EC371 – Environmental Economics

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Practice Problems for Unit 3: Air Pollution

There are three problems. Please read and think about them carefully, and work through them before *looking at the solutions. If you are having trouble, you can seek clarification and help from classmates and during my office hours, but it is highly recommended that you struggle through the questions yourself first. Your goal should be both to learn the mechanics and to grasp the intuition and think more deeply about the issues. Solutions will be posted by the afternoon of Friday, November 11, 2011. If you would like comments on your work and solutions, you can submit them to me at any time.*

1. Consider an economy with two firms that emit an environmentally harmful uniformly mixed fund pollutant as a by-product of their production process. These emissions are perfectly and costlessly monitored by the government. Suppose that it has been decided that there should be a *reduction* in total emissions of 21 units. The marginal cost relations faced by each firm for abating a given amount are $MC_1 = 100q_1$ and $MC_2 = 200q_2$ (in dollars) where q_1 and q_2 are the units of reduction (i.e. abatement) undertaken by firm 1 and firm 2 respectively. Each firm produces 32 units of *emissions* in the absence of any regulation, i.e. each firm has baseline emissions of 32 units. (You should be able to show that the aggregate abatement target of 21 together with aggregate baseline emissions imply that the aggregate emissions target is 43.)

a) Find the cost-effective allocation of individual abatement requirements. Does it make intuitive sense? Calculate the appropriate per-unit fee that the government would have to implement to achieve this allocation. Calculate the amount that would be paid by each firm towards total abatement costs and total fees to the government if this fee were in place.

b) Suppose that firm 1 has access to a new technology, which would cause its marginal abatement cost relation to become $MC_1' = 50q_1$ if adopted. Calculate the immediate benefit that the firm would enjoy if it were to adopt the new technology, assuming that the per-unit fee stays constant at the level you found in the previous part. Describe the two sources of this benefit. What are total industry-wide emissions after firm 1 adopts the technology?

c) Instead of using an emissions fee, suppose that the government prints 43 tradable emissions permits, gives 12 to firm 1 and the remaining 31 to firm 2, and sets penalties for over-emitting so stringent that neither firm ever wants to emit beyond the number of units that it is allowed to as determined by the number of permits that it holds. Firm 1 initially has the old technology (i.e. $MC_1 = 100q_1$). What is the cost-effective allocation of individual *emissions*? Describe in some detail, with a few calculations, the process by which this allocation will be achieved starting from the initial allocation of permits (and assuming that there are no frictional or transaction costs that would hinder bargaining between firms). What will be the price of permits *at this allocation* (i.e. at what price would the last permit be exchanged if each permit were for an infinitesimal unit of emissions)?

d) How much will each firm pay in terms of total abatement costs *at this allocation* plus total permit purchases made in getting to this allocation? (To make things as simple as possible, assume that each permit is for one discrete unit of emissions, and also that each permit is exchanged at the terminal price

you found in the previous part.) How does the total cost burden on firms in this case compare to that with the fee policy from part a)?

e) Now suppose that, with the permit policy in place and starting from this allocation, firm 1 adopts the new technology (i.e. its marginal cost curve becomes $MC_1' = 50q_1$). Explain briefly and *intuitively* how the allocation of emissions, the aggregate level of emissions and the price of permits will change.

2. The marginal damage costs from emissions of a uniformly mixed fund pollutant are given by $MD = 0.09Z^2 - 1.25Z + 8.6$, where Z is the aggregate level of emissions of the pollutant at any point in time. The economy-wide marginal control cost curve is given by $MC = 1.25Q + 2.6$, where Q is the aggregate amount of emissions abated at any point in time. The pollutant in question is emitted by a total of four firms, where *each* firm has baseline (current, pre-regulation) emissions of 30 units.

a) Find the efficient level of aggregate emissions of the pollutant in this economy.

b) The four firms have marginal abatement cost curves given by $MC_1 = 3 + 4q_1$, $MC_2 = 4 + 5q_2$, $MC_3 = 6 + 5q_3$ and $MC_4 = 7 + 6q_4$ respectively. Suppose that the government decides to mandate (and can fully enforce) the following firm-level reduction targets: firm 1 will abate 29 units; firm 2 will abate 23 units; firm 3 will abate 15 units; and firm 4 will abate 13 units. Will this policy achieve the efficient level of emissions? Will it be cost effective?

c) Suppose that instead of mandating reduction targets, the government chooses to levy a uniform fee of \$115/unit of the pollutant emitted on each firm. Will this alternative policy achieve the efficient level of emissions? Will it be cost effective?

3. Consider an economy with two firms that emit an environmentally harmful uniformly mixed fund pollutant as a by-product of their production process. These emissions are perfectly and costlessly monitored by the government. Suppose that it has been decided that there should be abatement of 30 units starting from the pre-regulation level of aggregate emissions. The marginal cost relations faced by each firm for abating a given amount are $MC_1 = 45 + 2(q_1)^2$ and $MC_2 = 9 + (q_2)^2$ (in dollars) where q_1 and q_2 are the units of abatement undertaken by firm 1 and firm 2 respectively. Baseline emissions, in the absence of any regulation, are 27 for firm 1 and 23 for firm 2.

a) Briefly discuss why the shape of the curves might be reasonable in terms of the abatement options available to firms in the real world.

b) Calculate the cost-effective allocation of individual abatement requirements that satisfies the total reduction requirement. If this allocation were to be achieved through implementing an emissions fee, what would be the appropriate amount of the per-unit fee? With this fee in place, how much would each firm remit to the government in the form of fee payments?

c) Describe some reasons why the fee policy might be preferred or not to a tradable permits system with permits initially grandfathered, by the firms on the one hand and by the government and society more broadly on the other hand.