Handout 14

1 Topics

- Externalities
- Tax Incidence
- Public goods

2 Review

2.1 Externalities

- Externalities are imposed costs or bestowed benefits to a third party as a result of actions or decisions from some actors.
- Negative externalities lead to marginal social cost (MSC) being higher than marginal private cost (MPC).
- Positive externalities lead to marginal social benefit(MSB) being higher than marginal private benefit (MPB).
- Without externalities, $MSC = MPC$ and $MSB = MPB$.
- Market equilibrium is where $MPC = MPB$ and social optimum is where $MSC = MSB$.
- We can introduce taxes in cases of negative externalities and subsidies in case of positive externalities to ensure that market equilibrium matches with social optimum.

2.2 Tax Incidence

- Taxes introduce a wedge between price that consumers pay and price that the suppliers get. As such, $P_P < P_C$.
- To solve for equilibrium, we can solve for $Q_D = Q_S = Q$. Moreover, tax revenue = $(P_C - P_P) \times Q$.
- Taxes generally create deadweight loss. In special cases of perfectly inelastic supply or a perfectly inelastic demand, there is no deadweight loss.
- Please refer to Prof. Hansen's notes for detailed discussion on tax incidence and deadweight loss.

2.3 Public Goods

- Public Goods are *nonrival* in consumption and their benefits are *nonexcludable.*
- *Nonrival*: A person consuming the good does not prevent someone else from doing so too.
- *Nonexcludable*: Once a good is produced, no one can be excluded from enjoying its benefits.
- Solution Concept: People have different demand for public goods. These demands describe their individual willingness to pay. Hence, for each quantity of public good, you can get the society's willingness to pay by adding up each individual willingness to pay. Graphically, this is equivalent to taking a **vertical sum** of individual demands to get an aggregate demand for the public good. *This is in contrast to the private goods case where you take horizontal sums to get aggregate demand.*
- Solution Method: Hence, given individual demands, you get individual P in terms of Q. You add the individual Ps to get an aggregate P that depends on quantity Q. **Note** that for certain values of Q, not all individuals may have a positive willingness to pay. So, you will likely get a piece-wise function for aggregate demand.

3 Exercises

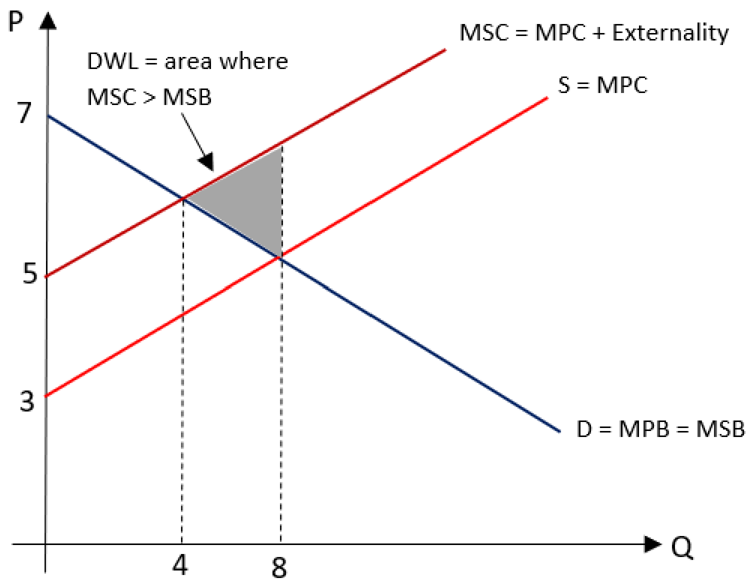
Externalities

1. Sriracha hot sauce is supplied according to $P = 3 + \frac{1}{4}Q$. Demand for sriracha is $P = 7 - \frac{1}{4}Q$.

   (a) What is the market quantity and price?
   Setting supply equal to demand gives a quantity of $Q = 8$ and $P = 5$.

   (b) The production of sriracha also produces noxious fumes that irritate residents that live near the sriracha plant in Irwindale, California (this is real; there have been several lawsuits). Suppose that these fumes represent a negative production externality of \$2 per unit. What is the marginal social cost (MSC) of a unit of sriracha?
   Note that demand and supply can be thought of a marginal private benefit (MPB) and marginal private cost (MPC) respectively. Then since this is a negative externality it makes the true cost to society higher than the cost to private individuals: $MSC = MPC + 2$, SO $MSC = 5 + \frac{1}{4}Q$. Usual rule of thumb: if it's a positive externality, then $MPC = MSC$ and $MSB = MPB + externality$, and if it's a negative externality then $MPB = MSB$, but $MSC = MPC + externality$.

   (c) What is the socially optimal quantity and the deadweight loss of the market equilibrium?
   Setting $MSC = MSB$ gives $Q = 4$. The deadweight loss is the triangle between the MSB and MSB and between the optimal quantity and market quantity (see chart below). the MSC at Q= 8 is 7 and the MSB at Q = 8 is 5. Then $DWL = \frac{1}{2}(8-4)(7-5) = 4$



(d) What policy could the Irwindale city council use to achieve the optimal quantity of Sriracha?
A tax of $2/unit would make the marginal private costs the same as the marginal social costs, thereby giving the optimal quantity.

Tax Incidence

2. Suppose demand is given by $P = 200 - Q$ and supply is $P = Q$.

(a) What is the competitive equilibrium price and quantity?
$P = 100$, $Q = 100$

(b) Suppose the government now imposes a $20 tax on consumers. What quantity will be traded?
In this question, government imposes a $20 tax on consumers. Therefore, $P_c = P_p + 20$, *i.e. consumer's price after tax = producer's price after tax + 20. From demand curve,* $P_c = 200 - Q$. *From supply curve,* $P_p = Q$. *We then will have* $200 - Q = Q + 20$. $\Rightarrow Q = 90$.

(c) What price will consumers pay? What price will producers receive?
Given $Q = 90$ *from (b), we plug this value back to demand and supply equations to get price for consumer and price for supplier.* $P_c = 200 - Q = 110$, $P_p = Q = 90$. *Consumers pay a price of $110, while sellers only receive $90. (Note that the price consumers pay went up by less than the amount of the tax.)*

(d) How much tax revenue does the tax raise?
$90 \times \$20 = \$1800$

(e) Who bears the economic burden of the tax?
As can be seen in the diagram below, half came out of consumer surplus and half

came out of producer surplus, so both sides of the market split the burden evenly.

(f) Is there any deadweight loss?
There is deadweight loss of $0.5 \times \$20 \times 10 = \$100$

(g) What would change if supply was perfectly inelastic, i.e. just $Q = 100$?
Then the quantity would remain at 100: the price consumers pay would stay at $100 to clear the market, so sellers would receive only $80 per unit. Tax revenue would be $2000 and there would be no deadweight loss. The intuition here is that sellers don't care about price at all, so they don't change their behavior at all in response to the tax.

Public Goods

3. What are the two characteristics of public goods that distinguish them from private goods?

4. Alice, Bob and Charlie are looking forward to the end of semester: they are getting tired of appearing in so many questions. To celebrate they plan to have a fireworks

display after the final exam. Their individual demand curves for fireworks are:

$$\text{Alice:} \quad P = 5 - \frac{1}{4}Q$$

$$\text{Bob:} \quad P = 10 - \frac{1}{2}Q$$

$$\text{Charlie:} \quad P = 20 - Q$$

Suppose fireworks cost \$14 each.

(a) Draw the individual demand curves separately. If Alice, Bob and Charlie each have their own separate fireworks displays, how many fireworks will each of them buy?
If they work separately Alice and Bob will not be willing to buy any fireworks, while Charlie will buy 6 fireworks. (Substitute $P = \$14$ into the separate demand curves to see this.)

(b) Now vertically sum the three demand curves to form a market demand curve. What key feature of public goods makes vertical summation appropriate (instead of the horizontal summation we have been doing all semester?).
Since one person watching a fireworks display does not prevent others from also watching it, fireworks displays are non-rival, so we must sum the valuations of the individuals. The market demand is therefore $(5-\frac{1}{4}Q)+(10-\frac{1}{2}Q)+(20-Q) = 35-\frac{7}{4}Q$.

(c) What is the optimal quantity of fireworks that Alice, Bob and Charlie should buy together?
Note that MSB is the same thing as the market demand curve found in (b) and MSC is \$14. Then substituting $P = \$14$ into the demand curve gives $Q = 12$, so they should buy 12 fireworks.

(d) How much should Alice, Bob and Charlie contribute per-firework to ensure the optimal quantity of fireworks is purchased?
At $Q = 12$, Alice is willing to pay $5 - \frac{12}{4} = \$2$ per unit, Bob is willing to pay \$4 per unit and Charlie is willing to pay \$8 per unit, which adds up to \$14 per unit, as needed.

5. (Questions 108-109 from Review Questions with extra question added) Andrew, Bob and Christian live on Short Street outside Madison. They decided to build a small public garden at the corner of the street right by the lake. They each have a different demand curve for the garden given by the following equations:

Andrew: $P_A = 60 - Q$
Bob: $P_B = 60 - 2Q$
Christian: $P_C = 30 - 3Q$

The marginal cost of building the garden is given by MC = 2Q where Q represents the area in terms of square feet that will be allocated to the garden.

(a) Find the aggregate demand.
Solution:

$P_A + P_B + P_C = (60 - Q) + (60 - 2Q) + (30 - 3Q) = 150 - 6Q.$

And we need to add qualification that all three participate (in the previous problem it was given to us). To figure out the conditions on when and who is willing to participate look at the intersection of the demand curve with the horizontal axis or plug P=0 into the demand equation.

Then, we can see that

Andrew: $0 = 60 - Q \Rightarrow Q = 60$
Bob: $0 = 60 - 2Q \Rightarrow Q = 30$
Christian: $0 = 30 - 3Q \Rightarrow Q = 10$

These numbers tell us that, for example, if the optimal quantity is 20, then Christian won't be willing to pay. Hence, such quantity is optimal only if Andrew and Bob are paying for that.

So we have 3 cases:

1) all three participate if the optimal quantity is less than 10;
2) Andrew and Bob participate if the optimal quantity is less than 30 but above 10;
3) only Andrew participates if the optimal quantity is less than 60 but above 30.

We have already found the aggregate demand for case 1 above. For case 3, the aggregate demand is just Andrew's demand. So we need to find the aggregate demand for case 2:

$P_A + P_B = (60 - Q) + (60 - 2Q) = 120 - 3Q.$

Here is what we have:

Case 1: $P = 150 - 6Q$ *if* $Q < 10$.
Case 2: $P = 120 - 3Q$ *if* $Q < 30$ *and* $Q > 10$.
Case 3: $P = 60 - Q$ *if* $Q < 60$ *and* $Q > 30$.

(b) What is the optimal area to be allocated for this public garden?
Solution: MC represents supply, so equate the aggregate demand and supply.

Case 1: $150 - 6Q = 2Q \Rightarrow Q = 18.75$.

It's larger than 10, so Christian won't pay. Hence, this case is not feasible.

Case 2: $120 - 3Q = 2Q \Rightarrow Q = 24$.

That quantity satisfies restrictions.

Case 3: $60 - Q = 2Q \Rightarrow Q = 20$.

It violates the restriction $Q > 30$.

So, we learnt that Andrew and Bob will fund the garden.

(c) How much each person is going to pay?

Solution: Plug the optimal quantity into Andrew's and Bob's demands:

$P_A = 60 - 24 = 36.$

$P_B = 60 - 2 \cdot 24 = 12.$

And Christian pays nothing, though still enjoys the garden. We call that free riding.