

## Seminar 2

### Problem 1

Consider an economy where profit maximizing producers of a private good emit a uniformly mixing flow pollutant, which damages the environment. Let there be  $K$  firms in the economy, where  $K$  is a fixed number, and let firm  $k$ 's production be a (weakly) increasing and concave function of firm  $k$ 's emissions. Let  $M = \sum_k m_k$  be aggregate emissions, where  $m_k$  is firm  $k$ 's emissions. Let the social benefits of pollution,  $B(M)$ , be given by the maximal private good production that is possible for an aggregate emission level  $M$  (keeping other inputs constant), and let the social damage of pollution  $D(M)$  be determined by consumers' valuation of the environmental quality, measured in units of the private good.

An environmental regulator wants to maximize the net social benefits of pollution. To achieve this, the regulator will choose one of two alternative policy instruments: a uniform Pigouvian emission tax, or a tradable permit regime.

a) Provide an expression for  $B'(M)$  in terms of firms' production functions. In particular, discuss which firm(s) influence(s) the expression: Is it all firms, only one, and if it is only one, does it matter which one? Provide reasons for your answers.

b) If the regulator announces that it will use a tax, and then asks firms about their abatement costs, can the firms be expected to tell the truth? Why/why not? Can firms be expected to tell the truth if the regulator asks *before* it has announced its choice between taxes and permits?

Let the marginal social damages of pollution be given by

$$(1) \quad D'(M) = 2M - 1.$$

Assume now that the regulator knows  $D'(M)$ , and also knows that the marginal social benefits of emissions,  $B'(M)$ , are given by

$$B'(M) = X - 3M.$$

The regulator does not know  $X$ , only that either  $X = 10$  or  $X = 8$ . Firms know their own abatement costs.

c) Can you, without further calculations, recommend an instrument choice (emission taxes or tradable permits)? Provide reasons for your answer.

d) Calculate the optimal emission level and the Pigouvian emission tax in the following two cases:

i)  $X = 10$

ii)  $X = 8$ .

e) Assume now that the regulator believes that  $X = 10$ , and introduces a Pigouvian tax based on this assumption. Assume, however, that the true  $X$  value is 8. What will actual emissions be? Show graphically (using a figure) the loss in net benefits due the regulator's mistaken estimate of  $X$ .

f) Assume again that the regulator believes that  $X = 10$ , while the true value of  $X$  is 8. The regulator introduces a permit market regime based on the assumption that  $X = 10$ . Show graphically (using a figure) the loss in net benefits due the regulator's mistaken estimate of  $X$ . Is this loss larger or smaller than the loss you found in 1 e)? Why?

g) If the regulator cannot know the true  $X$ , should it then choose a tax or a permit market? Would your answer be affected if, instead,  $B'(M)$  was given by  $B'(M) = X - 0.5M$ ?

## Problem 2

Assume that the profit maximizing emission level of a firm, in the absence of any environmental regulation, is 10. Then the regulator introduces a command-and-control policy implying that the firm faces an emission cap of 8.

Denote the actual emissions of the firm  $m$ . The probability that the firm will be monitored is 0.5. If the firm is monitored and caught exceeding its emission cap ( $m > 8$ ), it will have to pay a fine  $F$  as a function of  $m$ , such that

$$F(m) = 2(m-8) \quad (\text{for } m > 8. \text{ If the firm is not monitored, or if } m \leq 8, \text{ then } F=0.)$$

Assume that the firm can clean its emissions has the following abatement cost function:

$$c(a) = \frac{1}{2} a^2$$

where  $a = 10 - m$ .

i) If the firm is risk neutral and is minimizing its total expected emission-related costs (abatement costs plus expected fines), will it obey or violate the new regulation?

ii) If the penalty function is changed to

$$F(m) = 100 + 2(m-8),$$

how would that influence the firm's decision?