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Economics of Environmental Policy

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Take Home Exam 1
Spring 2013

Due at 426 Eggers by 5:00 pm on Friday 3/8 if submitted on paper.
Due by 11:59 pm on Friday 3/8 if sent by email.

DO NOT OPEN THIS EXAM UNTIL YOU ARE READY TO BEGIN
(SEE POINT 6 BELOW)

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. That's why you shouldn't open it until you are ready to begin.

7. Rule number 6 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 with Diminishing Marginal Damage

Consider a good purchased by two types of buyers, S (small) and L (large). There 200 type S buyers and 10 type L buyers. The WTP equations for individual *i* of each type are shown below. The WTA curve for suppliers as a group (that is, the market supply) is also given.

Type S individual:	WTPsi = 200 – 20*Qsi
Type L individual:	WTPli = 200 – Qli
Market WTA:	WTA = Q/20

In addition, it is known that the good produces a negative externality. The damages from the externality are subject to diminishing returns: each additional unit of the good causes more damage, but the amount of additional damage gradually decreases. In other words, the first unit of emissions in a clean environment does more harm than the an additional unit in a dirty environment. The MCext curve is shown below:

Externality:	MCext = 150 – Q/20

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

(b) Suppose policy makers wish to use a tax to move the market to the efficient level of output. What should the tax rate be in dollars per unit?

(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?

Question 2: Renewable Portfolio Standards, Part 1

In the US, many states have adopted renewable portfolio standards (RPS) to increase the share of renewables in their electricity generation. An RPS operates in the wholesale market and requires electricity utilities to obtain a specified share of their power from renewable sources. This question explores the operation of a hypothetical RPS in a state roughly the size of New York.

Suppose the state does not have an RPS now but is considering one. In the state's wholesale market, electricity is demanded by 100 identical utilities who buy power and deliver it to end users. Electricity is supplied by two groups of generators: those using fossil fuels (type F) and those using renewables (type R). The WTP for an individual utility is given below, along with the overall supply curves for type-F and type-R generators. In each equation, quantity is measured in millions of MWh per year (i.e., Qi=1 means utility *i* is buying 1 million MWh per year) and prices are $/MWh.

Individual utility WTP for power:	WTPi = 360 – 200*Qi
Supply curve for fossil producers:	Qf = 70 + 2*Pf
Supply curve for renewables:	Qr = 2*(Pr-35)

In the absence of an RPS, utilities regard fossil and renewable electricity as perfectly substitutable. In that case, Pr and Pf will be equal and there will be a single market with two sources of supply but just one price P (i.e., Pr=Pf=P).

(a) Please compute the market equilibrium without an RPS. What is the price? The total quantity of electricity? The amount produced by fossil generators? The amount produced by renewable sources? What fraction of the total comes from renewables?

Now suppose the state is considering imposing an RPS aimed at increasing the amount of renewable power to approximately 20% of total consumption. To keep things simple, suppose the state implements the policy by requiring 20 utilities to buy only power from type-R producers and allowing the remaining 80 utilities to buy only from type-F producers.

(b) With the RPS in place, there will now be two electricity markets: one for Qf and one for Qr. Please solve for the equilibrium price and quantity in each market. What fraction of electricity comes from renewables?

(c) Now calculate the changes in surplus for each of the four groups: the two groups of utilities and the two groups of generators. What is the overall effect on the two groups of utilities together? The result is probably not what you would have expected at the outset. Why does it turn out that way?

(d) What is the overall effect of the policy on social surplus? That is, what is the efficiency gain or loss?

Question 3: Renewable Portfolio Standards, Part 2

Now let's look at an RPS from the perspective of firm thinking of building a new power plant. This question is motivated by the results from Question 2 but does not use any of the specific numerical results. You can do this question even if you didn't get the right answer to Question 2.

The firm is considering a plant that would produce 4 million MWh per year. It has narrowed things down to three options: natural gas (G), wind (W), or a hybrid that combines a half-scale gas plant with a half-scale wind farm. It knows the information below about the G and W plants, where BAU indicates business as usual without the RPS. Annual profit is revenue less all annual costs: fixed, variable and fuel costs. The only cost *not* accounted for by the profit numbers is the capital cost. The half-scale versions of each plant cost half as much and produce half the profit.

	Gas	**Wind**
Capital cost	$500 million	$3,000 million
Annual profit, BAU	$70 million	$130 million
Annual profit, RPS	$10 million	$210 million

The plant would be built in year 0 and operate for 40 years (1 through 40). The investor believes there is a 60% chance the RPS will be adopted in year 1. If it is adopted, profits immediately and permanently change to the RPS values above (that is, the firm would receive the RPS profits in years 1-40). The firm uses a 5% interest rate in present value calculations.

(a) Please calculate the NPV of each plant in each of the two cases (BAU and RPS).

(b) What is the expected NPV of each type of plant? If the firm were risk neutral, which should it build?

Now suppose the firm is run by a risk averse manager whose preferences can be represented by an expected utility function in which the utility of payoff X (in millions) is given by u(X) = X^(1/3). The firm has a budget of $2000 million for this project and the manager regards the payoff X of any given outcome to be $2000 million plus the NPV. That is, if the project produces a net gain of $1 billion, the gross payoff X (in millions) would be the starting $2000 plus the $1000 gain or $3000 in total.

(c) What is the expected utility of each plant? What is the certainty equivalent for each? Which option would the manager choose? Give a brief intuitive explanation for your result

Just for your information (do not use in doing the exam): a real RPS usually requires *each* firm to buy a specified share of renewables. That has the effect of requiring the firms to carry out a cross subsidy program between the power sources.