ECON4910 Environmental Economics — Seminar 4

March 24, 2015

Problem 1

In this exercise we examine issues related to asymmetric information between the polluting firms and the regulator. Assume that an environmental policy has been put in place, but that the level of emissions is not observable directly by the regulator. However, the regulator can audit a polluter at some cost and obtain the desired information. Furthermore, if the regulator discovers a violation of the regulations, he will impose some penalty on the cheaters.

(a) Intuitively discuss how the level of penalty (size of the fine) and the frequency of auditing are correlated.

Consider N identical firms with emitting some pollutant e with cost $C(e)$ where $C'(e) \leq 0$ in the region of interest (i.e. close to the quota).[1] The regulator has a decree that each firm can emit at most $\bar{s}$ units of pollution. The firms report emissions to the regulator and have a probability π of being audited. If it is found to be emitting more than allowed, the firm must pay a fixed amount D and a fine f per unit of emission above $\bar{s}$. Therefore the total cost before knowing if audited is:

$$TC(e) = C(e) + F(e)$$

where

$$F(e) = \begin{cases} \pi[f(e - \bar{s}) + D] & \text{if } e > \bar{s} \\ 0 & \text{if } e \leq \bar{s} \end{cases}$$

(b) Discuss when a firm will respect the emission limit and when it will be optimal to violate.

Now assume firms' cost function is given by $C(e) = \frac{1}{2}e^2 - be + a$, where a and b are positive constants.[2]

[1] What is this cost? Think about how polluting benefits the firm, alternatively how reducing pollution imposes costs.

[2] This cost function does not satisfy $C'(e) \leq 0$ for $e > b$, but that is not important for the solution.

(c) Write down the total cost function. How can the firm calculate their optimal level of pollution?

(d) Discuss what considerations the regulator makes regarding auditing and penalties. What are the limitations on the size of the penalties? What is the level of the marginal fine the regulator has to set?

Problem 2

There is a large number N of identical polluting firms in the economy, each having an abatement cost function $c(a_i; y_i)$, where a_i and y_i are abatement and technology levels of firm i, respectively.

(a) The function c has the properties assumed in "Environmental R&D" by Hoel (2010). What are these?

(b) The technology level of firm i is given by $y_i = x_i + \gamma \sum_{j \neq i} x_j$ where x_i is the number of useful ideas firm i purchases from the R&D sector. Give an interpretation of this equation.

(c) The R&D sector produces ideas at a cost $f(X)$ per idea, where $X = \sum_j x_j$. Discuss what the sign of f' might be.

(d) Assume that there is one firm per produced idea in the R&D sector, and that there are zero profits in this sector in equilibrium. The government has an environmental cost function $D(E)$ with $D' > 0$ and $D'' \geq 0$, where E denotes total emissions. Prior to the production and trade of useful ideas, the government can commit to a particular level of total emission quotas. In this setting, what is the first-order-condition that defines the amount of ideas that firm i is buying? What is the market condition that defines the total number of ideas that are bought?

(e) What is the optimal policy of the government (i.e. it minimizes abatement cost, R&D costs, and environmental damages subject to the market constraint)?

(f) The necessary condition for optimality is given by:

$$c_a - D'(E) = \frac{(-\gamma(N-1)f + Nxf')c_{ya}}{[1+\gamma(N-1)]c_{yy} + Nf'}.$$

Assume that the denominator is positive. Given that $\gamma > 0$ and $f' < 0$, what does the necessary condition imply as compared to the benchmark case when there are no externalities relating to the R&D sector?

(g) Does your result depend on whether the quotas are allocated for free to the polluting firms or are auctioned?

(h) How would the outcome be changed if instead of committing to a quota the government committed to an emission tax?

References

Hoel, M. (2010): "Environmental R&D," Memorandum 12, Department of Economics, University of Oslo, Oslo.