for each country.

$$\emptyset^i(\bar{z}) = 0 \rightarrow \emptyset^i(z^*) > 0 \Longleftrightarrow \frac{Y_i^* - \bar{Y}_i}{\bar{Y}_i} > \frac{Q^* - \bar{Q}_i}{\bar{Q}_i}.$$

$\bar{Q}_i = f_i'(\bar{z}_i)$ is a domestic price of emissions in country i.

- This is always met for the countries to purchase the permits.
- But not certain for the countries to sell the permits.

- ET is said to make environmentally friendly at least the countries to buy the permits, and *can* have such impact for the countries to sell the permits.

Question 2: Instationarity

If there exist some countries with $\phi^{\iota}<0$ in ET equilibrium, they may negotiate to increase total emission under ET, because increasing emission is socially desirable for them.

This may be referred to as a problem of instationarity of ET.

Question: Is there an initial situation $(\bar{z}_i)_{i=1}^{N}$ from which ET equilibrium is stationary, i.e., $\emptyset^i(z^*) = 0$ for all countries?

Result 2

$\phi^{\iota}(z^*)=0$ for each country under ET equilibrium if and only if

$$Y_1^* = Y_2^* = \cdots = Y_N^*$$

Income of each country must be the same after ET, which is not in general achieved from an arbitrary initial allocation.

In general, some countries are tempted to change the level of emission after ET, which might cause a difficulty to reduce total emissions in the long run.

Result 3

To make ET stationary, each country can introduce domestic taxation or subsidy τ on emission under ET. In this case, the following equilibrium will be implemented.

$$(Q^{**}, (z_i^{**})_{i=1}^N, (Y_i^{**})_{i=1}^N), (\tau_i^{**})_{i=1}^N)$$

where

$$f_i'(z_i^{**}) = Q^{**} + \tau_i^{**}$$

$$\phi^i(z_i^{**}) = 0, \forall i$$

Summary

①Initial State	②Emissions Trading	③Emissions Trading Plus Domestic Policy
$(\bar{z}_i)_{i=1}^N$	$(z_i^*)_{i=1}^N$	$(z_i^{**})_{i=1}^N$
		$(\tau_i^{**})_{i=1}^N$
$\phi^i(\bar{z}) = 0, \forall i$	$\phi^i(\mathbf{z}^*) > 0, \forall i$	$\phi^i(\mathbf{z}^{**}) = 0, \forall i$
	$f_i'(z_i^*) = Q^* \forall i$	$f_i'(z_i^{**}) = Q^{**} + \tau_i^{**} \forall i$

Under certain conditions, emissions trading enhances the social desirability of emissions reduction for all countries.

Domestic emissions policies declines efficiency.

Thank you!