Advanced Trade Theory: Research Paper #2

International Capital Mobility and Pollution Tax Coordination

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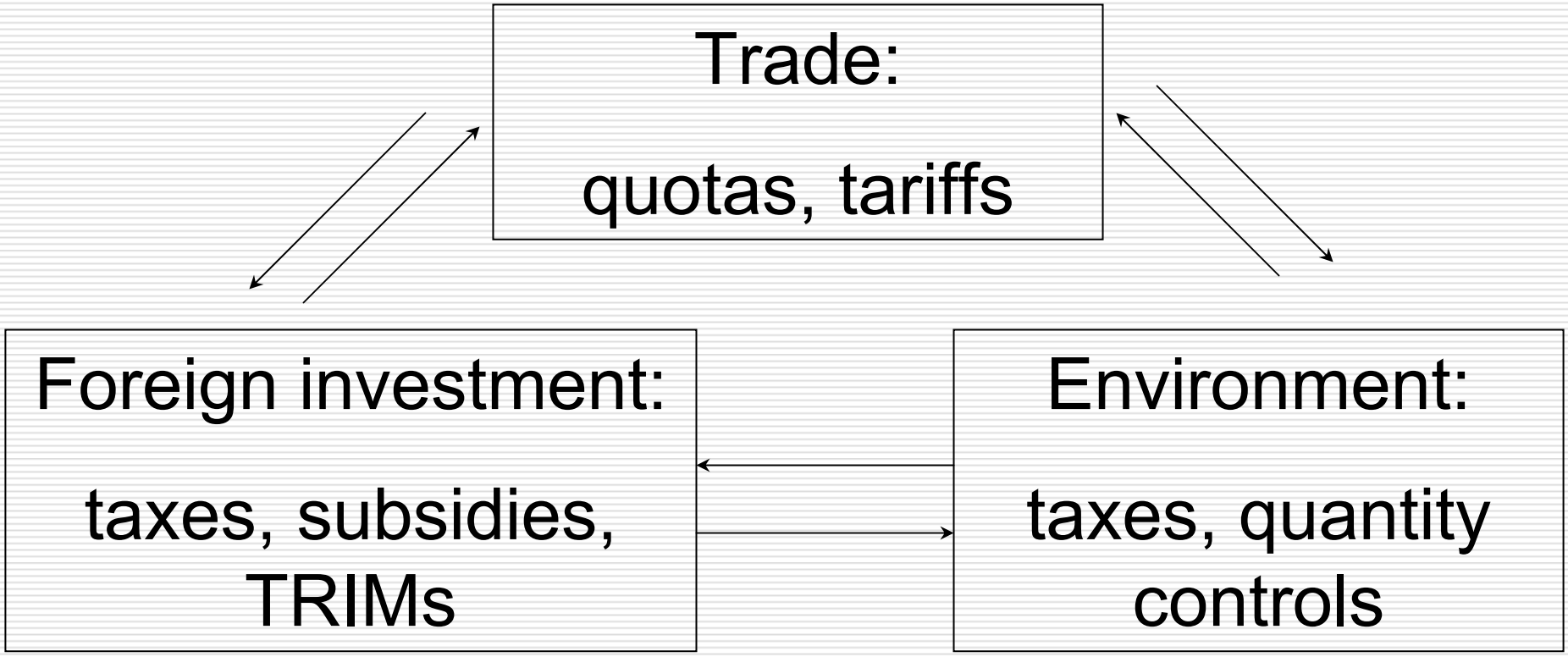
Background

- More interdependent world economy
  coordination of economic policies
  especially for regional trading blocks

- Transboundary issues
  e.g. environment
  foreign investment
  international trade

Linkages and Policies



2. Purpose

- To examine the welfare implications of pollution policies in the presence of international capital movement, in a two-country setting.

- Specifically, the effects of 3 alternative schemes for coordinating pollution taxes:

to compress the tax rates

(i) "Concertina" rule: lower the higher tax rate or raise the lower tax rate

(ii) uniform radial adjustments: to adjust the tax rates toward their second-best tax rates

(iii) harmonization: adjust the tax rates toward a weighted average rate

3. The Model and Assumptions

- Two nations: home and foreign
- Two goods: x and y (numeraire)

  Goods price: p_x p_y $p = p_x / p_y$
- One pollution (by-product): z

  $z = z_x + z_y$.

  s = tax rate on pollution → environmental policy

- Capital is internationally mobile; home total capital

$$\bar{k} + k$$

home endowment capital inflow

k is the key link between the two economies.

Revenue function for producers

$$\max\left\{\underbrace{px+y}-\underbrace{sz}:(x,y,z)\in\underbrace{T\left(\bar{k}+k\right)}\right\}=R\left(p,s,\bar{k}+k\right)$$

producers' output value — pollution tax payment — technology

By duality:

$$\partial R/\partial p \equiv R_p = x$$

$$\partial R/\partial s \equiv R_s = -z$$

$$\partial R/\partial k \equiv R_k = r = \textit{Domestic rate of return on capital}$$

- Equilibrium in capital market

$$r = r^* \quad (^* = \text{foreign})$$

$$\Rightarrow \qquad R_k\left(p, s, \bar{k} + k\right) = R_k^*\left(p, s^*, \bar{k}^* - k\right) \qquad (1)$$

To simplify, assume p is exogenous

- Effect of pollution taxes on capital movement

Homework: Differentiating (1) to show:

$$dk/ds = -R_{ks} \Big/ \left(R_{kk} + R_{kk}^{*}\right) < 0 \qquad (2)$$

(-) (-) (-)

$$R_{ks} = R_{sk} = -\frac{\partial Z}{\partial K} < 0$$

(+)

$$dk/ds^{*} = R_{ks}^{*} \Big/ \left(R_{kk} + R_{kk}^{*}\right) > 0 \qquad (3)$$

(-) (-) (-)

→ Differential environmental regulations can induce international capital movement

Effects of Pollution Taxes on Pollution Emissions

From Revenue functions:

$$R_s\left(p, s, \bar{k} + k\right) = -z \qquad (4)$$

$$R_s^*\left(p, s^*, \bar{k}^* + k\right) = -z^* \qquad (5)$$

→ $\left\{ \begin{array}{l} z \text{ is affected by } s \text{ and } s^* \text{ (via } k\text{)} \\ z^* \text{ is affected by } s^* \text{ and } s \text{ (via } k\text{)} \end{array} \right\}$ interdependence

Differentiating (4) & (5) and using (2) & (3):

$$dz/ds < 0 \tag{6}$$

$$dz/ds^{*} > 0 \qquad \left(s^{*} \uparrow \rightarrow k \uparrow \rightarrow z \uparrow\right) \tag{7}$$

$$dz^{*}/ds > 0 \tag{8}$$

$$dz^{*}/ds^{*} < 0 \tag{9}$$

- Demand side

Expenditure function:

$$E\left(p, z+\alpha^{*} z^{*}, \underbrace{u}_{\text{utility}}\right)=\min\left\{\underbrace{pD_x+D_y}_{\text{Total value of consumption}} : u\left(D_x, D_y, \underbrace{z+\alpha^{*} z^{*}}_{\text{Total pollution level}}\right)=u\right\}$$

α^{*} = fraction of the foreign pollution transmitted into the home country

By duality:

$\partial E/\partial z \equiv E_z$ = marginal damage of pollution > 0

$\partial E/\partial u \equiv E_u > 0$

$\partial E/\partial p \equiv E_p = D_x$

- Equilibrium for the home country (budget constraint)

$$E\left(p,(z+\alpha^{*}z^{*}),u\right)=R\left(p,s,\bar{k}+k\right)+sz-rk \qquad (10)$$

Pollution tax revenue

Payment to foreign capital

- Equilibrium for the foreign country (foreign budget constraint)

$$E^{*}\left(p,(z^{*}+\alpha z),u^{*}\right)=R^{*}\left(p,s^{*},\bar{k}^{*}-k\right)+s^{*}z^{*}+rk \qquad (11)$$

- Welfare Effects of Pollution Taxes

Differentiating the two budget constraints:

$$du = -\underbrace{\left(E_z - s\right)}_{(+)\quad(+)}dz - \alpha^* E_z dz^* - kdr \qquad (12)$$

$$?$$

$$du^* = -\left(E_z^* - s^*\right)dz - \alpha E_z dz + kdr \qquad (13)$$

Here, set $E_u = 1 = E_u^*$

Two direct effects → E_z, s

One indirect (transboundary) effect: z^*

Note:

1. u is negatively affected by E_z and positively by s.

2. u (u^*) is also negatively affected by z^* (z)

➔ coordination of environmental policies.

Pareto-improving tax coordination

Let $du^* = 0$ in (13) and into (12):

$$du/ds = -\underbrace{(E_z - s)}_{?}\,dz/ds - \alpha^* E_z\, dz^*/ds$$
$$(-) \qquad (+)\ (+) \quad (+) \quad (+)$$

$$-\underbrace{(E_Z^* - s^*)}_{?}\,dz^*/ds - \alpha^* E_Z^*\, dz/ds \gtrless 0 \qquad (15)$$
$$(-) \qquad (+)\ (+) \quad (+) \quad (-)$$

optimal tax: $s^o = A - s^*(dz^*/ds)/(dz/ds)$ (16)

See Figure 1.1

Optimal tax:

$$s^o = A - s^* (dz^* / ds) / (dz / ds)$$

$$A > 0$$

$$\text{slope} > 0$$

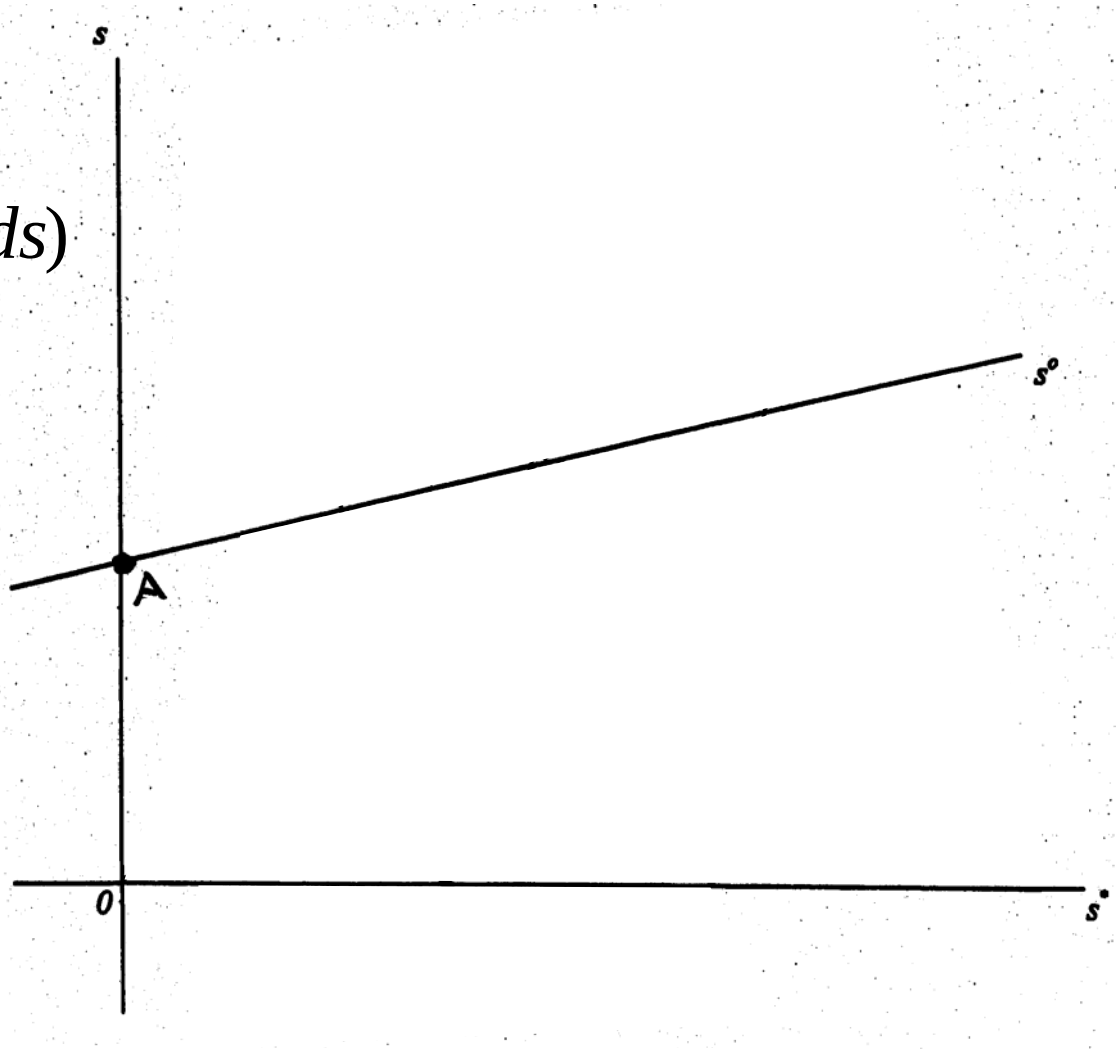


Figure 1.1

Similarly,

$$du/ds^* = -(E_z - s)dz/ds^* - \alpha^* E_z\, dz^*/ds^*$$

$$-(E_z^* - s^*)dz^*/ds^* - \alpha^* E_z^*\, dz/ds^* \gtrless 0 \qquad (17)$$

Optimal foreign tax (for home country):

$$s^{*o} = B - s(dz/ds^*)/(dz^*/ds^*) \qquad (18)$$

See Figure 1.2

Optimal tax:

$$s^{*o} = B - s(dz/ds^*)/(dz^*/ds^*)$$

$$B > 0;$$

$$\text{slope} > 0$$

• For any given s^*, s moves to s^o → ↑ u

• For any given s, s* moves to s^{o*} → ↑ u

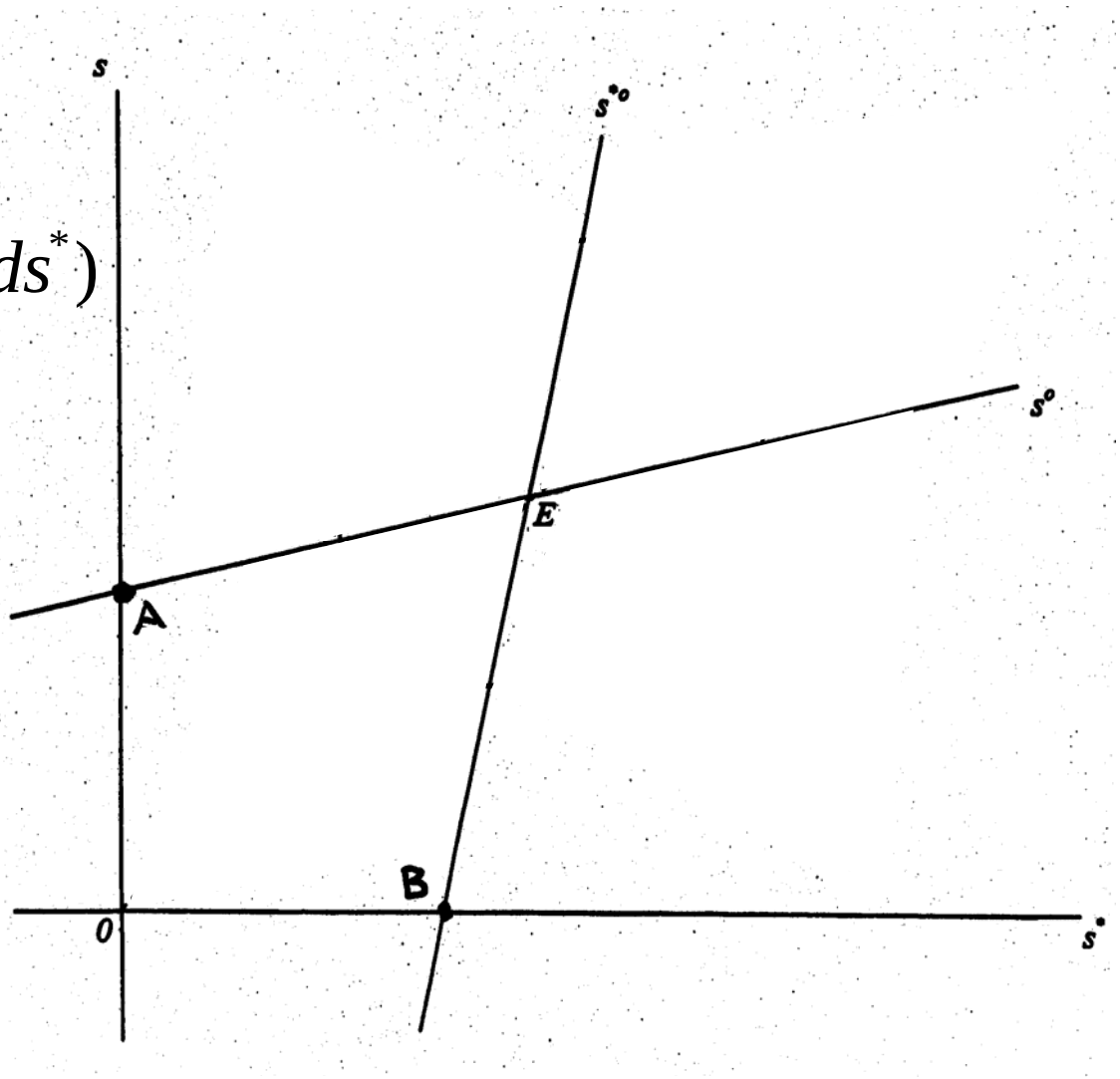


Figure 1.2

Welfare Contours

Using (16) and (18) into (12):

$$du = \underset{(-)}{(dz/ds)}(s - s^{o})ds + \underset{(-)}{(dz^{*}/ds)}(s^{*} - s^{*o})ds^{*} \qquad (19)$$

Set $du = 0$ → W contour in Figure 1.3

Welfare contour: W

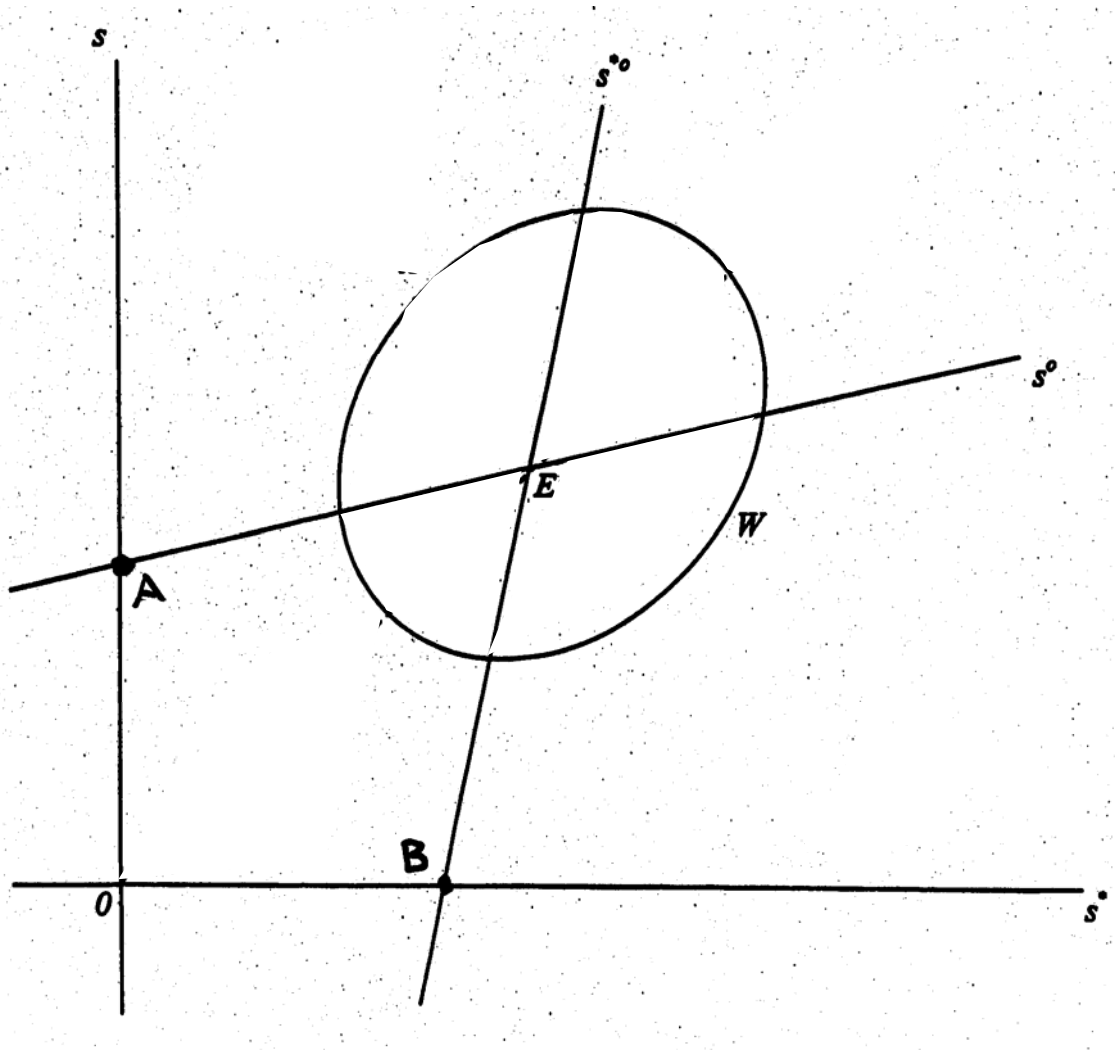


Figure 1.3

Jointly Optimal Taxes

Solving (16) and (18):

$$s^{oo} = E_z + \alpha E_z^* > 0 \qquad (20)$$

$$s^{*oo} = E_z^* + \alpha^* E_z > 0 \qquad (21)$$

Intersection on 45-degree line

See Figure 1.5

(1) *E* is the jointly optimal

(2) 4 regions:

Region I (III): - slope of W

Region II (IV): + slope of W

Assume: $E_z = E_z^*$

$\alpha = \alpha^*$

$\Rightarrow s^{oo} = s^{*oo}$

(on 45-degree ray)

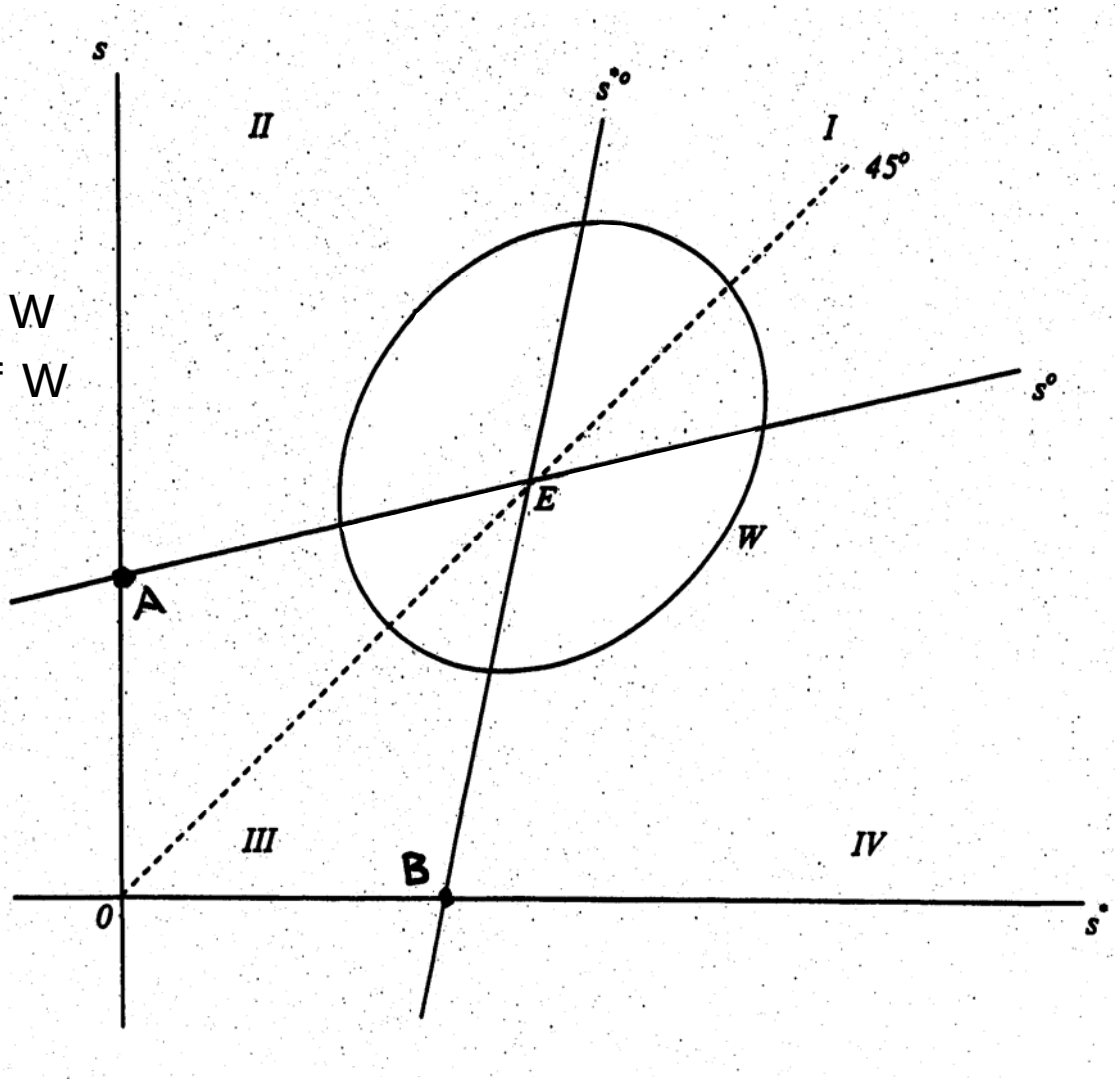


Figure 1.4

- Welfare effects of 3 alternative tax reforms

- Concertina Rule

  compressing the tax structure by lowering the higher tax rate

  See Figure 1.5

Consider Region I and II

Lowering Home's higher tax rate:

A to C $(ds^* = 0)$

$$du = (dz/ds)(s - s^o)ds \quad (23)$$

(-) (-)

Here, $ds < 0$, $du > 0$

(as $s > s^o$)

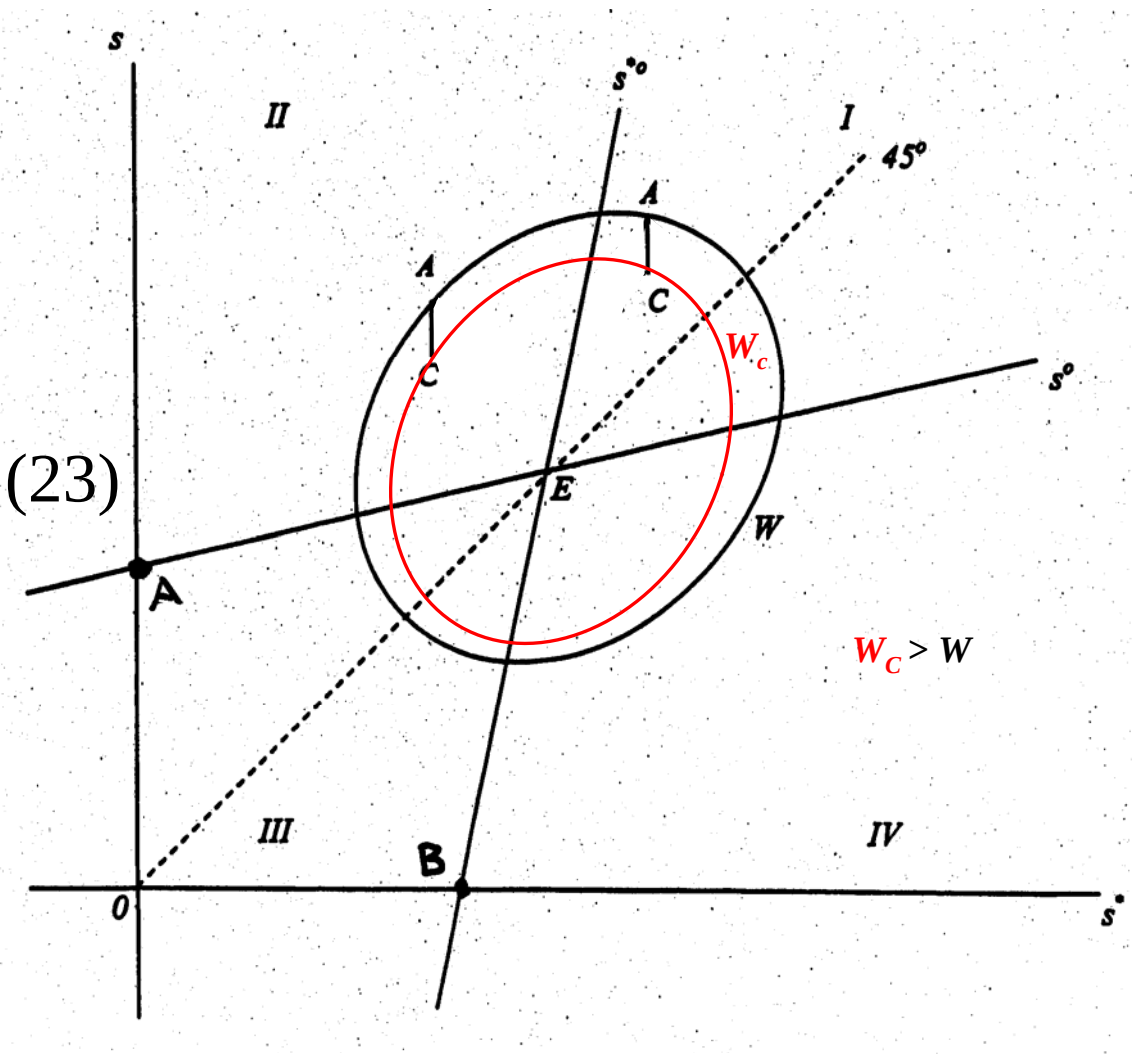


Figure 1.5

Uniform Radial Rule

Adjusting both tax rates toward their second-best rates

$$ds = -\sigma(s - s^o) \tag{24}$$

$$ds^* = -\sigma(s^* - s^{*o}) \tag{25}$$

$$(1 > \sigma > 0)$$

σ: adjustment coefficient

Relative adjustment of s to s^*:

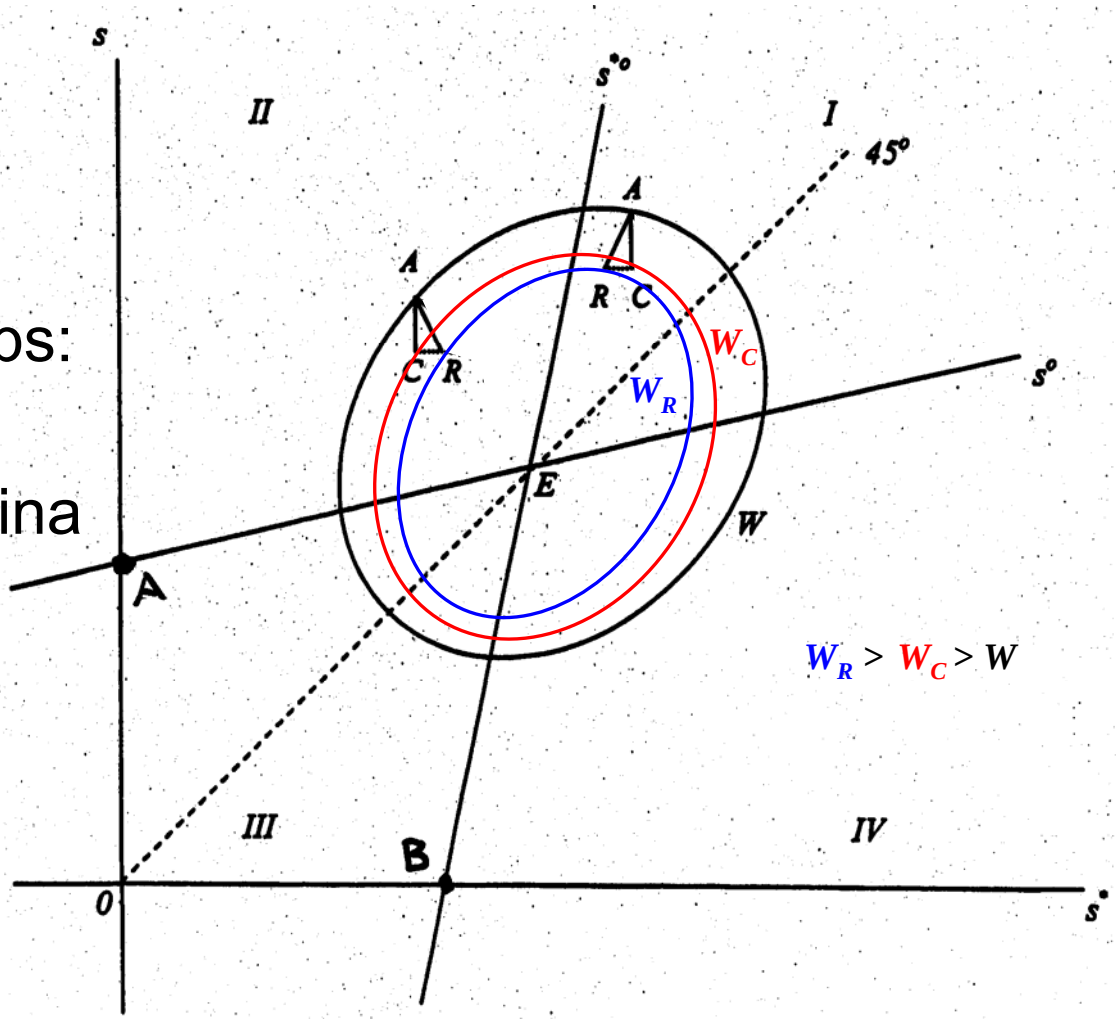
$$ds/ds^*\Big|_R = (s - s^o)/(s^* - s^{*o}) \tag{26}$$

See Figure 1.6

Welfare change in two steps:

(1) A to C (u↑) → concertina

(2) C to R (u↑ again)



→ Uniform radial adjustments of the pollution tax rate are welfare-superior to concertina. Figure 1.6

Harmonization Rules

Adjustments towards an appropriate weighted average of the initial tax rates

Here $s > s^*$, so $\downarrow s$ and $\uparrow s^*$

Let $h = vs + (1-v)s^*$ (29)

$(1 > v > 0)$

$\downarrow$

weight

$$ds/ds^*\Big|_H = -(1-v)/v < 0 \quad (32)$$

See Figure 1.7

Region I:

A: $s \downarrow$ and $s^* \uparrow$

→ H (inside W) → u ↑

Region II:

A: $s \downarrow$ and $s^* \uparrow$ → H → u ↑

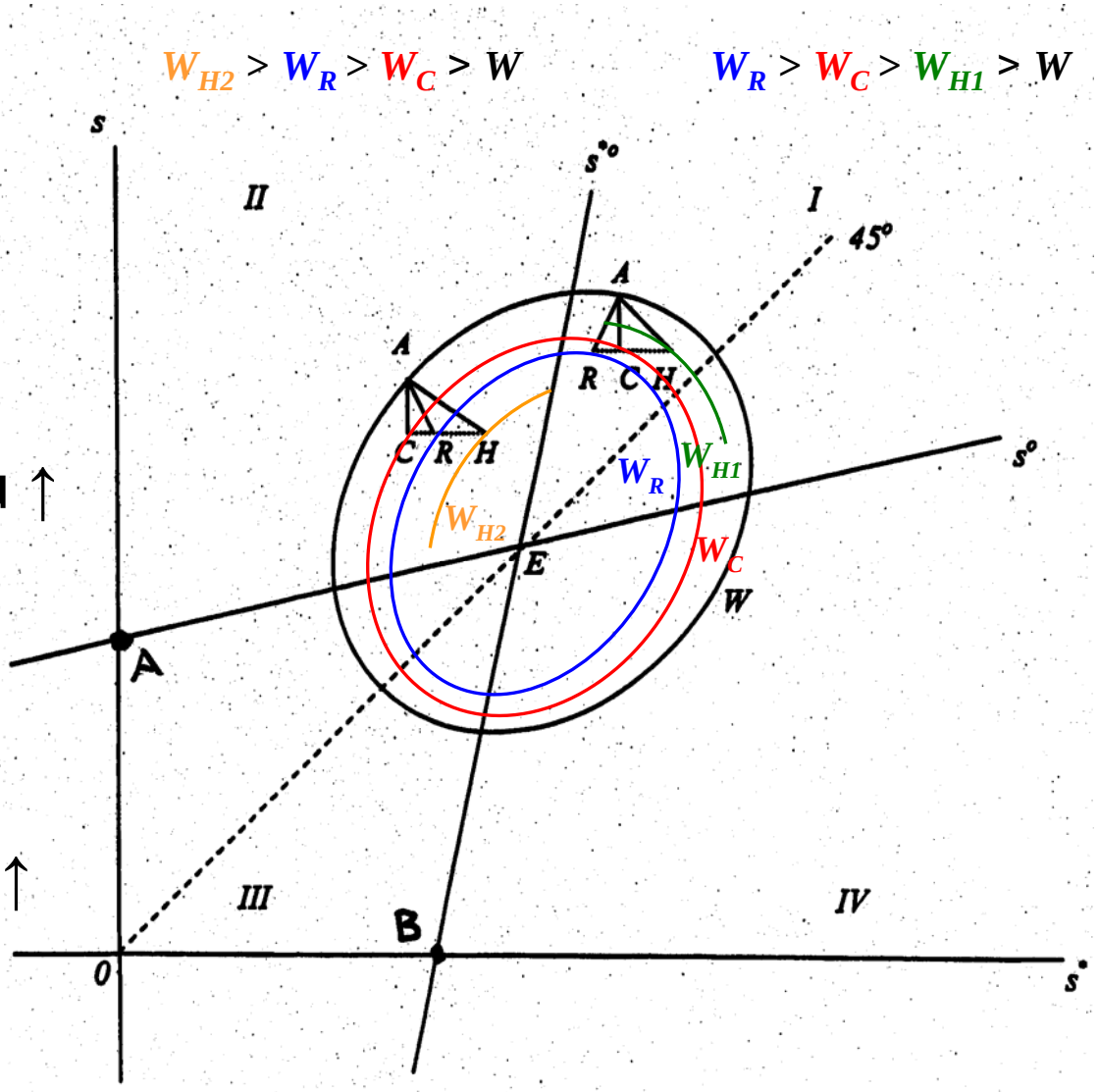


Figure 1.7

Welfare Rankings

From (19):

$$du = \underbrace{(dz/ds)(s - s^{o})ds}_{\text{direct}} + \underbrace{(dz^{*}/ds^{*})(s^{*} - s^{*o})(ds^{*}/ds)ds}_{\text{indirect } (ds \rightarrow ds^{*})} \qquad (36)$$

Recall: (1) $ds^{*}/ds\big|_{C} = 0$

(2) $ds^{*}/ds\big|_{R} = (s^{*} - s^{*o})/(s - s^{o})$

(3) $ds^{*}/ds\big|_{H} = -v/(1-v) < 0$

Remarks:

(1) Uniform radial rule is always welfare-superior to concertina rule (same ds).

(2) Harmonization rule is welfare inferior to concertina rule in region I, (but welfare superior in region II).

(3) In region I, radial uniform rule is welfare-superior to harmonization rule (in region II, welfare-inferior).

Future Research

- International labor movement
- Pollution as input rather than output
- Consider welfare effects in Region III and IV
- Consider Pareto-improving welfare effects of foreign country
- Consider joint welfare effects of both countries

To move on to: Research Paper #3

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