

## 4.5 A Quick Repetition

- In case there are no international spillover, a Pigovian tax leads to a efficient allocation of pollution which is

$$p = f_S = -\frac{U_{S^*}}{U_Y} = \frac{dY}{dS^*}|_U$$

- The intuition is simply that the tax rate is equal to the marginal damage as judged by the citizens.
- If international spillover exist, an country  $i$ 's immis-sion are one  $n$ th of total emissions, the Pigovian tax is set too low

$$p_i = f_{S_i} = -\frac{U_{S_i^*}}{U_{Y_i}} = \frac{1}{n} \frac{dY_i}{dS_i^*}|_{U_i}$$

- There is an externality imposed on the other coun-tries, which implies that the tax rate is inefficiently low and the level of pollution inefficiently high.

## 4.6 Alternatives to Taxation: Tradable Permits

- Taxation can be used as an instrument to make the allocation of resources efficient.
- An alternative is to set up a market for tradeable permits.
- Under this mechanism, countries (or industries within countries) buy, or are given, the right to pollute.
- To the extent that the marginal benefit of polluting are different, there will be possibilities for trade.
- In equilibrium, the market price of the permits will be such that the marginal benefit of polluting is identical in all countries, which is the cost minimizing condition. (This can also be achieved with taxes.)

- Markets for tradeable permits for e.g.  $SO_2$  and  $NO_2$  have been used in the US since 1974. More recently markets have developed in the UK, Canada, Singapore and within the European Union.

### **The allocation of permits — grand fathering versus auction.**

- Most markets are characterized by grand fathering, i.e., permits are given away. There are, however, good arguments for using auctions.
- Considering the efficiency aspect only, trading will lead to an efficient outcome independent of the allocation of the permits.
- The money can be used to reduce other distortions.

- However, on the international level auctions may be difficult to use.
- It is very important to include poorer countries. To do this, they will have to be given a large amounts of the permits.
- Compensation in forms of side-payments may also be necessary in order to make poorer countries participate.

## **Market power**

- It may be a problem that large agents hoard permits in order to influence the market price.
- For example Russia and Ukraine, who will be sellers, may hoard permits.

- On the other hand, US, as the largest buyer, may act monopsonistic, pressuring the price below the price in perfect competition.
- Burniaux (1999) estimates that the cost for permits in the Kyoto market would be about 20 percent higher than under the competitive scenario.

## **Transaction costs**

- Transaction costs may be a problem because it will reduce trading of permits.
- It is costly to find out what the prevailing price is, identifying possible buyers and sellers, and making the transaction.
- There is some small scale evidence from Chile showing that this has been a significant problem (Borre-gaard et al. 2001).

- On an international market, however, the traders would probably be professionals and there are reasons to believe that trade will work smoothly.

## **Enforcement**

- Firms of course have incentive to pollute more than what they are entitled to.
- Also, firms may set the level of emission such that marginal profits equal the permit price plus the expected fine, which distorts the environmental outcome.
- Now, the permits may be of two kinds, either periodical or permanent.

- Periodical tradeable permits result in a variable flow of payments to the government just like a Pigovian tax and is in fact, from an economic point of view, no different from a tax.
- We now study two different mechanisms. One where permits are given out periodically and one where the permits are given out permanent.
- This latter case is equivalent to environmental standards.

## **4.7 A Model of Tradeable Permits**

- The model of the small open economy introduced in the beginning of the chapter serves as a starting point.

- As a reminder:
  - Production results in waste such that the environment becomes a production factor.
  - The linear homogenous production function is given by  $f(L, S, K)$  where  $S$  is emissions.
  - Labor,  $L$ , is internationally immobile; Capital is perfectly mobile across countries.
  - The wage rate,  $w$ , is determined endogenously; the rate of interest,  $r$ , is fixed at the world capital market.
- Moreover, a share,  $\alpha$ , of the environmental return flows to foreign countries (in addition to the usual interest payments to the physical capital invested).
- It is assumed that a fixed number of permits is already in circulation at the time the reform is made.

- The annual flow of environmental waste is given by  $Q$ .
- The government carries out an environmental policy by granting  $S - Q$  permits.
- The annual rental income per unit of waste is given by  $p$ .
- As before, the market's evaluation of waste is reflected in the following first order condition

$$p = f_S(K, S, L)$$

where  $S$  is the sum of old and new permits.

- The stock price of the permits among private firms is  $p/r$

- If the government invests its sales revenues in the international market it will receive

$$r \frac{p}{r} (S - Q) = p(S - Q).$$

- Accordingly, transfers to households are given by

$$T = p(S - Q)$$

- The rental income from owning the existing certificates, which accrues to the domestic residents, is given by

$$(1 - \alpha)Qp.$$

- Therefore, households income states

$$Y = wL + r\bar{K} + p(S - \alpha Q).$$

- Hence, national income is the sum of wages, capital income earned at home and abroad, and rental income stemming from the domestically owned  $(S - \alpha Q)$  old and new certificates.

- Making use of the linear homogeneity of the production function and the firm's first order condition, income can be rewritten as

$$Y = f(L, S, K) + r(\bar{K} - K) - f_S \alpha Q.$$

- Income is the sum of the domestic product,  $f(L, S, K)$ , and the capital income earned abroad,  $r(\bar{K} - K)$ , minus the rental income accruing to foreigners,  $f_S \alpha Q$ .
- The benevolent government has the following problem

$$\max_S U(Y, S^*)$$

$$\text{s.t.}$$

$$f_L = w, f_S = p, f_K = r,$$

$$S = S^*$$

$$Y = f(L, S, K) + r(\bar{K} - K) - f_S(L, S, K) \alpha Q.$$

- The first order condition is equal to

$$U_Y \left( f_S - \frac{\partial f_S}{\partial S} \alpha Q \right) + U_{S^*} = 0.$$

- Given the total derivative of the utility function

$$-\frac{U_{S^*}}{U_Y} = \frac{dY}{dS^*}$$

- the level of pollution is finally determined by

$$p = f_S = -\frac{U_{S^*}}{U_Y} + \frac{\partial f_S}{\partial S} \alpha Q = \frac{dY}{dS^*} + \frac{\partial f_S}{\partial S} \alpha Q.$$

- This condition says that the government selects the number of permits such that the marginal product of waste emissions equals the marginal social damage plus the marginal change in the rental income accruing to foreigners.
- So this is a marginal policy externality imposed on people who do not belong to the electorate and whose preferences are therefore neglected.

- Because the production function is linear homogeneous and because  $L$  is internationally immobile the policy externality is negative, i.e.  $\frac{\partial f_S}{\partial S} < 0$ , which implies excessive pollution compared to the social optimum.
- *Proposition 5.4:* When the environment is regulated by means of permanently valid permits and when some of the permits have found their way into the pockets of foreign owners, a government that maximizes national welfare will implement too lax an environmental policy.
- The result comes from a rent-dissipation effect affecting foreign direct investors who came before the environmental policy was chosen.
- By granting more permits, the government reduces the market price for permits. The point is that it does only care about owners in the home country. The loss foreign owners suffer from a lax environmental policy is not taken into account.

- Over time, this effect will become increasingly important, because globalization will cause the ownership structure to become more and more diversified.
- Note that the result holds independently of whether the waste emission spread across the country's borders or not.
- However, if the technological spillover effect analyzed in the previous section is added to the rent-dissipation effect, the two effects will reinforce one another.

## **4.8 Environmental Standards**

- We now model the case when the government regulates the economy with quantity standards.

- In the present setup, this implies that  $Q = S$ . In other words, there is no initial stock of permits.
- We are first looking for the national income, which is given by

$$Y = f(L, S, K) + r(\bar{K} - K) - f_S(L, S, K)\alpha S$$

- Note that compared before, the given historical quantity,  $Q$ , has been replaced with the actual emission volume  $S$ .
- The benevolent government has now the following problem

$$\max_S U(Y, S^*)$$

s.t.

$$f_L = w, f_S = p, f_K = r,$$

$$S = S^*$$

$$Y = f(L, S, K) + r(\bar{K} - K) - f_S(L, S, K)\alpha S.$$

- The first order condition is equal to

$$U_Y \left( f_S - \frac{\partial f_S}{\partial S} \alpha S - f_S \alpha \right) + U_{S^*} = 0.$$

what is equivalently to

$$p = f_S = -\frac{U_{S^*}}{U_Y} + \alpha \left[ f_S + \frac{\partial f_S}{\partial S} S \right].$$

or

$$p = f_S = \frac{dY}{dS^*}|_U + \alpha \left[ f_S + \frac{\partial f_S}{\partial S} S \right].$$

- Once again, the marginal product of waste emissions may differ from the marginal damage to the households because there is a policy externality on foreigners ( $\alpha > 0$ ).
- The price effect,  $\alpha \frac{\partial f_S}{\partial S} S$ , which we just analyzed is still there (but here  $Q = S$ ).
- There is also an additional term,  $\alpha f_S$ .

- It measures the marginal return from an increase in waste emissions, given the implicit rental rate.
- When new certificates are sold, foreigners do not participate in the marginal return.
- But when certificates are granted for free to firms that have foreign shareholders, they do.
- This externality goes in the direction of a too restrictive environmental policy.
- In other words, part of the benefits of pollution goes to foreign owners and is therefore not taken into account when the decision of how many certificate to issue is taken.

- Or in other words, a marginal increase in emissions increases the overall return from using the environment, and this effect partially dissipates to foreigners.
- Both terms taken together are the marginal revenue to the polluters from an increase in waste emissions, and it is unclear whether this marginal revenue is positive or negative.
- If  $f_S$  is steeply downward sloping (inelastic), then the price effect is strong, which speaks in favor of too lax environmental standards.
- However, we note that  $\frac{\partial f_S}{\partial S}$  also reflects the mobility in capital and labor.
- More mobile  $K$  and  $L$  leads to a more elastic demand curve for the environmental factor. Because  $K$  and

$L$  can be assumed to become more mobile in the future, the price effect may be reduced and we may expect the tendency to go toward tighter standards.

- In fact, if  $K$  and  $L$  are perfectly mobile, there will be no price effect at all.