EC 238
Environmental Economics
Instructor: Sharif F. Khan

Department of Economics
Wilfrid Laurier University
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# Suggested Solutions to Assignment 1 (Optional)

## Part A True/ False/ Uncertain Questions

*Explain why the following statement is True, False, or Uncertain according to economic principles. Use diagrams and / or numerical examples where appropriate. Unsupported answers will receive no marks. It is the explanation that is important.*

**A1.**

**In the presence of a negative externality, the competitive equilibrium is characterized by an under-allocation of resources such that too little of the good is produced. [Diagrams Required]**

**False**

In the presence of a negative externality, the competitive equilibrium is characterized by an over-allocation of resources such that too many of the good is produced.

[Note: This is not a full answer to this question. Please see the following for a complete answer.]

See Page 64-67 and Figure 3.4 of the textbook (6th ed.) for an explanation with a diagram.

Or,

See Page 64-67 and Figure 3.4 of the textbook (5th ed.) for an explanation with a diagram.

Or,

See Page 56-59 and Figure 3.4 of the textbook (4th ed.) for an explanation with a diagram.

**A2.**

**According to the Coase Theorem, an efficient outcome cannot be achieved if the polluters control the property rights. [Diagrams Required]**

**False**

The Coase Theorem argues that under certain conditions the assignment of property rights will lead to bargaining between the parties such that an efficient solution can be achieved, no matter which part holds the property rights.

[Note: This is not a full answer to this question. Please see the following pages and diagrams for a complete answer.]

See Page 69-72 and Figure 3.6 of the textbook (6th ed.) for an explanation with a diagram.

Or,

See Page 69-72 and Figure 3.6 of the textbook (5th ed.) for an explanation with a diagram.

Or,

See Page 62-63 and Figure 3.6 of the textbook (4th ed.) for an explanation with a diagram.

## Part B Problem Solving Questions

***Read each part of the question very carefully. Show all the steps of your calculations to get full marks.***

**B1. Assume that a small town uses a referendum to overcome the free-ridership problem and determine how its residents might value a new water filtration system for its public water supply. The voting results are aggregated by the town's two districts, yielding the following demand estimates:**

**District 1:** $Q = 160 - 20P_1$
**District 2:** $Q = 60 - 5P_2$,

**where $Q$ is the expected percent of copper to be filtered by the system and $P$ is the price in millions of dollars.**

**a. Based on these estimates, determine the town's market demand for this public good, the new filtration system.**

Because this is a public good, the two demands must first be written in inverse form and then summed (vertical summation). The reasoning is that, for a public good, each demander is expressing a willingness to pay for the same quantity. The inverse demand equations are:

$$P_1 = 8 - 0.05Q$$
$$P_2 = 12 - 0.2Q$$

Summing these yields the market demand, which is

$$P_1 + P_2 = (8+12) - (0.05Q + 0.2Q)$$
$$\Rightarrow P = 20 - 0.25Q \,. \quad [\text{Define, } P \equiv P_1 + P_2]$$

**b. If the market supply for the system were $P = 6 + 0.15Q$, what would be the equilibrium price and quantity for the town?**

Equate the market demand and market supply and solve, as follows:

$$\begin{aligned} 20 - 0.25Q &= 6 + 0.15Q \\ 0.4Q &= 14 \\ Q_E &= 35 \text{ percent} \end{aligned}$$

Substitute $Q_E$ into either equation to find $P_E$ as follows:

$$P_E = 20 - 0.25(35) \text{ or } 6 + 0.15(35) = \$11.25 \text{ million}$$

**B2. A New Hampshire textile mill releases pollution into nearby wetlands, and the associated health and ecological damages are not considered in the private market. Suppose you are an environmental economist working with the following marginal benefits and costs for this market, where Q is thousands of pounds and P is price per pound.**

$$\begin{aligned} &\boldsymbol{MPB = 800 - 0.5Q} && \boldsymbol{MPC = 20 + 0.3Q} \\ &\boldsymbol{MEB = 0} && \boldsymbol{MEC = 0.4Q} \end{aligned}$$

**a. Find the competitive equilibrium, $Q_C$ and $P_C$, and the efficient equilibrium, $Q_E$ and $P_E$.**

Competitive equilibrium is found where:

$$\begin{aligned} MPB &= MPC \\ 800 - 0.5Q &= 20 + 0.3Q \\ 0.8Q &= 780 \\ Q_C &= 975 \text{ thousand pounds} \end{aligned}$$

$P_C = 800 - 0.5(975)$ or $20 + 0.3(975) = \$312.50$

Efficient equilibrium is found where:

$$\begin{aligned} MSB &= MSC \\ MPB + MEB &= MPC + MEC \\ 800 - 0.5Q + 0 &= 20 + 0.3Q + 0.4Q \\ 800 - 0.5Q &= 20 + 0.7Q \\ 1.2Q &= 780 \\ Q_E &= 650 \text{ thousand pounds} \end{aligned}$$

$P_E = 800 - 0.5(650)$ or $20 + 0.7(650) = \$475$

**b. Suppose the textile mill owned the rights to the wetlands, and it is negotiating with a private environmental group that is willing to pay the mill to produce less output. For the 800th unit of output, determine the range within which a payment would be acceptable to both parties.**

The acceptable payment, $\rho$, must be greater than the forgone marginal profit $(M\pi)$ to the mill associated with the 800th unit of output but less than the marginal external damage $(MEC)$ to the wetlands incurred by the environmental group.
Therefore, there is opportunity for bargaining to proceed ass long as the following condition is satisfied:

$$MEC \rangle \rho \rangle M\pi$$

where $M\pi = MPB - MPC = 800 - 0.5Q - (20 + 0.3Q) = 780 - 0.8Q$
and $MEC = 0.4Q$.

Substituting the values results in the following:

$$0.4(800) > \rho > 780 - 0.8(800)$$
$$\text{or} \quad 360 > \rho > 60$$

We conclude, therefore, that the payment must be between \$140 and \$320 per pound to be acceptable to both the textile mill and the environmental group.

**B3. It is well documented that carbon monoxide (CO) emissions from combustible engines increase in colder climates. This implies that damages are expected to be less severe in summer months than in winter. Nonetheless, air quality control authorities use a standard for CO that is uniform throughout the year with no allowance for seasonal effects. Use this information and the following model to answer the questions:**

| | | |
|---|---|---|
| ***MSB* of CO abatement in winter** | **=** | **$350 - 0.5A$,** |
| ***MSB* of CO abatement in summer** | **=** | **$140 - 0.2A$,** |
| ***MSC* of CO abatement** | **=** | **$0.2A$,** |

**where $A$ is the level of CO abatement.**

**a. Graph the *MSB* and *MSC* functions on the same diagram.**

See **Figure B3** where $MSB_W$ represents MSB of CO abatement in winter, $MSB_S$ represents MSB of CO abatement in summer, $MSC_W$ represents MSC of CO abatement in winter and $MSC_S$ represents MSC of CO abatement in summer.

**b. Assume the government sets a uniform standard for winter and summer at *A* = 500. Support or refute this policy based on the criterion of allocative efficiency, using your model to explain your response.**

Under a uniform abatement standard of 500,

$$MSB_W = 350 - 0.5 * 500 = 100$$
$$MSB_S = 140 - 0.2 * 500 = 40$$
$$MSC_W = MSC_S = 0.2 * 500 = 100$$

Since the standard does not correspond to the abatement level where *MSB* = *MSC* for *both* seasons, it is not efficient.

**c. If you were in charge of setting policy for CO emissions, what action would you recommend to ensure an allocatively efficient outcome across the two seasons?**

Two different abatement standards are needed for efficiency. For each season, abatement targets are established where *MSC* equals the respective *MSB* function. This assures an efficient solution for each season.

The efficient solution for winter season:

$$MSB_W = MSC_W$$
$$\Rightarrow 350 - 0.5A = 0.2A$$
$$\Rightarrow 0.7A = 350$$
$$\Rightarrow A_W = 500$$

The efficient solution for summer season:

$$MSB_S = MSC_S$$
$$\Rightarrow 140 - 0.2A = 0.2A$$
$$\Rightarrow 0.4A = 140$$
$$\Rightarrow A_S = 350$$

$A_W$ and $A_S$ should correspond to the abatement level at each intersection in **Figure B3.**

**B4. Assume that two power plants, Firm 1 and Firm 2, release sulfur dioxide ($SO_2$) in a small urban community that exceeds the emissions standard. To meet the standard, 30 units of $SO_2$ must be abated in total. The two firms face the following abatement costs:**

$$MAC_1 = 16 + 0.5A_1 \qquad MAC_2 = 10 + 2.5A_2,$$

**where costs are measured in thousands of dollars.**

**a. Prove that a uniform standard will not meet the cost-effectiveness criterion.**

A uniform standard means that each firm must abate the same amount, which in this case would be 15 units of $SO_2$ each. Using this value, we find each firm's marginal abatement costs. The results are $MAC_1 = 16 + 0.5(15) = \$23.5$ thousand, and $MAC_2 = 10 + 2.5(15) = \$47.5$ thousand. Since the MACs are not equal, we know the cost-effectiveness criterion is not met.

**b. Determine how the abatement levels should be reallocated across the two firms to minimize costs.**

To achieve cost-effectiveness, the abatement requirements per firm must be reallocated so that the MACs are equal, subject to the sum of the two abatement levels, $A_1 + A_2$, equaling 30 units. This is found as follows:

| | |
|---|---|
| Cost-effectiveness requires: | $MAC_1 = MAC_2$ |
| | $\Rightarrow 16 + 0.5A_1 = 10 + 2.5A_2$ |
| Abatement standard requires: | $A_1 + A_2 = 30$ |
| Solving simultaneously: | $16 + 0.5(30 - A_2) = 10 + 2.5A_2$ |
| Therefore: | $31 - 0.5A_2 = 10 + 2.5A_2$, |
| | so $3A_2 = 21$, or $A_2 = 7$, and |
| | $A_1 = 30 - 7 = 23$ |

Check your result by finding $MAC_1$ and $MAC_2$ evaluated at the abatement levels found, and make sure they are equal. In this case, $MAC_1 = 16 + 0.5(23) = \$27.5$ thousand, and $MAC_2 = 10 + 2.5(7) = \$27.5$ thousand.

FIGURE B3: EFFECT OF SEASONAL DIFFERENCES ON ACHIEVING ALLOCATIVE EFFICIENCY