CHAPTER 6

Factor Endowments, Policy Differences and Pollution
Evidence: Countries with strict environmental regulation export dirty commodities.

Pollution Haven Hypothesis versus Factor Endowment Hypothesis

Outline:
1. Exogenous policy: role of factor endowments
2. Endogenous policy: factor endowments and comparative advantage
3. Example
1.1 Exogenous Policy - Equal Environmental Policy

1.1.a. Patterns of Trade.

\[ e = e^* \quad \text{or} \quad \tau = \tau^* \]

- **Relative Demand** (autarky prices):

\[ RD(p) = \frac{a(p)}{b(p)} \quad \text{(homothetic preferences)} \]

- **Relative Supply**:

\[ RD(p, e, k/l) = \frac{x(p, e, k/l)}{y(p, e, k/l)} \]
1.1 Exogenous Policy - Equal Environmental Policy

\[ RD = RD^* \]

\[ RD_p < 0, \ RS_p > 0 \]

Assume \( k/l > k^*/l^* \). Then \( RS \) to the right of \( RS^* \).

Hence

\[ (p^A)^* > p^A \]

North exports capital abundant (=dirty) commodity.
1.1 Exogenous Policy - Equal Environmental Policy

1.1.b. Welfare Consequences.

**North:**
Dirty industry and pollution in North expands: welfare effect ambiguous

**South:**
Clean industry expands and pollution decreases in South: welfare effect positive

No necessary link between income and impact of trade on environment.
1.2 Exogenous Policy - Unequal Environmental Policy

1.2.a. Patterns of Trade.

\[ e \neq e^* \quad \text{and} \quad \tau \neq \tau^* \]

If \( e > e^* \), then \( RS \) shifts to the right and vice versa.

There exists \( e_l = e_l(k/l, k^* / l^*, e^*) \)

Such that \( p^A = (p^A)^* \)

or \ldots
1.2 Exogenous Policy - Unequal Environmental Policy

...or:

\[ RS(p^A, e_I, k/l) = RS^* ((p^A)^*, e^*, k^* / l^*) \]

Properties of \( e_I \):

1. \( e_I < e^* \), since \( k/l > k^* / l^* \).
2. \( e_I \uparrow (\downarrow) \) as \((k/l) \downarrow, ((k^* / l^*) \uparrow)\)
1.2 Exogenous Policy - Unequal Environmental Policy

If $e < e_t < e^*$, North exports clean goods. Pollution in North falls. North benefits, South might lose.

If $e_t < e < e^*$, North exports dirty goods, in spite of more stringent policy. Pollution in North increases. South benefits, North might lose.
2 Endogenous Policy

Recap.

Social welfare maximization:

$$\text{Max } u(x, y) - h(z)$$

subject to

1. $$x = z^{-\alpha} [F(k_x, l_x)]^{1-\alpha} - sx$$
2. $$y = H(k_y, l_y) - sy$$
3. $$k_x + k_y = k$$
4. $$l_x + l_y = l$$
5. $$pxs + yxs = 0$$
2 Endogenous Policy

Necessary condition for welfare maximization is maximization of national income at world market prices:

\[
\text{Max } pz^{-\alpha} [F(k_x, l_x)]^{1-\alpha} + G(k_y, l_y)
\]

Subject to 3 and 4.

This yields \( G(p, k, l, z) \)
2 Endogenous Policy

Next step is to maximise \( u(x, y) - h(z) \)
subject to

\[
px + y = G(p, k, l, z)
\]

\( u(x, y) \) can be written as \( g(f(x, y)) \) with
\( g \) increasing and \( f \) linearly homogeneous.

That yields

\[
G_z = \frac{h'(z) \beta(p)}{g'(G / \beta(p))} = MD(p, R, z)
\]

\[
R = G / \beta(p) \quad \text{with (see 2.62, 2.65)}
\]
3 Example

Suppose

\[ x = z^\alpha k^{1-\alpha} \]

\[ y = l \]

\[ U(x, y, z) = \varphi \ln x + (1 - \varphi) \ln y - \gamma z \]
3 Example

Social optimum:

Step 1. Maximal national income at world market prices:

\[ G(p, k, l, z) = pz^\alpha k^{1-\alpha} + l \]

Step 2. Maximal social welfare:

Max \[ U(x, y, z) - \gamma z \]

subject to \[ px + y = G(p, k, l, z) \]
3 Example

Solution:

\[ px = \varphi / \lambda, \]
\[ y = (1 - \varphi) / \lambda, \]
\[ \gamma = \alpha \lambda p z^{\alpha-1} k^{1-\alpha} \]

with \( \lambda \) Lagrangian parameter.

\[ \lambda = 1/(px + y) = 1/G \]
3 Example

Decentralization:

Maximal profits: \( \max \ p z^\alpha k^{1-\alpha} - \tau z \)

It follows that social optimum is realized in decentralized setting by putting

\[ \tau = p \alpha z^{\alpha-1} k^{1-\alpha} = \gamma / \lambda = \gamma G \]
3.1 Exogenous Policy

\[ \tau = p \alpha z^{\alpha - 1} k^{1 - \alpha} \]

Not necessarily optimal from social point of view.

**Relative Supply:**

\[ RS = x / y = z^\alpha k^{1 - \alpha} / l = (\alpha p / \tau)^{\alpha / (1 - \alpha)} k / l \]

\[ RS^* = (\alpha p / \tau^*)^{\alpha / 1 - \alpha} k^*/l^* \]
3.1 Exogenous Policy

Define $\tau_I$ by $(1/\tau_I)^{\alpha/(1-\alpha)} k/l = (1/\tau^*)^{\alpha/(1-\alpha)} k^*/l^*$

$(\tau_I > \tau^*)$

$RS > RS^*$ if and only if $\tau < \tau_I$

• If $\tau > \tau_I > \tau^*$ the North has strict environmental policy and exports the clean commodity

• If $\tau^* < \tau < \tau_I$ the North has stricter environmental policy but still exports the dirty commodity.
3.1 Exogenous Policy

\[
\frac{\tau_I - \tau^*}{\tau^*} = \left\{ \frac{k/l}{(k/l)^*} \right\}^{(1-\alpha)/\alpha} - 1
\]

So, the greater the disparity in endowments the more room for the case where the North has strict environmental policy and still exports the dirty commodity.
3.2 Endogenous Policy

3.2.1. Relative supply

\[ RS = \left( \frac{\alpha p}{\gamma} \right)^{\alpha/(1-\alpha)} I^{\alpha/1-\alpha} \left( \frac{k}{l} \right) \]
3.2 Endogenous Policy

Autarky Prices

$$\max \ \varphi \ln z^\alpha k^{1-\alpha} + (1-\varphi) \ln l - \gamma z$$

Optimal Pollution: $$z = \alpha \varphi / \gamma$$

Also $$px/y = \varphi / (1-\varphi)$$. Hence

$$p = \frac{\varphi}{1-\varphi} \frac{l}{z^\alpha k^{1-\alpha}} = \frac{\varphi}{1-\varphi} \left( \frac{k}{l} \right)^{\alpha-1} \left( \frac{\gamma l}{\alpha \varphi} \right)^\alpha$$

Make sure that firms abate:

$$\frac{z}{x} < 1 \iff \frac{\alpha \varphi}{\gamma} < l \frac{k}{l}$$
3.2 Endogenous Policy

Given world market price:

\[
\frac{RS}{RS^*} = \left( \frac{\alpha p}{\tau} \right)^{\alpha/(1-\alpha)} \frac{(k/l)}{\left( \frac{\alpha p}{\tau^*} \right)^{\alpha/(1-\alpha)} (k/l)^*}
\]

\[
= \left( \frac{I^*}{I} \right)^{\alpha/(1-\alpha)} \frac{k/l}{(k/l)^*}
\]
3.2 Endogenous Policy

a. Income differences
Suppose \((k, l) = \lambda(k^*, l^*)\) with \(\lambda > 1\). Then \(I > I^*\).
Consider autarky prices:

\[
p^A / (p^A)^* = [l^A / (l^A)^*]^\alpha
\]

With trade relative price of dirty commodity decreases in North. North has comparative advantage in clean commodity.
Pollution in North falls, pollution in South increases.
3.2 Endogenous Policy

Total pollution??

\[ z^A = (z^A)^* = \frac{\alpha \varphi}{\gamma} \]

\[ z^T = \frac{\alpha px}{I} = \alpha \varphi, \quad (z^T)^* = \frac{\alpha px^*}{I^*} = \alpha \varphi^* \]

Variable \( x \) refers to production.
3.2 Endogenous Policy

Relationship between $\varphi$ and $\mathcal{I}$.

$$px^c = \varphi I, \quad p(x^c)^* = \varphi I^*$$

$$p(x^c + (x^c)^*) = p(x + x^*) = \varphi(I + I^*)$$

Hence: \[ \varphi = \mathcal{I}s + \mathcal{I}^*(1-s) \quad \text{with} \quad s = \frac{I}{I + I^*} \]

$$z^T + (z^T)^* - z^A - (z^A)^* = \frac{\alpha}{\gamma} [\mathcal{I} + \mathcal{I}^* - 2\varphi] = \frac{2\alpha}{\gamma} [((\mathcal{I}^* - \mathcal{I})(s - \frac{1}{2})]$$

Since \( \mathcal{I}^* > \varphi > \mathcal{I} \) pollution increases.
3.2 Endogenous Policy

b. Factor Endowment Differences.

Suppose countries have same income (be careful with this)

\[
\frac{RS^*}{RS} = \frac{k/l}{(k/l)^*}
\]

\[
p = \frac{\varphi l}{1 - \varphi z^\alpha k^{1-\alpha}} = \frac{\varphi k}{1 - \varphi l} \left[ \frac{k}{l} \right]^{\alpha - 1} \left[ \frac{\gamma}{\alpha \varphi} \right]^\alpha
\]

\[
p^A (p^A)^* = \left[ k^A / (l^A)^* \right]^{1-\alpha} / (k/l)^{1-\alpha}
\]
3.2 Endogenous Policy

Claim: North is exporter dirty commodity. Not correct. This only holds with equal but then not equal incomes. However claim is correct for more general technology with \( h(z) = \gamma z \).
3.2 Endogenous Policy

c. Correlated Attributes
Capital abundance and income.
Suppose North is rich and capital abundant.

Define $R_l = R^* \left[ \frac{k/l}{(k/l)^*} \right]^{(1-\alpha)/\alpha}$, with $R = I/\beta(p)$
3.2 Endogenous Policy

- North imports dirty good if and only if \( R > R_I \)

- \( R_I > R^* \) (from capital abundance in North)

North exports dirty good if

\[
\left[ \frac{k/l}{(k/l)^*} \right] > \left( \frac{R^*}{R} \right)^{\alpha/(\alpha)}
\]

\((R/R^*\) can be varied independently by varying \( k \) and \( k^* \))
3.2 Endogenous Policy

- If $R > R_I > R^*$ then North exports the clean good. Gap between $R_I$ and $R^*$ is important. As long as $R$ is in that range the North remains a dirty good exporter. Gap widens when endowments gap increases.

If North exports the dirty good world pollution falls with trade.