Environmental Economics: Problem Set 1

This assignment allows for groups of up to three members. However, even if you choose to work in a group, each person must submit their own individual Problem Set 1, even if the answers were discussed within the group. If the assignment is done in a group, *please include the names of all group members* *on each person's submission.*

Group member 1:   Group member 2:   Group member 3:

This handout includes the questions for Problem Set 1. It will be due before the lecture on <mark>*Aug 9*</mark>*. Answers need to be turned in via Canvas. T/F question requires* *1-line elaboration.*

Part I. **Economic efficiency.**

1. Suppose that a policymaker can choose Policy option A or B. There are five people in the economy whose consumption of a single composite good under A is (2, 5, 7, 13, 15), and under B is (12, 9, <mark>4</mark>, 18, 22).

   True or <mark>False</mark>: Moving from allocation A to B is a Pareto improvement. (2 points)

2. <mark>**True**</mark> **or False:** Moving from allocation A to B in the above example is a Kaldor-Hicks improvement. (2 points)

3. <mark>**True**</mark> **or False:** Any change in resource allocation that is a Pareto improvement is also a Kaldor-Hicks improvement. (2 points)

4. Consider an economy with two people, Donald and Melania, and one good, yachts, denoted y. There are <mark>4</mark> yachts total in the economy. Both people have the same utility function $U^i(y) = y^{1/2}$. (Assume yachts can be consumed in continuous measure, not just integers.)

   <mark>**True**</mark> **or False:** An allocation in which Donald has 4 yachts and Melania has 0 yachts is <u>Pareto efficient</u>. (2 points)

5. Now suppose that Donald and Melania live in an economy with two goods, yachts and condos, denoted c. There are 4 yachts and 10 condos in the economy. Both people have the same utility function, $U^i(y, c) = y^{1/2}c^{1/2}$.

   <mark>**True**</mark> **or False:** An allocation where Donald has 3 yachts and 10 condominiums (and Melania has 1 yacht and 0 condos) is Pareto efficient. (2 points)

Part II. **Externalities.**

6. There are 10 farms along a river. Each uses fertilizer that causes run off that lowers the profits of a downstream fishery by adding nitrates to the water. The amount of runoff (nitrates that reach the river) per ton of fertilizer used depends on the slope of the land and the proximity of fields to the river. Half of the farms are steeper and closer, so they produce 1 unit of nitrates in the water for every ton of fertilizer. Half are farther and flatter and producer 0.1 units of nitrates in the water for every ton of fertilizer. Suppose that the damage done to the fishery is $4 for every **unit** ~~ton~~ of nitrates in the water.

   True or False: Because of the externality, the market for fertilizers is not Pareto efficient. Imposing a tax of $4 per ton of fertilizer paid by all farmers would correct this market failure and ensure that the allocation of fertilizers was Pareto efficient. (2 points)

7. Many farmers regularly feed their livestock antibiotics (even while healthy) in order to reduce infections in their populations. The widespread use of antibiotics can accelerate the evolution of bacteria that are resistant to antibiotics, however, which can increase the vulnerability of livestock in the future throughout the country and the world.

   True or False: An individual farmer's use of antibiotics constitutes an externality that implies a market failure. (2 points)

Part III. **Pigouvian tax algebra problem.** The Pigouvian prescription says to fix an externality by setting a tax rate equal to marginal damages at the optimal quantity. When marginal external damages are constant, the "at the optimal quantity" part is redundant. But, when marginal external damages are changing with the quantity of the good, you have to figure out the right quantity to determine the right tax rate. This problem illustrates this with an algebra example.

   Consider a market where total private benefits are equal to $TB = 50Q - Q^2$. Total private costs are $TC = 12.5Q + 0.25Q^2$. Total external damages (costs) are equal to $TED = 2.5Q^2$.

8. Graph this market, showing the supply curve, demand curve, private equilibrium and optimal allocation.* (Upload an image of your graph with your answers. You can draw this by hand and take a picture. Label key values.) (3 points)

9. What is the optimal tax rate on the good? (2 point)

Part IV. **Optimal taxes and deadweight loss.** The Pigouvian tax does not directly depend on the slope of supply and demand, which means that the tax does not depend on how big the quantity response will be to the imposition of a tax. But, does this mean that the quantity response is irrelevant? This problem provides an illustrative example.

Consider a market where total private benefits are equal to $TB = 660Q - Q^2$. Total private costs are $TC = 66Q + 0.5Q^2$. Total external damages (costs) are equal to $TED = 66Q$.

10. What is the optimal tax? (2 points)

11. What is the change in quantity that results from introducing the tax? (2 points)

12. Calculate the welfare gain from introducing the optimal tax. (2 points)

Now, suppose that the MB curve was much more vertical (less elastic). Specifically, suppose that $TB = 2,244Q - 5Q^2$.

13. What is the optimal tax now? (Think to yourself: is this different than your answer in question 10? Why or why not?) (2 points)

14. What is the change in quantity that results from introducing the tax? (Think to yourself: is this different than your answer in question 11? Why or why not?) (2 points)

15. Calculate the welfare gain from introducing the optimal tax. (Think to yourself: is this different than your answer in question 12? Why or why not?) (2 points)

Think to yourself: what does this example suggest about the relationship between the welfare gain (elimination of deadweight loss) and the slopes of demand and supply?

Part V. **Incidence**

Consider a market for a good X with the following equations. Total benefit is $100X - 0.25X^2$. Total cost is $2X^2$. The good has a total externality equal to $2X + 0.125X^2$.

16. What is the consumer surplus, producer surplus and total externality in this market when there is no tax? (2 points)

17. Suppose that a corrective tax following the Pigouvian prescription is employed. What is that tax rate? (2 points)