THE UNIVERSITY OF BRITISH COLUMBIA

Economics 371

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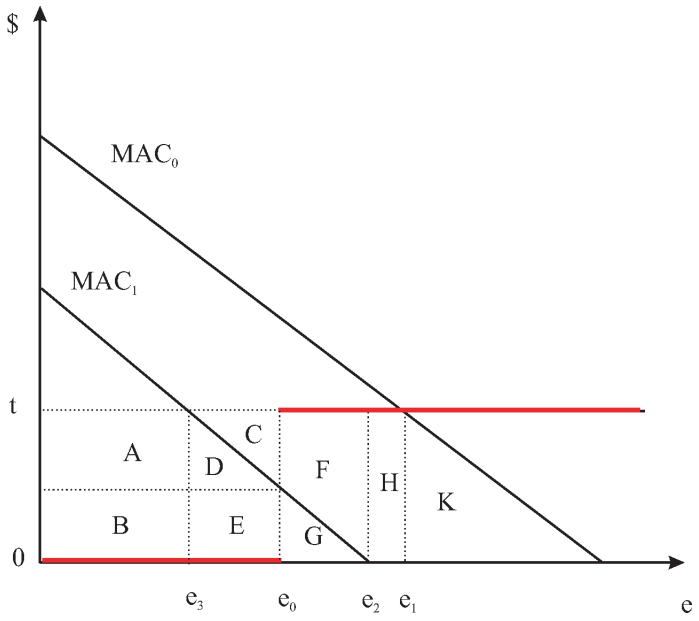
Assignment 2 (Due: Nov. 15)

1. Suppose a polluting firm initially has a technology that results in a marginal abatement cost curve MAC_0. It can pay a fixed cost R to adopt a new technology that yields MAC_1.

   (a) Suppose there is no emission tax and the government has an emission target that requires that the emissions of the firm not exceed e_1. Using areas in the diagram below, under what conditions would the firm adopt the new technology?

   (b) Suppose the government regulates pollution with a two-part emission tax. The firm pays no tax on the fist e_0 units of emissions. It must pay a tax t per unit of emissions on any emissions above e_0.
   - (i) What is the initial level of emissions (using the old technology)?
   - (ii) What is the level of emissions if the new technology is adopted?
   - (iii) Using areas in the diagram below, under what conditions would the firm adopt the new technology? Are the incentives to innovate greater under the tax or under the emission target?

   (c) Finally, suppose there is a tax t per unit of emissions and that this applies to <u>all</u> emissions (even those less than e_0). Under what conditions would the firm adopt the new technology? Are the incentives to innovate greater in this case than in part (b)?



2. Suppose there is uncertainty about the MAC curve (but that the MD curve is known). As in class, the MAC curve can be either high or low, but the regulator does not know which in advance. In class, I compared a pollution tax with an emission target and showed that when MAC turned out to be <u>higher</u> than expected, a target is better if MD is steep relative to MAC, and a tax is better if MAC is steep relative to MD. Suppose instead that MAC turns out to be <u>lower</u> than expected. Using diagrams, prove the same result for this case (i.e. show that a target is better if MD is steep relative to MAC, and a tax is better if MAC is steep relative to MD).

3. Consider an aluminum smelter that produces air pollution which damages trees. Suppose the trees are privately owned. Let q be the amount of pollution, and suppose that the marginal abatement cost is

$$MAC(q) = 100 - q.$$

Suppose that the marginal external cost of damage to the trees is

$$MD(q) = q.$$

For the sake of this problem, assume that all relevant costs and benefits are given by MAC and MD.

(a) Draw the MAC and MD curves on the same diagram. If the aluminum company has the right to emit pollutants into the air, and if negotiation is impossible, how much pollution will be produced?

(b) If the owner of the trees has the right to clean air, and if negotiation is impossible, how much pollution will be produced?

(c) Suppose now that negotiation is costless, and that the smelter has the right to emit pollutants into the air.

(i) How much pollution will be produced?

(ii) What is the *maximum* amount that the owner of the trees will be willing to pay to the owner of the smelter in return for reducing pollution to the level given in (i)?

(iii) What is the *minimum* amount that the smelter owner will be willing to accept in return for agreeing to reduce pollution to the level given in (i)?

(d) Continue to assume that negotiation is costless, but now assume that the tree owner has the right to clean air.

(i) How much pollution will be produced?

(ii) What is the *maximum* amount that the smelter owner will be willing to pay to the owner of the trees in return for permission to increase pollution to the level given in (i)?

(iii) What is the *minimum* amount that the tree owner will be willing to accept in return for agreeing to allow pollution to rise to the level given in (i)?

(e) Suppose now that negotiation is costly; i.e. transactions costs, T, are positive. Suppose that the social cost of negotiating any agreement to raise or lower pollution is given by $T = 3000$. If we ignore income distribution, does it matter who gets the property rights? Why? How much pollution will be produced? Why?

(f) Now let us revert to the assumption that negotiation is impossible. However, suppose that government regulation is costless and that the government decided to impose an emission standard (target). What level should the target be set at (i.e., how much pollution should be allowed)?

(g) Continue to assume that negotiation is impossible. Suppose instead that the government decides to impose a pollution tax (that is, a charge per unit of pollution emitted). How much should the pollution tax be?

(h) Suppose now that negotiation is costless, but that the government nevertheless decides to impose a pollution tax of $t = 50$. That is, the firm must pay a fee of \$50 for each unit of pollution released. If the smelter owner and the tree owner are free to negotiate with each other after the tax is imposed (the tax rate is fixed by the government and is non-negotiable, but the level of pollution can be negotiated), how much pollution will be produced? Compare this with the socially efficient level of pollution. Does the government's decision to impose a tax raise or lower social welfare (relative to the situation where no tax is imposed)? Why?

(i) Again, suppose that negotiation is costless, and that the government decides to impose a pollution target which requires that $q \leq q^*$, where q^* is the socially optimal level of pollution. If the owners of the smelter and the trees are free to negotiate pollution levels (subject to the government's rule), how much pollution will be produced? Compare your result with that which was obtained with a tax. Is there any difference? Explain why or why not.

4. Suppose a region has two factories that emit smoke.
The marginal abatement cost from factory 1 is $MAC_1 = 100 - 2e_1$, where e_1 is factory 1 emissions.
The marginal abatement cost from factory 2 is $MAC_2 = 100 - e_2$, where e_2 is factory 2 emissions.
Each unit of pollution from each of these firms causes a marginal damage of MD = 30. (That is, each additional unit of emissions has an external cost of $30).

   (a) Draw a diagram to illustrate the socially efficient level of pollution. Compare this with the amount of pollution that is generated in an unregulated free market.

   (b) Suppose the local authorities decide to improve air quality. If they use an emissions tax as their policy instrument, should they charge each firm the same tax? Why or why not? What should the tax(es) be set at?

   (c) If the authorities decide instead to use an emissions standard, should each firm be given the same emissions target? Why or why not? What should the emission target be for each firm?

   (d) Suppose now that the government does **not** know the MD curve, but does know the MAC curves of each firm. Suppose the industry is initially unregulated. Scientists convince the government that total pollution emissions should not exceed 90. What is the least cost method of achieving this reduction? That is, how much pollution should each firm be allowed to emit if the objective of the policymaker is to minimize the total compliance costs? What pollution tax level would achieve this?

   (e) Now go back to the assumption that the government knows the MD curve. Suppose that a new firm enters but locates farther away from population centres. Suppose that only one fifth (1/5) of its emissions cause environmental damage. The rest blow out to sea, where they cause no damage. The MAC (that is, the marginal cost of reducing emissions) for this firm is $MAC_3 = 50 - e_3$, where e_3 is the level of emissions from the new firm. If an emissions tax is used, what tax should the new firm be charged?

5. Suppose a community has 120 tons of liquid waste to dump in the ocean. There are three locations, A and B and C. Dumping waste causes environmental damage. The marginal damage curve for waste dumping at sites A and B and C are

$$MD^A = 2W^A,$$
$$MD^B = 50,$$
$$MD^C = W^C$$

where W^i is tons of waste dumped at site i. Note that marginal damage at site B is constant - each unit of waste dumped at B causes an increase in damage of 50.

(a) If the government wants to minimize the social cost of dumping the waste, how much waste should be dumped at each site?

(b) Now suppose that everything is the same as in (a) except that $MD^B = 90$. How much waste should be dumped at each site?

(c) Now suppose that everything is the same as in (a) except that $MD^A = 50 - W^A$. How much waste should be dumped at each site?

6. Consider a plan under which major carbon emitters pay a tax of $30 per ton of emissions generated. In addition, they would receive an abatement subsidy of $40 per ton of emissions reduced from their initial level. Consider a firm with a standard downward sloping marginal abatement cost curve.

   (a) Draw a diagram to illustrate how this policy would affect the level of emissions generated by the firm. Using areas in the diagram, illustrate the net cost of this policy to the firm.
   (b) Compare this policy with an emissions tax of $70 per ton of emissions generated. Would the tax result in more or less emissions than the combined tax and subsidy program outlined above?

7. Three firms (A,B and C) are located at different points near a city. They each pollute the air. The marginal abatement cost for each firm is MAC = 120 - e, where e is the level of emissions from the firm. There is one air quality monitoring point at the centre of the city.

   2/3 of the emissions from firm A reach the monitoring point
   All of the emissions from firm B reach the monitoring point.
   1/3 of the emissions from firm C reach the monitoring point.

   Suppose the regulator's target is that 120 units of emissions reach the monitoring point.

   (a) If the regulator gives each firm a pollution emissions target, how much should it allow each firm to pollute (assuming the objective is to minimize the total cost of meeting the target)?

   (b) If the regulator uses emission taxes of t_i per unit of emissions from firm i, what levels of taxes should be applied to each firm? (I.e., find the efficient tax rates t_1, t_2 and t_3).

   (c) If an emission permit trading scheme were adopted (instead of the tax) and the target was that 120 units of emissions reach the monitoring point, explain how to design a set of trading rules so that one could achieve cost-effectiveness and meet the target.