Homework 7 (48 Points)

Suggested Solutions

Part I

Multiple Choices (2 Points Each)

1. The tragedy of the commons is

   (a) a problem due to common resources being over-consumed

   (b) a problem due to negative externality

   (c) none of the above

   (d) **both a and b**

2. Which of the following is not an example of externality?

   (a) Lung cancer caused by second-hand exposure to cigarette smoke

   (b) Pollution from a factory on the health of people in the vicinity of the factory.

   (c) **Increase in health care costs on the health of individuals in society.**

   (d) Traffic accidents caused by alcohol consumption

3. Two firms, A and B, each currently dump 20 tons of chemicals into the local river. The government has decided to reduce the pollution and from now on will require a pollution permit for each ton of pollution dumped into the river. The government gives each firm 10 pollution permits, which it can either use or sell to the other firm. It costs Firm A $100 for each ton of pollution that it eliminates before it reaches the river, and it costs Firm B $50 for each ton of pollution that it eliminates before it reaches the river. After the two firms buy or sell pollution permits from each other, we would expect that

   (a) Firm A will no longer pollute, and Firm B will not reduce its pollution at all.

   (b) **Firm B will no longer pollute, and Firm A will not reduce its pollution at all.**

   (c) Firm A will dump 10 tons of pollution into the river, and Firm B will dump 10 tons of pollution into the river.

   (d) Firm A will increase its pollution and Firm B will reduce its pollution.

4. Information tend to be non-excludable because it can be spread easily, and non-rival in consumption because one person's "consumption" of information does not directly diminish another person's "consumption" of information. Hence, information tend to be a

   (a) Private good

   (b) **Public good**

   (c) Club good

   (d) Common resource

5. Suppose that Company A's railroad cars pass through Farmer B's corn fields. The railroad causes an externality to the farmer because the railroad cars emit sparks that cause $1,500 in damage to the farmer's crops. There is a special soy-based grease that the railroad could purchase that would eliminate the damaging sparks. The grease costs $1,200. Suppose that the railroad is not liable for any damage caused to the crops. Assume that there are no transaction costs. Which of the following characterizes the efficient outcome?

   (a) The railroad will continue to operate but will pay the farmer $1,500 in damages.

   (b) The railroad will purchase the grease for $1,200 and pay the farmer nothing because no crop damage will occur.

   (c) The farmer will incur $1,500 in damages to his crops.

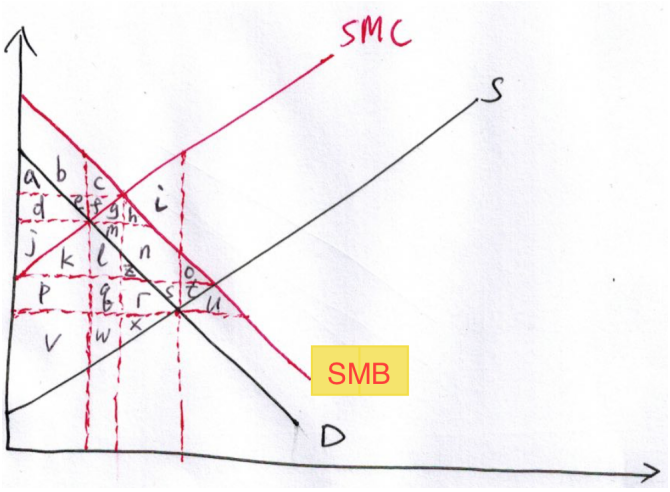
   (d) **The farmer will pay the railroad $1,200 to purchase the grease so that no crop damage will occur.**

Part II

Problems

Problem 1 (4 Points)

The following graph illustrates the market for a good that generates both positive and negative externalities[1]. Note: the government has not imposed any tax or subsidy on the market. Hence the market is at its free-market equilibrium.



SMB: social marginal benefit; SMC: social marginal cost

Find out the following:

1. Consumer surplus + Producer surplus
   `a+d+j+k+l+p+q+r+v+w+x+z`

2. External benefit
   `b+c+e+f+g+h+m+n+s`

3. External cost
   `g+h+i+k+l+m+n+p+q+r+s+v+w+x+z`

4. Deadweight loss
   `i`

[1]For example, self-driving cars can both reduce road accidents and generate pollution and congestion.

Problem 2 (4 Points)

There are three industrial firms in Happy Valley.

Firm	Initial Pollution	Cost of Reducing Pollution by 1 Unit
A	70 units	\$20
B	80 units	\$25
C	50 units	\$10

The government wants to reduce pollution to 120 units, so it gives each firm 40 tradable pollution permits.

1. Who sells permits and how many do they sell? Who buys permits and how many do they buy? (2 Points)

   B buys 40 permits and C sells 40 permits.

   Reasoning: If B buys permits from C at a price $\in (\$10, \$25)$, then both B and C would benefit from the trade. If A buys permits from C at a price $\in (\$10, \$20)$, then both A and C would benefit from the trade. Who gets to buy from C? Since B is willing to pay a price $\in (\$20, \$25)$, A would not be able to compete with B, therefore, B would be able to buy all 40 permits from C. After buying 40 permits from C, B no longer needs permits and C no longer has permits to sell, therefore, A will not participate in any trade and will keep its 40 permits[2].

2. What is the total cost of pollution abatement in this situation? How much higher would the cost of pollution abatement be if the permits could not be traded? (2 Points)

   C sells all 40 of its permits and needs to reduce its pollution by 50 units at a cost of \$10 × 50 = \$500. A still has 40 permits and needs to reduce its pollution by 30 units at a cost of \$20 × 30 = \$600. After buying 40 permits, B has 80 permits and does not need to reduce pollution. Therefore, the total cost of pollution reduction is \$1,100.

[2] What if B buys 40 permits from A instead? It could also happen, but in this case, after selling 40 permits to B at a price $\in (\$20, \$25)$, A can then buy 40 permits from C at a price $\in (\$10, \$20)$. So in the end, B will get 80 permits, A will have 40, and C will have none.

If the permits could not be traded, then A would have to reduce its pollution by 30 units at a cost of \$20 × 30 = \$600, B would have to reduce its pollution by 40 units at a cost of \$25 × 40 = \$1,000, and C would have to reduce its pollution by 10 units at a cost of \$10 × 10 = \$100. The total cost of pollution reduction would be \$1,700, \$600 higher than in the case in which the permits could be traded.

Problem 3 (8 Points)

Four roommates are planning to spend the weekend in their dorm room watching old movies, and they are debating how many to watch. If it costs \$8 to rent a movie. Here is their willingness to pay for each film:

	Judd	Joel	Gus	Tim
First film	\$7	\$5	\$3	\$2
Second film	6	4	2	1
Third film	5	3	1	0
Fourth film	4	2	0	0
Fifth film	3	1	0	0

1. What is the total surplus if they rent 1 movie? What is the total surplus if they rent 5 movies? (2 Points)

   `1 movie:` $7+5+3+2-8=9$
   `5 movie:` $7+5+3+2+6+4+2+1+5+3+1+4+2+3+1-8\times 5=9$

2. How many movies should the roommates rent to maximize total surplus? (2 Points)
   3

3. If they choose the optimal number from 2. and then split the cost of renting the movies equally, how much surplus does each person obtain from watching the movies? (2 Points)

   `Judd:` $7+6+5-2\times 3=12$
   `Joel:` $5+4+3-2\times 3=6$
   `Gus:` $3+2+1-2\times 3=0$
   `Tim:` $2+1-2\times 3=-3$

4. Is there any way to split the cost to ensure that everyone benefits? (2 Points)

   `Split according to each person's willingness to pay`[3].

[3] However, in reality, it is hard to know each person's WTP, as people may not have the incentive to reveal their true WTP.

Problem 4 (4 points)

There are three groups in a community. Their demand curves for public television in hours of programming, T, are given respectively by

$$W_1 = \$200 - T$$
$$W_2 = \$240 - T$$
$$W_3 = \$320 - 2T$$

Suppose public television is a public good that can be produced at a cost of \$200 per hour.

1. What is the efficient number of hours of public television? (2 points)

   `Total demand for public TV:`

   $$W = 760 - 4T$$

   `Social optimum:`

   $$760 - 4T = 200 \Rightarrow T^* = 140$$

2. If the government charges each group for watching public TV at a price of \$200/hour, then it becomes excludable. In such a case, how many hours of programming would the three groups consume, respectively (2 points)

   $T_1 = 0, T_2 = 40, T_3 = 60.$

Problem 5 (8 points)

Services like Uber are called **two-sided markets**: the riders are on one side and the drivers are on the other side. Two-sided markets have an important feature: the more users there are on the other side, the happier users on this side are. For example, if you are a potential rider that uses Uber, then the more Uber drivers there are, the happier you are because it means you can get a ride more easily, everything else being equal. In other words, when a driver joins Uber, she will make you happier. Similarly, by using the Uber app as a potential rider, you are making Uber drivers happier. This has been called **indirect network externality**.

1. Explain in what sense is indirect network externality an externality, and in what sense it may not be a true externality.

   `Since the action of people on one side will positively affect the people on the other side, it can be considered a positive externality. However, people are actually "getting paid" for this positive externality since the platform takes this externality into consideration in its pricing decision. Therefore, it is not an externality in a strict sense.`

2. What other services that you know are two-sided platforms? List at least three.

   `Didi, Taobao, Dianping, ...;`

3. Suppose the demand function for the two sides of the market is

$$\begin{aligned} Q_A &= 1 - 0.3p_A + 0.5Q_B \\ Q_B &= 1 - 0.6p_B + 0.5Q_A \end{aligned} \tag{1}$$

   , i.e., demand on side A (Q_A) depends on the the amount of users on side B (Q_B) and vice versa. Suppose the platform company's profit function is

$$\pi = p_A Q_A + p_B Q_B$$

   Calculate the optimal price (p_A^*, p_B^*) this platform company should charge each side of the market.

Solving (1) ⇒

$$Q_A = 2 - 0.4p_A - 0.4p_B$$
$$Q_B = 2 - 0.2p_A - 0.8p_B$$

Hence, optimizing the profit function with respect to p_A and p_B gives us:

$$\frac{\partial \pi}{\partial p_A} = 2 - 0.8p_A - 0.6p_B = 0$$
$$\frac{\partial \pi}{\partial p_B} = 2 - 0.6p_A - 1.6p_B = 0$$

⇒

$$p_A^* = \frac{50}{23}, p_B^* = \frac{10}{23}, Q_A^* = \frac{22}{23}, Q_B^* = \frac{20}{23}$$

4. Compare with the no indirect network externality case:

$$Q_A = 1 - 0.3p_A$$
$$Q_B = 1 - 0.6p_B$$

Do the optimal prices increase or decrease for side A and B when there is indirect network externality? Can you explain why?

Without indirect network externality,

$$\frac{\partial \pi}{\partial p_A} = 1 - 0.6p_A = 0 \Rightarrow p_A^* = \frac{5}{3}$$
$$\frac{\partial \pi}{\partial p_B} = 1 - 1.2p_B = 0 \Rightarrow p_B^* = \frac{5}{6}$$

Hence, with indirect network externality, optimal prices for side A increases, while optimal price for side B decreases. This is because everything else being equal, side B tends to have higher elasticity of demand than side A (see (1)). Rysman (2009) offers insight into the pricing behavior of two-sided markets as follows:

"In any market, prices typically fall as the price elasticity of demand increases, but in a two-sided market the effect can be even larger: The low price on one side not only attracts elastic consumers on that side but also, as a result, leads to higher prices or more participation on the other side. The

increased value extracted from the other side magnifies the value of having consumers on the first side, which leads to a yet bigger price decrease and quantity increase for the side that experiences the increase in elasticity ... Such seeming anomalies as price below marginal cost or even negative prices can easily arise in a two-sided market. For example, a platform might charge a price below cost on one side if those agents have a large price elasticity and their participation attracts a large number of participants on the other side who are relatively price inelastic'' -- Rysman (2009)