Emissions Fees and marketable Permits

Kolstad - Chapter 9

Introduction

- Problems when using incentives to control pollution:

1. Space
2. Time
3. Imperfect Competition

- Space analyze two terms:

1. Source
2. Receptor

- concentration of pollution at any receptor j:

$$p_j = f_j(e_1, e_2, ..., e_I) + Bj$$

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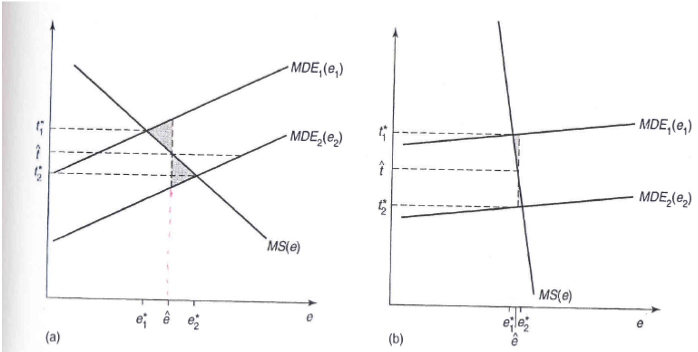
$$p_j = \sum_i a_{ij} e_i + Bj$$

- Definition: Suppose a change in emissions from source i ($\triangle e_i$) results in a change in pollution at receptor j ($\triangle p_j$). The transfer coefficient between the source i and the receptor j is defined as the ratio of the change in pollution at j to the change in emissions at i:

$$a_{ij} = \frac{\triangle p_j}{\triangle e_i}$$

- Efficient Pollution (equating marginal damage (Ambient Pollution) with marginal savings (Emissions)):
  - $$\begin{aligned} MDE(e_i) &= \{D(p+\triangle p) - D(p)\}/\triangle e_i \\ MD(p)\frac{\triangle p}{\triangle e_i} &= MD(p)a_i \\ -MC &= MD(p)a_i \quad \forall i = 1, ..., I \\ \frac{MC_n(e_n)}{a_n} &= -MD(p) \end{aligned}$$
  - MC/a is the marginal cost per unit of ambient pollution
  - This is the equimarginal principle modified for ambient pollution.

- $$MC_i(e_i) = -t_i \quad \forall i = 1, ..., I$$
- **Therefore from above:** $t_n = MD(p)an \quad \forall firm\ n$
- All firms face the same emission fee per unit of ambient pollution. It must be multiplied by the transfer coefficient
- Inefficiencies of uniform emission fee:
- 

- **Definition: An ambient pollution permit for a receptor j gives the holder the right to emit at any location, provided the incremental pollution at receptor j does not exceed the permitted amount.**
- **Example:**
  - Two Firms
  - EPA issues L_1 ambient permits to firm 1 and L_2 permits to firm 2.
  - $L = L_1 + L_2$
  - $L_1 + L_2 = l_1 + l_2$ (where l_1 and l_2 is the number of permits after trade)
  - $a_1 e_1 = l_1$
  - $a_2 e_2 = l_2$
  - Assume π is the price of the permits (unknown)

- **Example:**
  - $TC_1(e_1) = C_1(e_1) + \pi(l_1 - L_1) = C_1(e_1) + \pi(a_1 e_1 - L_1)$
  - $TC_2(e_2) = C_2(e_2) + \pi(l_2 - L_2) = C_2(e_2) + \pi(a_2 e_2 - L_2)$
- FOC :
  - $MTC_1(e_1) = MC_1(e_1) + \pi a_1 = 0$
  - $MTC_2(e_2) = MC_2(e_2) + \pi a_2 = 0$
  - $\frac{MC_1(e_1)}{a_1} = \frac{MC_2(e_2)}{a_2} = -\pi$ or
  - $\frac{MS_1(e_1)}{a_1} = \frac{MS_2(e_2)}{a_2} = \pi \quad (A)$
  - Marginal Savings = Permit Price!
  - We can obtain values of e_1 and e_2 using (A) and $L = a_1 e_1 + a_2 e_2$

- How much will be emitted?
- Many permits a firm may hold, if the price of permits is higher than the marginal savings from emitting (Sell)
- If the permit price is lower than the firm's marginal savings from polluting, buying permits is easier than controlling emissions (buy)

- **Different zones have different fees (More Flexible)**

- Time: *Stock Pollutant* (Pollutants that accumulate over time)

- Definition: Assume a pollutant accumulates in the env. according to the process:

$$s(t) = \delta s(t-1) + e(t)$$

where δ is he persistent rate of the pollutant and s the stock o

- Assume that pollution damage depends only on $s(t)$. Then if $\delta > 0$ the pollutant is a stock pollutant. If $\delta = 0$, the pollutant is a flow pollutant. $(1-\delta)$ is the fraction of stock that is cleansed out of the env. in one period.

- There is no sharp line between flow and stock pollutants. Efficiency is more complex.
- **The Net Cost of pollution emissions $\mathbf{e_t}$:**

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\begin{aligned}
NC &= \sum_{t=1}^{\infty} \beta^{t-1} \{ C_t(e_t) + D_t(s_t) \} \\
\frac{dNC}{de_1} &= \sum_{t=1}^{\infty} \beta^{t-1} \{ C_t'(e_t) + \frac{dD_t(s_t)}{ds_t} \times \frac{ds_t}{de_1} \} = 0
\end{aligned}
$$

- Note that

$$
\begin{aligned}
s_t &= e_t + \delta e_{t-1} + \delta^2 e_{t-2} + \ldots + \delta^i e_{t-i} + \delta^t s_o \backslash \\
\frac{ds_t}{de_1} &= \delta^{t-1} \\
\frac{dNC}{de_1} &= MC_1(e_1) + \sum_{t=1}^{\infty} \beta^{t-1}\delta^{t-1} MD_t(s_t) = 0 \\
MS_1(e_1) &= \sum_{t=1}^{\infty} \beta^{t-1}\delta^{t-1} MD_t(s_t)
\end{aligned}
$$

- Marginal Savings from emitting a unit of pollution today equal to the sum of all mg. damages that may occur in the future.
- The discount factor diminishes future marginal damages

- Initial Permit Issuance: For the purpose of efficiency does not matter which firm initially receive marketable permits
- **Dominant Firm:**
- If there is a single large firm (or potentially several large firms), it can make a difference how permits are initially allocated:
  - $TC(E) = C(E) - P(L-E)[L_B - E]$
  - $\frac{dTC(E)}{dE} = C'(E) + P'(L-E)[L_B - E] + P(L-E)$
  - $\frac{dTC(E)}{dE} = MC(E) + MP(E)[L_B - E] + P(E) = 0$
  - $MS(E) = MP(E)[L_B - E] + P(E) \Rightarrow E^{**}$
  - $E^{*} = MS = P(E)$
- Therefore

$$
\begin{aligned}
L_B &= E^* \Rightarrow E^{**} = E^* \\
L_B &< E^* \Rightarrow L_B < E^{**} < E^* \\
L_B &> E^* \Rightarrow L_B > E^{**} > E^*
\end{aligned}
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