Problem Set #1
14.41 Public Economics

DUE: September 24, 2010

1 Question One

For each of the examples below, please answer the following:

1. Does an externality exist? If so, classify the externality as positive/negative (or both).

2. If an externality exists, determine whether the Coase theorem applies (i.e. is it possible to asign property rights and solve the problem?)

3. If an extenality exists and the Coase theorem does not apply, argue which of the government's tools are best suited to address the issue: quantity regulation, taxes/subsidies, tradeable permits, or something else.

Consider the following examples:

1. British Petroleum drills for oil in the gulf coast

2. Carbon emissions from vehicles

3. Your upstairs neighbors throwing an awesome, but loud party

4. Buying a car with added safety features that prevent the drivers/passengers' deaths in the event of an accident

5. Bringing crying babies on a plane

2 Question Two

An natural gas company in San Francisco owns many pipelines running underneath what is now populated areas. The company can invest \$$u$ in the maintenance of the pipes. Maintenance affects two things. First, more maintanence means that the gas company will lose less gas in the pipes.

Assume that the value of lost gas is given by $\frac{1}{u}$ so that more maintenance reduces the amount of lost gas. Second, more maintenance means less damage to the land above the pipes. Assume that value of the damage to the land above the pipes is given by $3 \cdot \frac{1}{u}$, so that more maintenance decreases the amount of damage to the land above.

1. What is the socially optimal level of maintenance, u? What is the value of lost gas? What is the value of land damage?

2. What level of u is chosen by the gas company when no one owns the land above the pipes? Now what are the total amount of damage reduction? What is the deadweight loss?

3. Suppose now that the gas company owns the land above the pipes. What level of u will they choose now? Is this optimal?

4. Suppose now that Jimmy Fallon, an ordinary private citizen, owns the property above the plant and can costlessly sue the natural gas company for the losses to his property. What level of u will be chosen by the natural gas company? How much will be paid from the gas company to Jimmy Fallon?

5. Suppose now that the courts are imperfect: For every \$1 in actual damage, only 50% of the damage can be recouped in court. So, if the true damage to Jimmy is L, the gas company will only pay $\frac{L}{2}$.

   (a) Suppose Jimmy Fallon owns the property. What level of u will be chosen by the gas company? Is this efficient? If not, what is the deadweight loss?

   (b) Suppose the gas company owns the property. What level of u will be chosen? Is this efficient? If not, what is the deadweight loss? If your answer is different than in (a), why? Have we violated an assumption of the coase theorem?

Question Three

Two power plants provide power to all of Cambridge: an MIT plant and a Harvard plant. Both power plants burn coal to produce electricity, and consequently produce smog as a by-product. The MIT power plant could reduce its smog, but at a total cost:

$$c_M(x_M) = 5 \cdot x_M^2$$

where x_M indicates the total number of units of smog abated by MIT. The Harvard plant is slightly less efficient, and its total cost for cutting down on smog by x_H is:

$$c_H(x_H) = 7 \cdot x_H^2 + 10 \cdot x_H.$$

The Cambridge government hires a team of environmentalists who calculate that the total benefit of smog abatement to the city of Cambridge is $100 \cdot (x_M + x_H)$.

1. Calculate the socially optimal level of abatement for each power plant.

2. The Cambridge government considers imposing a tax on power production.

    (a) What tax should it impose to reach the abatement amounts you calculated in part (1)?[1]

    (b) Write down each firm's optimization problem under the tax, and show that each will privately choose the socially optimal abatement amount.

3. Suppose that instead of taxation, the Cambridge government tries to regulate quantities. However, the city of Cambridge cannot write a law for each firm, so it simply declares that all Cambridge power plants must cut down on smog by $x_C \equiv 1$ units each year. Show that this is not efficient with BOTH math and intuition.

4. Suddenly, an economist is voted in as Mayor of Cambridge. She declares that Cambridge power plants must cut down on smog by 5 units *overall*. Additionally, she declares that firms will be able to competitively trade permits that will allow them NOT to abate. One of the mayor's old classmates from graduate school runs the MIT power plant, so the Mayor grants MIT 5 permits and Harvard 0 permits. As a result, Harvard is expected to abate by 5 units, and MIT (since it owns all the permits) is not expected to abate at all.

    (a) Harvard will surely want to buy some of MIT's permits. Explain intuitively (no math), why this trade might happen.

    (b) Denote the number of permits that MIT holds as y_M (so that $x_M = 5 - y_M$), and denote the competitive price of permits as p. Derive the amount of permits that MIT will eventually hold as a function of p.

    (c) Calculate the amount of permits that Harvard will hold as a function of p.

    (d) Using that fact that $y_M + y_H = 5$, calculate p.

    (e) If the new mayor had divided the permits up differently, what outcomes would have changed and what would have stayed the same?

Question Four

Vermont Hardwood crafts solid wood furniture using a combination of time-tested hand construction and modern finishing techniques. Residual wood finishing chemicals are washed away as run-off and deposited in the nearby lake, a favorite fishing site for locals. A variety of technologies, including

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[1] Hint: we can think of a Pigouvian tax here as a subsidy on abatement. So taxes on pollution provide firms an incentive to abate.

high volume, low pressure sprayers and on-site solvent recovery sills are available for implementation. These technologies allow the manufacturer to reduce chemical emissions at a cost:

$$C_1(a) = 20 \cdot a^2$$

where a is the level of pollution abatement. A city planner determines that the benefit to the residents of pollution abatement is 10 per unit.

1. Sketch a graph depicting the private marginal costs and benefits of abatement, and label the private market equilibrium. On the same set of axis, sketch the social marginal costs and benefits of abatement, and label the efficient outcome. Indicate the DWL if the city takes no action.

2. Calculate the level of pollution abatement that is socially efficient.

3. If the city institutes a per-unit tax on chemical emissions, what specific tax (τ^*) will reach the socially optimal amount of abatement?

   The city planner is considering either taxing the firm's pollution or requiring the firm to reach a minimum level of pollution abatement. However, given constant progress in abatement technologies the costs of abatement *might* reduce to: $C_2(a) = 20 \cdot a^2 - a$. Thus while the social benefits of abatement are known, the social costs are uncertain.

4. Suppose that the planner institutes the per-unit tax calculated in (b). Assume that the true costs of abatement are revealed as $C_2(a) = 20 \cdot a^2 - a$. Illustrate the problem graphically and indicate the DWL relative to the social optimum. What level of abatement will be undertaken by the firm? Calculate the DWL.

5. Suppose instead that the planner institutes a mandatory minimum abatement at the socially optimal level found in (2). Again, assume that the true costs of abatement are revealed as $C_2(a) = 20 \cdot a^2 - a$. Illustrate the problem graphically and indicate the DWL relative to the social optimum. What level of abatement will be undertaken by the firm? Calculate the DWL.

6. Given the uncertainty in abatement costs, which strategy makes the most sense for reducing pollution in this context?

7. Intuitively discuss what is driving this result.

Question Five

Gilroy, CA is the garlic capital of the world. Unfortunately, the stench of garlic permeates all aspects of life in the city. There are only two residents willing to live within city-limits, Abe and

Betty. Abe earns an income of 460, and Betty earns an income of 440. A traveling salesman is visiting the town, offering odor conversion units which conveniently inputs garlic odor and outputs clean air. Preferences over clean air (C) and all private consumption goods (x_i) for individual i are given by:

$$U_i = 5 \cdot ln(x_i) + ln(C)$$

The total provision of clear air is given as the sum of individual purchases: $C = C_A + C_B$ $(+C_G$ when the local government purchases clean air in parts (4)-(5)). The price of clean air is 2 while the price of all other consumption goods is 1.

1. For both Abe and Betty, calculate each individual's private provision of clean air, taking the other's provision as given. That is, solve for C_A as a function of C_B in Abe's optimization problem (and solve for C_B as a function of C_A in Betty's optimization problem). Can you explain the sign on the contribution of the other resident in these response functions?

2. If the government does not intervene, what level of clean air will be provided? How many units are provided by Abe? How many by Betty?

3. What is the socially optimal level of clean air provision? (You may assume a utilitarian social welfare function) Does this value differ from that found in (2)? Explain in the context of externalities.

4. Suppose the local government is dissatisfied with the level of private provision. The government taxes both Abe and Betty 30 each in lump-sum fashion (net-of-tax incomes are effectively reduced to 440 and 410 respectively) to provide 30 units of clean air. Both Abe and Betty are free to purchase additional units of clean air if they find it privately optimal to do so. What is the total level of clean air provided? Clearly explain the impact of the taxation/provision by the local government on the private provision by each resident. How does this answer compare to (2)?

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