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Economics of Environmental Policy

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Take Home Exam 1
Spring 2012

Due at the 12:45 pm on 3/8 if submitted on paper or by midnight if sent by email.
Do not open this exam until you are ready to begin.

Instructions

1. Write your **SUID** on your answer and **DO NOT** write your name.

2. Please write your answers on regular paper (not a blue book). You do not need to type them.

3. There's no hard time limit on the exam but try to do it in one sitting of no more than about 3 hours.

4. Show all your work. Answers without supporting work will receive little or no credit.

5. The exam is "open book/open notes": you are welcome to refer to your notes, to the exercises and their answer sheets, the class web site, or to readings listed on the syllabus.

6. It is NOT "open friend": you must do the exam yourself MAY NOT talk with anyone about it until after the due date.

7. The item above includes your friend Google: you can use materials that you already have on hand but please don't go hunting for more.

8. Using a spreadsheet is OK as long as you attach a printout showing the details of your calculations. However, you should have no problem doing the exam with a calculator as long as you take advantage of some of the compound PV formulas.

Question 1: Managing an Externality

Consider a good whose market demand is given by W2P = 200 – (1/100)*Q. The market is competitive and the marginal cost curve for producing the good is given by MC = (1/100)*Q. However, production of the good creates a negative externality and the marginal cost of the externality is given by MCext = (1/200)*Q.

(a) Please determine the market equilibrium and the efficient level of output given the externality.

(b) Suppose policy makers wish to use a unit tax (that is, a specified dollar tax on each unit of output) to move the market to the efficient level of output. What should the tax rate be?

(c) Please determine the welfare effects of the tax: compute the changes in consumer surplus, producer surplus, etc. What is the overall gain from the policy?

Now suppose the government wants to use the revenue to lower a tax in a different market, in this case for good "B". Raising taxes on externalities and lowering other taxes is known as "green tax reform". The second market has the following characteristics: W2Pb = 114 – (1/500)*Qb and MCb = $40. There is currently a $10 tax per unit in effect.

(d) Please determine the current market equilibrium and the amount of tax revenue being raised in the market for good B. Then determine how much the tax on good B could be lowered given the revenue from the externality tax. That is, what is the new tax rate on B that keeps the total revenue from the two taxes equal to the original revenue from the tax on B?

(e) Please determine the welfare effects of the change in the tax on B. What is the overall gain combining both parts of the policy?

Question 2: Risk and Regulatory Compliance

US environmental regulations often take the form of "performance standards" that require firms to reduce their emissions to a specified level; for example, limiting dioxin in water discharged from paper mills to 2 mg per day. In principle, the firms are allowed to adopt any technology or change in their production process that will achieve the target. However, firms are usually uncertain about how well technologies will work before they're actually in place. In practice, they often choose particular approaches designated by EPA as Best Available Control Technologies (BACT) even when other alternatives might be equally effective and cheaper. This question explores why.

Suppose that a regulation requires a firm to reduce its emissions of a particular pollutant from 10 mg (milligrams) per day without controls to 2 mg. The firm is considering two approaches, the BACT technology and an alternative we'll call ALT (alternative). It has the following data about the two technologies:

	BACT	ALT
Construction cost (year 0)	$1 million	$1 million
Useful life	10 years	10 years
Annual operating cost (years 1-10)	$110,000	$0
Probability of achieving 2 mg	50%	50%
Probability of achieving 4 mg	50%	50%

To be clear: each technology will work to some extent: the firm will definitely reduce emissions to no more than 4 mg. However, there's a 50% chance each technology will fail to achieve the 2 mg standard. If the firm doesn't achieve 2 mg, it will be subject to a $200,000 year fine for each of the 10 years. The firm now earns $400,000 per year in profit on this product and it must adopt one technology or the other to stay in business. It uses a 5% interest rate in present value calculations and you may assume that the analysis only needs to include payments in years 0-10.

(a) Please calculate the expected net present value of each option. What would a risk neutral firm choose?

(b) In practice, firms know they are less likely to be fined for failing to meet a performance standard if they've adopted EPA's BACT option: choosing BACT allows them to make a strong argument that they made a good-faith effort to comply. Given the data above, what is the net present value of the BACT technology if there's no risk of a fine? In this case, would that change the decision? Explain.

(c) Finally, suppose as in (2) that there's no chance of a fine with BACT but now the firm's management is risk averse and maximizes its expected utility. The utility the management gets from an NPV payoff of C dollars is the square root of C: U=C^0.5. What is the firm's decision in this case? What is the certainty equivalent associated with the ALT technology? Is this decision efficient? Discuss briefly.

Question 3: PACE Bonds

Property Assessed Clean Energy (PACE) bonds are recent innovation some states have adopted to help home owners finance energy efficiency improvements. Roughly speaking, a PACE bond allows a home owner to avoid borrowing for up-front capital costs. Instead, those costs are paid by the home owner's municipality and the home owner repays the city through a higher property tax. This question explores how they work.

Suppose a home owner is considering installing a residential photovoltaic (PV) system. The system would have an AC capacity of 3.1 kW, and would cost $4 per watt to build. It would last 30 years and would have a capacity factor of 17% (typical for PV in NYS). Every kWh generated by the system would allow the home owner to avoid paying $0.145 (average price in NYS) to buy that electricity from the grid. The system is expected to last 30 years and you may assume it has no annual costs—the only cost is the up-front capital. The home owner can borrow or lend at an interest rate of 10%.

(a) Please compute the net present value of the system to the home owner. Assuming that her only interest is in avoiding electricity costs (no other environmental motivation), would she go ahead with it?

Now consider the system from the city government's point of view. Suppose that the system would provide $45 per year in external benefits (avoided damages from conventional electricity generation). Also suppose that the city has a good credit rating and can borrow or lend at 2%.

(b) Including both the private benefits and the externality, what is the NPV of the system from the city's perspective?

(c) Now suppose the city considers offering the homeowner PACE bond financing with the following characteristics. The city would pay the entire construction cost of the system, in exchange for which the homeowner would pay an extra $570 in property taxes every year for 30 years. What is the NPV of the PACE payments to the city? Does it cover the construction cost? Including the environmental benefits as well, what is the NPV to the city?

(d) If the project goes ahead, what is the net effect on the homeowner's annual costs including both energy savings and PACE repayments? What is the NPV to the homeowner? Is it a good idea from the homeowner's perspective to proceed?

Some additional information you might find interesting but DO NOT need to take it into account in answering the question: (1) PACE obligations remain attached to the property even if it's sold: future owners will have to continue repaying. Advocates of PACE argue that this means the bonds are very low risk for cities. However, actual city managers sometimes disagree: rust belt cities with declining property values often have a lot of real estate that's delinquent on property taxes. Syracuse does not have a PACE program for that reason. (2) The federal mortgage guarantee agencies Fannie Mae and Freddie Mac have effectively held up wide implementation

of PACE programs by disputing the priority of PACE obligations when homeowners default. By design, PACE obligations are supposed to be senior to mortgages, and therefore repaid first if a homeowner defaults. Fannie and Freddie have indicated that they will be unwilling to purchase loans with senior liens, effectively meaning that PACE bonds would have to be paid off in full at the time a property is refinanced or sold. However, this is still under very active debate at the moment and Fannie and Freddie's rules may change.

Question 4: Uncertain Technology

Suppose an electric utility is considering building a new 500 MW power plant and is choosing between two types: C (conventional) and A (advanced). Type C is well understood: it would operate with a capacity factor of 0.9 and would earn $10 of per MWh after deducing fuel and maintenance costs. (That is, all costs other than the construction cost are accounted for and you don't need to compute them.) Type A is advanced. It would use cheaper fuel and earn $20 of profit per MWh. However, its capacity factor is uncertain: there is a 50% chance it would be 0.9 and a 50% chance it would be 0.3 (down frequently for repairs). Both types cost $1 million per MW of capacity and would last for 30 years. Either plant can be constructed immediately (period 0) and will produce power for 30 years (periods 1-30). The utility uses an interest rate of 5% in present value calculations.

(a) Please determine the expected net present value of building each type of plant at year 0. Which type of plant would be best?

(b) Now suppose that the underlying reliability of Type A plants will become known by year 5. That is, if the utility waits until year 5 to build, it could know the capacity factor of Type A plants for certain. Please determine whether that changes the firm's decision and indicate the expected NPV of its best alternative.