

## Problem Set 2

Introduction to Environmental and Resource Economics, October 27, 2003

Due Oct. 28

(Some questions from Dr. Nora Underwood; some from Dr. Parker)

1. In your own words, define the term “externality”. Give an example of two things that you do every day that generate negative externalities. Give two examples of ways in which you generate positive externalities. What do you think would induce you to do more or less of each? Why?
2. The included graph represents the market for a good whose production generates external costs. Use the graph and points marked to answer the following questions:
  - (a) Explain the difference between the marginal private cost and marginal social cost curves.
  - (b) Identify the competitive market solution
  - (c) Identify the socially optimal solution
  - (d) Moving from  $Q_2$  to  $Q_1$ , what does area  $cde$  represent?
  - (e) Moving from  $Q_2$  to  $Q_1$ , what does area  $cdef$  represent?
  - (f) Which area represents the net gain to society in moving from the market solution to the socially optimal solution? Is this movement Pareto improving? Does it meet the Kaldor-Hicks criteria?
  - (g) Referring to your graph, use this example to explain why the competitive market solution is not economically efficient when exclusivity is violated.
3. Consider the market for cookies. At the market solution, bakers produce cookies at a private marginal cost of 5 cents per cookie. However, the social marginal cost of each cookie is only 3 cents, as each cookie generates 2 cents worth of pleasant aroma for passers-by.
  - (a) Draw a plausible demand curve for cookies, the private marginal cost curve (assuming no fixed costs), and the social marginal cost curve.
  - (b) In the competitive solution, identify all of the social gains from cookie production. Use letters to represent the areas on your graph, as in problem 2. (Hint: There are three types of benefits.)
  - (c) In the case of a positive externality, is there likely to be overproduction of cookies or underproduction? Explain.
  - (d) Suppose cookie producers are given a subsidy of 2 cents per cookie. Identify the new level of output on your graph.
  - (e) Does the subsidy lead to a social improvement? Compare the totals of the three types of benefits to make your argument.

4. Suppose that you own a house along a river and like to swim and fish in the river every day after work. Suppose further that several factories open upriver from your house and begin to dump waste into the river.

The factory faces the following demand curve for its product:

$$P = 300 - 6Q$$

and the factory's marginal cost curve is:

$$P = 30 + \frac{3}{2}Q$$

- (a) Assuming a perfectly competitive market, what level of output will the factory supply, and what will be the price? What are the values for consumer surplus, producer surplus, and total surplus?
- (b) Suppose that the pollution being dumped in the river is giving you a rash, and you are catching fish with more than two eyes. A highly-paid consulting firm estimates that these events impose a marginal cost to you represented by:

$$MEC = \frac{3}{2}Q$$

and a total external cost of:

$$TEC = \frac{3}{4}Q^2$$

Given this information, what is the socially optimal level of output for the factory? What would be the price at this level of output? What are the values of consumer and producer surplus? In terms of only consumer and producer surplus, does the move from the competitive to socially optimal solution improve welfare?

- (c) What are the total external costs for both the competitive market and socially optimal solutions? Why isn't the total external cost zero at the socially optimal solution?
- (d) Using the information from the previous two questions, calculate the net gain to society (improvement in total welfare) from moving from the competitive solution to the social optimum.
- (e) Graph the problem, labeling each level of output and price and indicating which area represents the net gain from moving to the social optimum.
- (f) Suppose that the factory had the legal right to pollute. Show how bargaining between you and the factory could lead to the socially optimal solution. Demonstrate graphically your willingness to pay to reduce pollution and the factory's willingness to accept. What is a possible price that would be acceptable to you both?

5. You are the head of the pollution control agency in charge of regulating emissions of coal-fired electric generating plants in a small town in Southern Indiana along the Ohio River. There are two plants. The two plants have the following marginal control cost functions (MCC), where costs are in millions of dollars, and  $e$  represents the level of pollution emitted in a given time period.

$$MCC_1 = 50 - 0.05e_1 \quad (1)$$

$$MCC_2 = 50 - 0.2e_2 \quad (2)$$

The social costs of emissions, which include acid rain damage and mercury contamination, are given by:

$$MDC = 0.15e$$

where  $e$  refers to the aggregate level of emissions.

- Verify that the aggregate marginal control cost function is  $MCC = 50 - 0.04s$  (Hint: Use the same approach that you would use to construct a market demand curve.)
  - If you do nothing to regulate the firms, what will be the level of emissions released by each firm? (Hint: Is the firm likely to spend any money on control costs if it doesn't have to?)
  - What is the efficient level of total emissions? Graphically illustrate this solution. (Hint: Measure emissions, not abatement, on the  $x$  axis.)
  - How much pollution should be released by each firm, given your answer for total emissions from above?
  - A typical problem when regulating pollution is that the individual firms' marginal control costs are not known. Assuming now that you don't know these costs, you decide to allow each firm to emit half of the level of pollution found above. Would this be an efficient allocation of pollution? Explain and illustrate graphically. (Hint: Focus on the equimarginal principle of optimality.)
  - If there were a uniform emissions allocation, what is the potential for bargaining or emissions trades between the two firms? Explain.
  - Briefly discuss the difference between allocative efficiency and cost efficiency. Need they occur together in general? If we want to achieve maximum social welfare, what implication must hold for both allocative and cost efficiency?
6. Suppose that there are two firms that each emit 20 units of pollution, and that the regulating authorities want to reduce this level to a total of 20 units between the two firms. They decide to initially allocate 10 permits to each firm, which allow 1 unit of emissions per permit. Firm 1's cost functions are given by:

$$TAC_1 = 10 + \frac{3}{4}A_1^2 \quad (3)$$

$$MAC_1 = \frac{3}{2}A_1 \quad (4)$$

Firm 2's costs are given by:

$$TAC_2 = 5 + \frac{1}{2}A_2^2 \quad (5)$$

$$MAC_2 = A_2 \quad (6)$$

Find the equilibrium level of abatement for each firm and a permit price which will achieve this solution. Note that a unique permit price cannot be determined, but there is a range of possible prices. Given that there is some trading, show that both firms are better off.

7. Read the two editorials about HOT traffic lanes, and discuss the HOT proposal using externality theory. Analyze three possible scenarios: the status quo (HOV lanes for carpool and mass transit only), HOV lanes with no congestion tolls, and HOV lanes with congestion tolls. In each case, what costs and benefits are generated? Who pays the costs and benefits? How might we try to evaluate whether the costs and benefits of each proposal would justify its implementation? How might the answer depend on specific conditions? How might the behavior of the different groups of users change in the different scenarios? *Note:* This is a very complicated question with no simple answers! So there is certainly no one correct answer.
8. Read the New York Times articles and editorials about the Bush administration's decision to relax pollution control regulations. What do you think the implications might be for cost efficiency of pollution control? The administration claims that the rule change will decrease emissions, while critics claim it will lead to increases. Can you sort out these arguments? Given that there is a tradable permits market for some of the emissions affected by this proposed change, how would you expect market activity to change under this new rule? Note that Eastern states are organizing legal opposition to this new action. What do these suits imply about the distribution of property rights in this case? Would you expect a Coasean bargaining solution to arise? Why or why not?
9. Read the articles about the conflicts between rice and cotton growers in central California. Do you think there is potential for a Coasean solution to this problem? What factors might favor it? What might stand in the way?