Market Failure: Negative Externality

Key ideas from earlier:
Market equilibrium, Efficiency, Invisible hand

Review and Preview
Review – Markets;

- Well-functioning markets generate good outcomes (i.e., efficiency) for society.
- Interfering with well-functioning markets can lead to deadweight loss.
  - Examples: municipal water supply, gasoline price controls

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<th>Individual perspectives</th>
<th>Demand Curve</th>
<th>Supply Curve</th>
<th>Social perspectives</th>
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In general, we have focused on the individual perspective when we discussed what choices we think people will make (i.e., predicting their behavior).

- Consumers choose a mix of goods and services to maximize their utility (consumer surplus) within the limits of their budgets.
  - Demand curves predict how their consumption choices will vary with market prices.
- Producers choose which and how many goods and services to produce to maximize profits (producer surplus).
  - Supply curves predict how their production choices will vary with prices.
- Market equilibrium is a prediction based on the interaction of these individual incentives (demand and supply).

On the other hand, we have evaluated the outcomes from a societal perspective, trying to assess whether they are “good” or “bad.”

- We have defined efficiency as maximizing the total net benefits (total surplus) for all members of society.
- Other criteria (e.g., fairness/equality) can also be evaluated from the social or aggregate perspective.

Market failures occur when people, acting rationally in their own self-interests, make choices that are not “best” (efficient) from a societal perspective.

When we talk about market failures and externalities in particular, we will have to expand these definitions a bit.

- Total surplus should include the benefits and costs of all members of society, not just consumers and producers of a product.
- In our earlier examples, all of the benefits and costs went to either consumers or producers, so there wasn’t anyone else to worry about.
Negative Externalities

A negative externality (one type of market failure) exists when an activity imposes some harm on a person not involved in the activity, an “external” party.

- Because the external person is not involved, his or her harm is typically not considered by the people making decisions about the activity, or at least given “full” weight in the decision.
- The negative externality creates a difference between private costs, affecting only the decision-makers, and social costs, the sum of all costs (including those of external parties).
- Social Marginal Cost (MCsocial) = MCprivate + external cost
- How does the presence of a negative externality (in an unregulated market) affect the equilibrium outcome, in comparison to the efficient outcome?
  - Condition of efficiency: MBsocial = MCsocial
  - MCsocial > MCprivate, therefore in general, the presence of a negative externality leads to overproduction (more than the socially optimal quantity) of that good or service.
  - \( Q > Q^* \)

What are some examples of negative externalities, particularly ones involving the environment and natural resources?

Driving a car generate negative externalities like air pollution, congestion, road rage:
  Driving itself is NOT the externality.

Development generates a negative externality because it displaces beautiful view of scenic land and habitat for animals we like to see, hunt, or just knowing that they have safe homes people feel happy.

Factory and automobile pollution in Quito, Ecuador
Let’s look at a model of a negative externality, such as acid rain.

In Kentucky, most electricity (~90%) is generated in coal-fired power plants. Suppose that aggregate supply (private marginal cost) is given by

\[ P = 200 + Q \]

and that aggregate demand (private marginal benefit) for that electricity is given by

\[ P = 500 - Q \]

The emissions (SO2, etc.) from producing electricity from coal cause damage in the form of acid rain (mostly in areas downwind of the plants). Suppose that the marginal damage (per unit of electricity) from acid rain is given by \( X = 100 \).

First find the equilibrium, based on the supply curve of profit-maximizing producers (i.e., private marginal cost) and the demand curve of utility-maximizing consumers (i.e., private marginal benefit). Fill in the table with your answers to the following questions.

- What are the equilibrium price \( (P) \) and quantity \( (Q) \)?
- What is the sum of consumer and producer surplus \( (CS + PS) \) at the equilibrium?
- What is the total external harm \( (TX) \) at the equilibrium?
- What is the total surplus \( (TS) \) at the equilibrium?
- Draw a graph illustrating this equilibrium.

Note: This outcome is sometimes called the unregulated equilibrium, to distinguish it from the equilibria that result from various policy measures.

Next, identify the efficient outcome, which is based on the social marginal benefit and cost curves.

- What is the social marginal cost curve \( (MC_{Social}) \)?
- What is the social marginal benefit curve \( (MB_{Social}) \)?
- What is the efficient quantity \( (Q^*) \)?
- What is the sum of consumer and producer surplus \( (CS^* + PS^*) \) at the equilibrium?
- What is the total external harm \( (TX^*) \) at the efficient outcome?
- What is the total surplus \( (TS^*) \) at the efficient outcome?
- What is the deadweight loss of \( (DWL) \) of the unregulated equilibrium?
- Draw a graph (or add to your previous graph) illustrating the efficient outcome.
We can show both scenarios on the same graph. It starts to get complicated, but also allows us to compare some things more directly.

### Table: Comparing Equilibrium and Efficiency

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<tr>
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<th>Equilibrium</th>
<th>Efficient Outcome</th>
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<tr>
<td><strong>Defining equations</strong></td>
<td>(Demand) $P = 500 - Q$</td>
<td>$MB_{social} = 500 - Q$</td>
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<tr>
<td></td>
<td>(Supply) $P = 200 + Q$</td>
<td>$MC_{social} = 300 + Q$</td>
</tr>
<tr>
<td><strong>Quantity</strong></td>
<td>$Q = 150$</td>
<td>$Q^* = 100$</td>
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<td><strong>Price</strong></td>
<td>$P = 350$</td>
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<tr>
<td><strong>Producer and consumer surplus</strong></td>
<td>$PS + CS = 11,250 + 11,250 = 22,500$</td>
<td>$PS^* + CS^* = 20,000$</td>
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<tr>
<td><strong>Total externality</strong></td>
<td>$TX = 15,000$</td>
<td>$TX^* = 10,000$</td>
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<td><strong>Total surplus</strong></td>
<td>$TS = 7,500$</td>
<td>$TS^* = 10,000$</td>
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<tr>
<td><strong>Deadweight loss</strong></td>
<td>$DWL = 2,500$</td>
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Other questions for discussion:

Why wouldn’t the consumers and producers of coal-fired electricity take the acid rain damage into account for their supply and demand functions?

Self-interested people (path of least resistance). $Q = 100$ (with $P = 350$) would reduce both consumer and producer surplus.

Even benevolent people may lack information about external costs/benefits, or be influenced by others’ choices (e.g., firms need low costs to be competitive).

What about the “real” numbers regarding SO$_2$ emissions from the production of electricity?

Total externalities from coal-fired electricity generation have been estimated at $56.4 billion per year. This includes not just acid rain, but all externalities except climate change ($68.7$ billion including CC at $27/ton of CO$_2$).

SO$_2$ emissions (vs. other pollutants) account for 87% of this figure and higher mortality rates are the highest proportion of the damage (94%).

Ratio of marginal damage to marginal benefit is 2.2.

Damage per kilowatt-hour is $0.028$ (or $0.036$ including CC), compared with average retail electricity prices of approximately $0.084$ (in 2002). Average retail rates for coal-dominated states is $0.06/kwh.

SO$_2$ emission rates are in the ballpark of 9 million tons/year, so damage per ton is a bit over $6,000/ton.

Figures
Equilibrium (Intersection of Supply and Demand)

Equilibrium calculations/graph:

What are the equilibrium price \((P)\) and quantity \((Q)\)?

Equilibrium occurs where supply intersects demand. Solve \(200 + Q = P = 500 - Q\) to get \(Q = 150\).

Plug \(Q = 150\) into the supply equation to get \(P = 350\).

What is the sum of consumer and producer surplus \((CS + PS)\) at the equilibrium?

\(CS\) and \(PS\) are both triangles (as is the sum).

\[CS = (1/2)(150)(500 - 350) = 11,250.\]
\[PS = (1/2)(150)(350 - 200) = 11,250.\]
\[CS + PS = 11,250 + 11,250 = 22,500.\]

What is the total external effect \((TX)\) at the unregulated equilibrium?

When the externality is constant (as it is here), just multiply the per unit external effect by the number of units.

At the equilibrium: \(TX = 100 \times 150 = 15,000\).
Alternatively, it is the parallelogram between \( MC_{Social} \) and \( MC_{Private} \) on the graph, up to the market quantity. [Show after doing the efficiency part.]

What is the total surplus (\( TS \)) at the equilibrium?

Total surplus can be defined as the sum of all the welfare effects:

\[
TS = CS + PS - TX
\]

\[
= 11,250 + 11,250 - 15,000 = 7,500.
\]

Recall that the external effect is a harm in this case (negative externality).

Efficiency calculations/graph:

What is the social marginal cost curve (\( MC_{Social} \))?  

- Add \( X = 100 \) to the firms’ marginal cost in order to get the marginal social cost equation, \( P = 200 + Q + X = 300 + Q \).

What is the efficient quantity (\( Q^* \))? 

Efficiency occurs where \( MB = MC_{Social} \), because that maximizes the total surplus.  
(Note: \( MB_{Private} = MB_{Social} \) in this example.)

Solve this system, \( 300 + Q = P = 500 - Q \), to get \( Q^* = 100 \).

Note: \( Q > Q^* \) is typical with negative externalities.

What is the sum of consumer and producer surplus (\( CS^* + PS^* \)) at the efficient outcome?  

[Skip until you look at the combined graph]

What is the total surplus (\( TS^* \)) at the efficient outcome?

Total surplus is the area above \( MC_{Social} \) and below \( MB \).

\[
TS^* = (1/2)(500 - 300)(100 - 0) = 10,000.
\]

What is the total external effect (\( TX \)) at the unregulated equilibrium? At the efficient quantity (\( TX^* \))?

When the externality is constant (as it is here), just multiply the per unit external effect by the number of units.

At the efficient outcome: \( TX^* = 100 \times 100 = 10,000 \).

We might also show both outcomes (equilibrium and efficiency), but not all of the curves.

Use just demand and supply to compare \( CS \) and \( PS \) for the two outcomes.

The difference is the triangle for \( Q = 100 \) to 150.

\[
CS^* + PS^* = CS + PS - (1/2)(150 - 100)(400 - 300) = 22,500 - 2,500 = 20,000.
\]
Consumer and Producer Surplus at Equilibrium

$P = 350$

Supply (MC_{private}): $P = 200 + Q$

Demand (MB_{private}): $P = 500 - Q$

$Q = 150$

Consumer and Producer Surplus at Efficient Outcome

$P = 350$

CS + PS

$Q^* = 100$

Supply (MC_{private}): $P = 200 + Q$

Demand (MB_{private}): $P = 500 - Q$
We can see why the market failure occurs, and leads us to inefficient outcomes.

The producers and consumers are the ones making the decision about how much electricity to generate.

Together, they get higher surplus at the equilibrium than at the efficient outcome.

Total Surplus and Deadweight Loss

What is the total surplus ($TS$) at the equilibrium? At the efficient outcome ($TS^*$)?

Total surplus is the area above $MC_{social}$ and below $MB$.

$$TS = \frac{1}{2}(500 - 300)(100 - 0) - \frac{1}{2}(450 - 350)(150 - 100) = 10,000 - 2,500 = 7,500.$$ [Note: Second term is DWL.]

Note: Need to plug in $Q = 150$ to get $MC_{social}(150) = 450$ and $MC_{private}(150) = 350$ for the height in the second term.

$$TS^* = \frac{1}{2}(500 - 300)(100 - 0) = 10,000.$$ 

What is the total external effect ($TX$) at the unregulated equilibrium? At the efficient quantity ($TX^*$)?

When the externality is constant (as it is here), just multiply the per unit external effect by the number of units.

At the equilibrium: $$TX = 100 \times 150 = 15,000.$$
At the efficient outcome: \( TX^* = 100 \times 100 = 10,000 \).

Note that the difference in \( TX \) is not equal to the difference in \( TS \). There are also changes in \( PS \) and \( CS \). (Which is why equilibrium is different.)

What is the total surplus (\( TS \)) at the equilibrium?

Total surplus can be defined as the sum of all the welfare effects: \( TS = CS + PS - TX \)

\[ = 11,250 + 11,250 - 15,000 = 7,500. \]

Recall that the external effect is a harm in this case (negative externality).

On the full graph, total surplus is the area above \( MC_{\text{Social}} \) and below \( MB_{\text{Social}} \). [Show after looking at efficiency part.]

\[ TS = [(1/2)(500 - 300)(100 - 0)] - [(1/2)(450 - 350)(150 - 100)] = 10,000 - 2,500 = 7,500. \] [Note: Second term is DWL.]

Note: Need to plug in \( Q = 150 \) to get \( MC_{\text{Social}}(150) = 450 \) and \( MC_{\text{Private}}(150) = 350 \) for the height in the second term.

\[ TS^* = (1/2)(500 - 300)(100 - 0) = 10,000. \]