

# **International Economics B**

## **6. Applications of international oligopoly models**

**Akihiko Yanase**  
**(Graduate School of Economics)**

**November 24, 2016**

## Applications of international oligopoly models

- **Strategic environmental policy**
  - Applying the third-market model
- **Preferential trade agreements**
  - Applying the reciprocal market model

## Strategic environmental policy

- **Environmental policy can be used as a potential rent-shifting device in the presence of imperfect competition in international markets.**
  - **Application of strategic trade literature to the analysis of environmental policy**
- **Pioneering studies:**
  - **Barrett, S. (1994), “Strategic environmental policy and international trade,”** *Journal of Public Economics* **54**, pp.325–338.
  - **Conrad, K. (1993), “Taxes and subsidies for pollution-intensive industries as trade policy,”** *Journal of Environmental Economics and Management* **25**, pp.121–135.
  - **Kennedy, P.W. (1994), “Equilibrium pollution taxes in open economies with imperfect competition,”** *Journal of Environmental Economics and Management* **27**, pp.49–63.

## A simple model of strategic environmental policy

- Consider a third-market model.
  - In each exporting countries (Home and Foreign), a single firm produces a homogeneous or differentiated good.
  - Production of the good generates pollution emission as a byproduct, which causes external diseconomies.
- Government in each producer country imposes payment  $\tau$  per unit of emission on the firm to control pollution.
  - $\tau$  can either be interpreted as emission tax rate or price of emission permits.

- Home firm's gross profit is given by  $\pi(a, a^*, Z)$ ,
  - $a$  ( $a^*$ ): level of Home (Foreign) firm's strategic variable
    - Quantity or price
  - $Z$ : emission level

and its profit net of tax payment is

$$\Pi = \pi(a, a^*, Z) - \tau Z.$$

- Each firm chooses the level of its strategic variable, taking the rival firm's strategy as given, and pollution emission.
- Home firm's FOCs:

$$\pi_a(a, a^*, Z) = 0,$$

$$\pi_Z(a, a^*, Z) = \tau$$

## Optimal environmental policy

- Home welfare is the sum of firm profit and tax revenue minus the environmental damage:

$$\begin{aligned} W &= \Pi + \tau Z - D(Z) \\ &= \pi(a, a^*, Z) - D(Z) \end{aligned}$$

- Pollution externality is assumed to be local (no transboundary pollution).
- Change in Home welfare:

$$dW = \pi_{a^*} da^* + (\tau - D')dZ$$

- Optimal environmental policy requires  $dW = 0$ , or

$$\tau = D' - \pi_{a^*} \frac{\partial a^*}{\partial Z}.$$

- Pigouvian tax, which is aimed at completely internalizing the externality and achieving the socially efficient resource allocation, must satisfy  $\tau = D'$ .
  - Pigou, A.C. (1920), *The Economics of Welfare*
- If the optimal environmental policy is lower than the marginal environmental damage (i.e.,  $\tau < D'$ ), the policy leads to “environmental dumping.”
  - Rauscher, M. (1994), “On Ecological Dumping,” *Oxford Economic Papers* 46, 822–840.
- If  $\pi_{a^*} \partial a^* / \partial Z > 0$ , environmental dumping occurs.

- Consider the goods are homogeneous and firms play Cournot competition.
  - $P(x + x^*)$ : inverse demand ( $x$  and  $x^*$  are outputs)
  - $c$ : constant marginal cost
- Emission is assumed to be proportional to the output, and firms can reduce or abate pollution by undertaking pollution abatement activities  $y$ .
  - $Z = \zeta x - y$ : net emission ( $\zeta$ : emission per unit of output)
  - $A(y)$ : pollution abatement cost (assumed to be strictly convex)
- Home firm's profit net of tax payment:

$$\Pi = [P(x + x^*) - c]x - A(y) - \tau(\zeta x - y)$$



- Home firm's FOCs:

$$\Pi_x = P(x + x^*) + P'(x + x^*)x - c - \zeta\tau = 0,$$

$$\Pi_y = \tau - A'(y) = 0$$

- If no environmental policy is implemented in Foreign, the Foreign firm's profit maximization implies

$$P(x + x^*) + P'(x + x^*)x^* - c^* = 0.$$

- Cournot–Nash equilibrium levels of  $x$ ,  $x^*$ , and  $y$  depend on  $\tau$ .
  - Comparative statics ( $P(\cdot)$  is assumed to be linear):

$$\frac{\partial x}{\partial \tau} = \frac{2\zeta}{3P'} < 0, \quad \frac{\partial x^*}{\partial \tau} = -\frac{\zeta}{3P'} > 0, \quad \frac{\partial y}{\partial \tau} = \frac{1}{A''} > 0$$

- $Z$  and  $\tau$  are negatively correlated:

$$Z = \zeta x - y \quad \Rightarrow \quad \frac{\partial Z}{\partial \tau} = \zeta \frac{\partial x}{\partial \tau} - \frac{\partial y}{\partial \tau} < 0$$

- $\pi_{x^*} \partial x^* / \partial Z > 0$  holds.

- $\pi_{x^*} = P'x < 0$
- $\partial x^* / \partial \tau > 0$  since reaction functions are negatively sloped  $\Rightarrow \partial x^* / \partial Z = (\partial x^* / \partial \tau) / (\partial Z / \partial \tau) < 0$

$\Rightarrow$  In a homogeneous-good Cournot duopoly, the optimal environmental policy implies environmental dumping.

- **Strategic environmental policy does not necessarily result in environmental dumping.**
  - Under Bertrand competition,  $\tau > D'$  holds
  - Even under Cournot competition, if the market is oligopoly (rather than duopoly), depending on the number of firms in each country,  $\tau > D'$  may hold.
- **Optimal  $\tau$  deviates from  $D'$  because the government implements a second-best policy.**
  - If the government use an export subsidy/tax in addition to the environmental policy, the government can achieve the first-best with  $\tau = D'$ .

## Preferential trade agreements

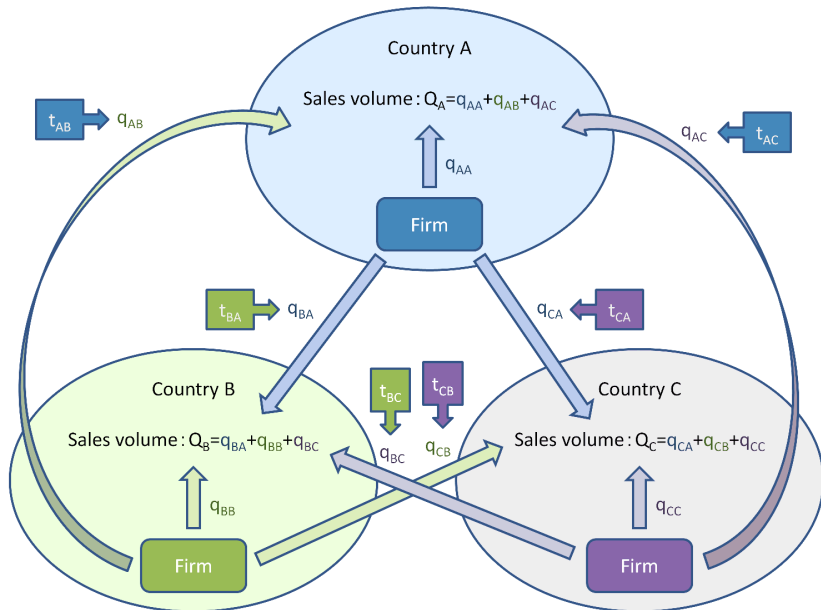
- **Preferential trade agreements (PTAs):** A trade pact between countries that reduces tariffs for certain products to the countries who sign the agreement.
  - A form of economic integration
- **PTAs have dramatically increased in the last two decades.**
  - In 2012, WTO receives 604 notifications of PTAs, and among them 398 in force.
  - More than 20 times from the corresponding number in 1990.
- **Types of PTAs**
  - **Free trade area:** member countries eliminate tariffs within the area, and set their external tariffs independently.
  - **Customs union:** member countries set a common external tariff, harmonizing their external trade policy.

## A Three country model of PTA

- **References:**

- **Krishna, P. (1998), “Regionalism and multilateralism: A political economy approach,”** *Quarterly Journal of Economics* 113, pp.227–251.
- **Freund, C. (2000), “Multilateralism and the endogenous formation of preferential trade agreements,”** *Journal of International Economics* 52, pp.359–376.
- **Saggi, K. (2006), “Preferential trade agreements and multilateral tariff cooperation,”** *International Economic Review* 47, pp.29–57.

- 3 countries (A, B, C)
  - Identical preference & technologies
- 1 firm in each country, producing a homogeneous product, Cournot competition in each market.
- Markets are assumed to be segmented.
- Tariffs on imports
  - A and B are potential PTA members  $\Rightarrow$  eliminate tariffs under a PTA.
- Assume a linear demand:  $P(Q_i) = \alpha - Q_i$ , and constant marginal costs:  $c \geq 0$ .



## Cournot competition

- **Total profits of firm A (i.e., the firm in country A):**

$\pi_A = \pi_{AA} + \pi_{BA} + \pi_{CA}$ , where

- $\pi_{AA} = [P(Q_A) - c]q_{AA}$ : domestic sales
- $\pi_{BA} = [P(Q_B) - c - t_{BA}]q_{BA}$ : export to country B
- $\pi_{CA} = [P(Q_C) - c - t_{CA}]q_{CA}$ : export to country C

- **Total profits of firm B:  $\pi_B = \pi_{AB} + \pi_{BB} + \pi_{CB}$ , where**

- $\pi_{AB} = [P(Q_A) - c - t_{AB}]q_{AB}$ : export to country A
- $\pi_{BB} = [P(Q_B) - c]q_{BB}$ : domestic sales
- $\pi_{CB} = [P(Q_C) - c - t_{CB}]q_{CB}$ : export to country C

- **Total profits of firm C:  $\pi_C = \pi_{AC} + \pi_{BC} + \pi_{CC}$ , where**

- $\pi_{AC} = [P(Q_A) - c - t_{AC}]q_{AC}$ : export to country A
- $\pi_{BC} = [P(Q_B) - c - t_{BC}]q_{BC}$ : export to country B
- $\pi_{CC} = [P(Q_C) - c]q_{CC}$ : domestic sales



- **Cournot equilibrium in country A's market**

- FOC for profit maximization of firm A:

$$\frac{\partial \pi_{AA}}{\partial q_{AA}} = P(Q_A) + P'(Q_A)q_{AA} - c = 0$$

- FOC of firm B:

$$\frac{\partial \pi_{AB}}{\partial q_{AB}} = P(Q_A) + P'(Q_A)q_{AB} - c - t_{AB} = 0$$

- FOC of firm C:

$$\frac{\partial \pi_{AC}}{\partial q_{AC}} = P(Q_A) + P'(Q_A)q_{AC} - c - t_{AC} = 0$$

- $\Rightarrow$  **Cournot equilibrium outputs:**  $q_{Aj}(t_{AB}, t_{AC})$ ,  
 $j = A, B, C$
- **Linear demand  $\Rightarrow$  equilibrium outputs are derived as**

$$q_{AA}(t_{AB}, t_{AC}) = (\alpha - c + t_{AB} + t_{AC})/4,$$

$$q_{AB}(t_{AB}, t_{AC}) = (\alpha - c - 3t_{AB} + t_{AC})/4,$$

$$q_{AC}(t_{AB}, t_{AC}) = (\alpha - c + t_{AB} - 3t_{AC})/4$$

- Similarly for other markets:
  - Cournot equilibrium in country B's market  $\Rightarrow$  equilibrium outputs:  $q_{Bj}(t_{BA}, t_{BC})$ ,  $j = A, B, C$
  - Cournot equilibrium in country C's market  $\Rightarrow$  equilibrium outputs:  $q_{Cj}(t_{CA}, t_{CB})$ ,  $j = A, B, C$
- Effects of a change in tariff rates:
  - An increase in tariff on import from country  $j$  reduces imports from that country, while it increases the domestic output and imports from country  $k$  ( $k \neq j$ ):

$$\frac{\partial q_{ii}}{\partial t_{ij}} = \frac{\partial q_{ik}}{\partial t_{ij}} = \frac{1}{4} > 0, \quad \frac{\partial q_{ij}}{\partial t_{ij}} = -\frac{3}{4} < 0$$

- An increase in tariffs reduces total output:

$$\frac{\partial Q_i}{\partial t_{ij}} = -\frac{1}{4} < 0$$

## Welfare

- National welfare is the sum of domestic firms' total profits, consumer surplus, and tariff revenue.
- Country A's welfare:

$$\begin{aligned}W_A &= \pi_A + CS_A + TR_A \\&= \pi_{AA}(t_{AB}, t_{AC}) + \pi_{BA}(t_{BA}, t_{BC}) + \pi_{CA}(t_{CA}, t_{CB}) \\&\quad + \int_0^{Q_A(t_{AB}, t_{AC})} P(x) dx - P(Q_A(t_{AB}, t_{AC}))Q_A(t_{AB}, t_{AC}) \\&\quad + t_{AB}q_{AB}(t_{AB}, t_{AC}) + t_{AC}q_{AC}(t_{AB}, t_{AC}) \\&= \left( \frac{\alpha - c + t_{AB} + t_{AC}}{4} \right)^2 + \left( \frac{\alpha - c - 3t_{BA} + t_{BC}}{4} \right)^2 \\&\quad + \left( \frac{\alpha - c - 3t_{CA} + t_{CB}}{4} \right)^2 + \frac{1}{2} \left[ \frac{3(\alpha - c) - t_{AB} - t_{AC}}{4} \right]^2 \\&\quad + \frac{t_{AB}(\alpha - c - 3t_{AB} + t_{AC}) + t_{AC}(\alpha - c + t_{AB} - 3t_{AC})}{4}\end{aligned}$$

## Pre-PTA situation

- **Pre-PTA situation: tariff wars**
  - Each government chooses tariffs noncooperatively.
- **Problem of the government in country A: taking other countries' tariffs as given, choose  $t_A$  to maximize  $W_A$ .**
  - $t_{AB} = t_{AC} = t_A$  (MFN treatment)

- **Country A's optimal tariff:**

$$\frac{\partial W_A}{\partial t_A} = 0 \quad \Rightarrow \quad t_A^* = \frac{3(\alpha - c)}{10}$$

- **Similar conditions hold for other countries  $\Rightarrow$  Optimal tariffs in the absence of PTAs:**

$$t_i^* = \frac{3(\alpha - c)}{10}, \quad i = A, B, C.$$

- **National welfare in each country:  $W_i^* = 21(\alpha - c)^2/50$ ,  $i = A, B, C$**

## PTA conclusion

- Countries A and B form a preferential trade agreement:  
 $t_{AB} = t_{BA} = 0$ 
  - Eliminate their mutual tariffs.
- Types of PTAs
  - Free trade area: member countries set their external tariffs independently.
    - $t_{AC} = t_A, t_{BC} = t_B$
  - Customs union: member countries set a common external tariff.
    - $t_{AC} = t_{BC} = t$
- In both types of PTAs, the government in country C (non-member country) chooses the pre-PTA optimal tariff:  $t_C^* = 3(\alpha - c)/10$ .

- **FTA**

- Member countries' optimal external tariffs:

$$\frac{\partial W_A}{\partial t_A} = \frac{\partial W_B}{\partial t_B} = 0 \Rightarrow t_A^f = t_B^f = \frac{\alpha - c}{7}$$

- National welfare in member and non-member countries:

$$W_A^f = W_B^f = \frac{2199(\alpha - c)^2}{4900}, \quad W_C^f = \frac{108(\alpha - c)^2}{245}$$

- **CU**

- Member countries' optimal external tariffs:

$$\frac{\partial W_A}{\partial t} = \frac{\partial W_B}{\partial t} = 0 \Rightarrow t_A^c = t_B^c = \frac{5(\alpha - c)}{19}$$

- National welfare in member and non-member countries:

$$W_A^c = W_B^c = \frac{869(\alpha - c)^2}{1900}, \quad W_C^c = \frac{732(\alpha - c)^2}{1805}$$

## Effects of PTA: tariffs

**Comparison of optimal (external) tariffs:**  $t_i^* > t_i^c > t_i^f$ ,  
 $i = A, B$

- “Tariff complementarity effect”: PTAs reduce the members’ optimal external tariffs.
  - PTAs reduce imports from country C  $\Rightarrow$  reduction in CS and TR  $\Rightarrow$  in order to offset these negative effects, A and B encourage the import from C.
- Optimal external tariffs are lower under FTA than under CU.
  - A reduction in  $t_{iC}$  has a negative impact on the profit from exporting to the PTA partner, which reduces national welfare  $\Rightarrow$  Member countries prefer higher tariffs under CU than under FTA.

## Effects of PTA: welfare

### Comparison of welfare

- Member countries:  $W_i^* < W_i^f < W_i^c$ ,  $i = A, B$ 
  - PTAs enhance member countries' national welfare.
  - CU achieves the highest welfare in member countries.
- Non-member country:  $W_C^c < W_C^* < W_C^f$ 
  - FTA achieves the highest welfare in the non-member country, while CU achieves the lowest.