Review: Second Challenge
Environmental Economics: ECO 345
Fall 2011

The following questions review only the class notes since the last homework. The formulas provided below will also be provided on the challenge. All questions come from the notes. Also review the second homework, chapters 12.1-12.4, 11.3, 13.2, 15, and 15.2b.

Finally, we have several graphs to know, but they are all similar.

a. Goods with externalities (e.g. Figure 28 in the notes).

b. Emissions with multiple polluters and victims (e.g. Figure 30).

   (a) Emissions with a monopolist (e.g. Figure 31).
   (b) Emissions standard (e.g. Figure 32).
   (c) Technology standard (e.g. Figure 33).
   (d) Tradeable permits (e.g. Figure 34).
   (e) Liability (e.g. Figure 35)

c. Single industry pollution under uncertainty (e.g. Figure 37).

   (a) Pigouvian tax with uncertainty (e.g. Figure 37).
   (b) Tradeable permit with uncertainty (e.g. Figure 38).
   (c) Safety valves (e.g. Figure 42).

The following formulas may be useful:

Efficient Allocation and market allocation of goods with externalities, Profits

$$P_S = MC(S) + MD(S) \quad , \quad P_S = MC(S) \quad , \quad \pi = p \cdot S - C(S) - \text{payments} \tag{1}$$

Efficient Allocation and market allocation of emissions

$$MD_1(E^*) + MD_2(E^*) = MD(E^*) = MC(E^*) = MC_1(E_1) = MC_2(E_2) \tag{2}$$

$$MC(E_{0,1}) = MC(E_{0,2}) = 0 \quad , \quad E = E_1 + E_2 \quad , \quad E_0 = E_{0,1} + E_{0,2} \tag{3}$$

Pigouvian Tax, Tradable permit

$$t^* = MD_1(E^*) + MD_2(E^*) = MD(E^*) = MC(E^*) = MC_1(E_1) = MC_2(E_2) \tag{4}$$

$$P' = MD_1(E^*) + MD_2(E^*) = MD(E^*) = MC(E^*) = MC_1(E_1) = MC_2(E_2) \quad (5)$$

Monopolist, market and Pigouvian tax

$$MR = MC, \quad P(q^*) = MC(q^*) + MD(q^*) \quad (6)$$

$$t^* = MD_1(q) + MD_2(q) = MD(q) = MC(q), \quad MR = t^* + MC \quad (7)$$

Compliance costs, Pigouvian Tax vs emissions standard

$$\text{Cost } = \frac{1}{2}(E_{0,1} - E)(MC_1(E) - 0) + \frac{1}{2}(E_{0,2} - E)(MC_2(E) - 0) \quad (8)$$

$$\text{Cost } = \frac{1}{2}(E_{0,1} - E_1^*)(t^* - 0) + \frac{1}{2}(E_{0,2} - E_2^*)(t^* - 0) \quad (9)$$

Taxes and Permits under uncertainty

$$\bar{t} = MD(E) = \bar{MC}(E) \quad , \quad MD\left(\bar{E}\right) = \bar{MC}\left(\bar{E}\right) \quad (10)$$

$$\bar{t} = MC_H(E_H) \quad , \quad MC_H(E_H^*) = MD(E_H^*) \quad (11)$$

$$\text{loss } = \frac{1}{2}(\text{ loss}_H + \text{ loss}_L) \quad (12)$$

$$\text{loss}_H = \frac{1}{2}(E_H - E_H^*)(MD(E_H) - MC_H(E_H)) \quad (13)$$

$$\text{loss}_H = \frac{1}{2}\left(E_H^* - \bar{E}\right)\left(MC_H\left(\bar{E}\right) - MD\left(\bar{E}\right)\right) \quad (14)$$

Question 1

Some argue that marginal damages are flat for climate change. Temperature increases are based on the stock of greenhouse gasses (GHGs), which is the total buildup of GHGs in the atmosphere from hundreds of years of emissions. A small change in emissions today has little effect on the stock and therefore temperature and therefore results in only a small change in marginal damages.

However, others think that threshold effects are possible. That is, a small change in GHGs could cause temperature to exceed a threshold which causes large damages, such as the melting of ice caps.

Which of the above groups favor tax regultion and which favor permit regulation? Explain.

Question 2

A common method for initially allocating tradeable permits is "grandfathering," whereby initially polluters are allocated permits based on historical emissions. That is, if firm 1 prior to the regulation had 20% of the total emissions, then firm 1 would get 20% of the permits. Can tradeable permit regulation with grandfathering be efficient? If so, under what conditions?

Longer Questions

Question 3

Suppose we have two firms that emit pollution. Marginal costs and damages are:

$$MC_1 = 12 - \frac{1}{2}e_1 \tag{15}$$

$$MC_2 = 6 - \frac{1}{4}e_2 \tag{16}$$

$$MD = \frac{e}{6} \tag{17}$$

a. Implement a tradeable permit market. Calculate the efficient number of permits to issue, the price of permits, marginal costs for each firm, and emissions for each firm given the efficient number of permits are issued.

b. Calculate the total cost of compliance for the firms given the tradeable permit regulation.

c. Graph the marginal costs for each firm, total marginal costs, and marginal damages. Show on the graph the permit price, supply of permits, and the compliance costs for each firm.

d. Suppose we have an emissions standard with each firm reducing emissions to $\frac{1}{2}e^*$, where e^* is the efficient emissions. Calculate the marginal costs of each firm.

e. Calculate the total cost of compliance for the firms given the standard.

f. Graph the marginal costs for each firm, total marginal costs, and marginal damages. Show on the graph the standard and the compliance costs for each firm.

g. Which has greater compliance costs? Explain.

Question 4

Suppose the law is such that oil companies are liable for any damage caused by oil spills from tankers. Let the probability of an oil spill by a tanker transporting a shipment is p. Oil companies may invest in various safety equipment to lower the probability of a spill. Some actions are relatively cheap, such as better training of captains. But to get the probability of a spill very low requires expensive equipment, such as double hulled tankers. Overall, the marginal cost of reducing the probability of a spill is:

$$MC = 10\,(1 - p)\,. \tag{18}$$

Marginal damages are related to the total number of spills, s:

$$MD = 3s. \tag{19}$$

Finally, assume the oil company transports 30 shipments.

a. Calculate the efficient probability of a spill.

b. Calculate the efficient average number of oil spills.

c. Explain why society is willing to accept some oil spills (why is the efficient p not zero?).

d. Suppose liability regulation in which victims may sue oil companies for the marginal damages caused by the spill. Does the efficient p result? Explain.

e. Calculate the total spending on safety equipment (hint: use a graph and find the triangle which shows the total cost of compliance).

f. On average, how much will the oil company pay in lawsuits?

Question 5

Suppose pollution, E has marginal damages and marginal cost of reducing emissions:

$$MD = 4 + 2E \tag{20}$$

$$MC = 4\,(6 + r) - 6E \tag{21}$$

The regulator is uncertain about the value of r, but guesses that it has a 50% chance of being either 0 or 6. Thus the average value of r is 3.

a. Graph the marginal damages, the marginal costs if r is low, the marginal costs if r is high, and the average marginal costs.

b. Calculate the Pigouvian tax, and the emissions, marginal costs, and marginal damages which result if r is low, and the emissions, marginal costs, and damages which result if r is high.

c. Show the welfare losses for r high and low on the graph.

d. Calculate the emissions with tradeable permits, the marginal damages, the marginal costs if r is low, and the marginal costs if r is high.

e. Calculate the average welfare loss with tradeable permits. Show the welfare losses for r high and low on the graph.

f. Calculate the average welfare loss with taxes. Show the welfare losses for r high and low on the graph.

g. Which would you recommend, tax or permit regulation? Explain.