File: Pollution2.doc

NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS

Pollution targets and instruments.

(a) Amend the data in the Excel workbook *Pollution.xls* so that the marginal abatement benefit (MAB) function is given by the following function:

MAB = 320 - Z

Then answer the following questions, explaining and commenting on your answers as you do so.

1. How does this change in the MAB function alter the efficient (or optimal) level of pollution abatement in the economy as a whole?
2. What will be the efficient (or optimal) level of pollution abatement for each firm?
3. Assume that the authority uses a (non transferable or non tradable) quota system to achieve the efficient aggregate level of pollution. Calculate the compliance costs when (a) quotas are allocated in identical amounts to each firm and (b) quotas are allocated to each firm in proportion to the firm's unregulated pollution level.
4. If a pollution tax system instrument is used, what will be the rate of the efficient tax?
5. If a tradable permit instrument is used, which firms will buy and which will sell permits? And in which quantities and at what prices will they be traded? (Answer this for the three types of permit regime investigated in the workshops; that is (i) where permits are issued freely to all firms in equal quantities, (ii) where permits are issued freely to all firms proportionately to previous pollution levels; and (iii) where permits are bought through a competitive auction. For the second and third cases, you will need to make up additional worksheets).
6. Calculate the total financial costs of compliance to firms under (i) a subsidy instrument, (ii) a tax instrument, (iii) the three alternative tradable permit regimes investigated in the workshops.
7. Calculate the net real resource gain by using any of the incentive-based instruments as compared with using the non-tradable pollution quota system in which quotas are issued in identical amounts to all firms.

(b) Briefly investigate the case where

MAB = 350 - Z

In particular, comment on your finding regarding abatement levels for each firm under any of the economic incentive based instruments? Do these results make sense?

Pollution targets and instruments: Information used in the "Illustrative Data" workbook:

Excel file: pollution2.xls

Marginal abatement cost functions.
The economy of interest consists of 5 firms. These are the only polluters in the economy, and the only organisations able to abate (reduce) pollution. The firms have marginal pollution abatement cost functions given by

$C_1 = 20 + 10\ Z_1$
$C_2 = 20 + 5\ Z_2$
$C_3 = 20 + (10/3)\ Z_3$
$C_4 = 20 + (10/4)\ Z_4$
$C_5 = 20 + 2\ Z_5$

Where C_i and Z_i are respectively the marginal abatement cost and the amount of pollution abatement for firm i (in units of tonnes of pollutant).

By inverting these marginal abatement cost functions, we obtain expressions for Z_i as functions of C_i as follows:

$Z_1 = -2 + 0.1\ C_1$
$Z_2 = -4 + 0.2\ C_2$
$Z_3 = -6 + 0.3\ C_3$
$Z_4 = -8 + 0.4\ C_4$
$Z_5 = -10 + 0.5\ C_5$

These can be used in Excel to obtain an aggregate marginal abatement cost schedule of the form:

$Z = f(C)$
where $Z = Z_1 + Z_2 + Z_3 + Z_4 + Z_5$
Specifically, the aggregate marginal abatement cost function (in inverted form) is given by

$$Z = \{(-2) + (-4) + (-6) + (-8) + (-10)\} + (0.1 + 0.2 + 0.3 + 0.4 + 0.5)C$$
$$= -30 + (3/2)\ C$$

which when inverted again to put into its usual form gives

$C = 20 + (2/3)\ Z$

The marginal abatement benefits (MAB) function
is given by
$MAB = 300 - Z$

Socially Efficient (Optimal) Pollution Abatement
is attained at the level of pollution abatement where
$C = MAB$
and so is obtained by solving for Z the equation
$20 + (2/3)\ Z = 300 - Z$ which yields
$Z^* = 168$

Note that at Z = 168, MAB (=damage avoided by last unit of abatement at the social optimum) is given by MAB = 300 – Z = 132, and so t = 132 would be the socially optimal tax rate, equal to the shadow price of pollution at the social optimum.

We can obtain a chart illustrating this using Excel.

The firms' total abatement cost functions
By integration of the five firms' marginal abatement cost functions, we obtain the five total abatement cost functions as follows:

$C_1 = 20 + 10\ Z_1 \quad \Rightarrow \quad TC_1 = 20\ Z_1 + 5Z_1^2$
$C_2 = 20 + 5\ Z_2 \quad \Rightarrow \quad TC_2 = 20\ Z_2 + (5/2)\ Z_2^2$
$C_3 = 20 + (10/3)\ Z_3 \quad \Rightarrow \quad TC_3 = 20\ Z_3 + (10/6)\ Z_3^2$
$C_4 = 20 + (10/4)\ Z_4 \quad \Rightarrow \quad TC_4 = 20\ Z_4 + (10/8)\ Z_4^2$
$C_5 = 20 + 2\ Z_5 \quad \Rightarrow \quad TC_5 = 20\ Z_5 + Z_5^2$

These can be used to calculate compliance costs under various instrument regimes.

Unregulated pollution levels
We simply assume that the unregulated (profit maximising) pollution levels of the firms are as follows:

F1	F2	F3	F4	F5	
88	85	75	65	60	(= 373 in total over all firms)

Allowable Pollution Quotas in a command and control framework (and initial zero charge allocations of marketable permits under Marketable Permit Regime 1) are taken to be:

F1	F2	F3	F4	F5	Total
41	41	41	41	41	205

which implies that abatement levels must be

F1	F2	F3	F4	F5	Total
47	44	34	24	19	168

The three alternative tradable permit regimes are:
Regime 1: Tradable Permits are allocated without charge in equal quantities to each of the five firms.
Regime 2: Tradable Permits are allocated without charge in quantities proportional to previous emissions to each of the five firms.
Regime 3: Tradable Permits are allocated through a competitive bid auction system. Each firm enters a bid, consisting of the maximum prices it is willing to pay for particular quantities of permits. A firm may bid one price for the first x units, another price for a further y units and so on, if it wishes. The regulator fixes a single permit price for all permits after all bids have been received. That price is the highest one that is consistent with selling all permits at that price.