EC 450 – Economics of Environmental Policy
Lecture 3 Efficiency and Markets

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Motivation

- We get back to fundamental questions in microeconomics:
  - For any given good, how much should be produced?
  - Who should produce and consume it?
- In the context of Environmental Economics:
  - What is the right amount of pollution?
  - Who should reduce pollution to achieve the target pollution level?

Sources of “inefficiency”

- What is the right amount of pollution?
  - Having too much or too little pollution may be “inefficient.”

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  - Pursuing too little pollution could be very costly.
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Sources of "inefficiency"

- What is the right amount of pollution?
  - Having too much or too little pollution may be "inefficient."
  - Pursuing too little pollution could be very costly.
- Who should reduce pollution to achieve the target pollution level?
  - Assigning the responsibility to a high-cost agent may be "inefficient."
  - Example: a law that prohibits the transport of wastes across regional boundaries

What is efficiency?

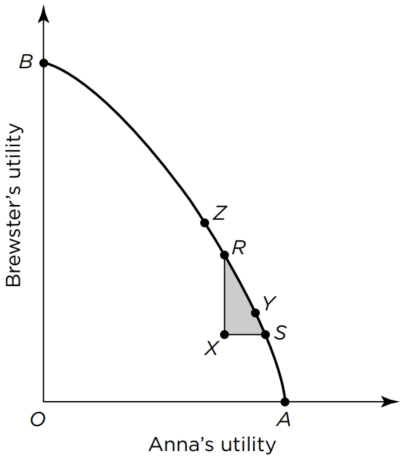
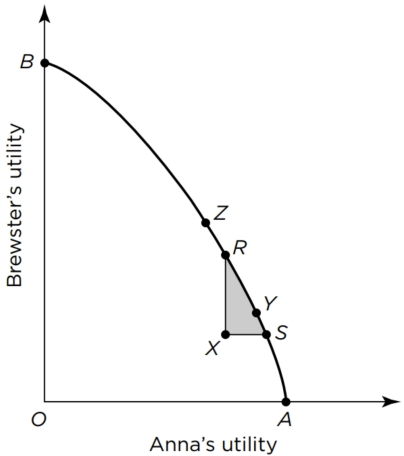


FIGURE 4.1 Pareto frontier and efficiency

- Which allocations are efficient?

What is efficiency?



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- Which allocations are efficient?
- Pareto frontier: Allocations which cannot be improved further.

What is efficiency?

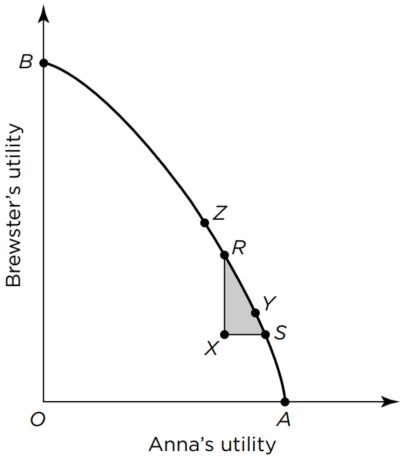


FIGURE 4.1 Pareto frontier and efficiency

- Which allocations are efficient?
- Pareto frontier: Allocations which cannot be improved further.
  - Curved line AB
- All allocations on the Pareto frontier are Pareto optimal or *efficient*.

Should efficiency be the only goal when we divide the social pie?

. . . even when some people are rolling in luxury and others are near starvation, as long as the starvers cannot be made better off without cutting into the pleasures of the rich . . . In short, a society or an economy can be Pareto optimal and still be perfectly disgusting.

—Amartya Sen (1970) "Collective Choice and Social Welfare"

Two important results in economics

1. First Theorem of Welfare Economics: Competitive markets are efficient.

2. Second Theorem of Welfare Economics: Any Pareto optimum can be achieved with a competitive market by appropriately transferring income among individuals.

A simple exchange economy

- Two goods:
  - Wine
  - Garbage disposal service
- Two members:
  - Anna
  - Brewster
- Could a trade of goods make both Anna and Brewster happier than without the trade?

Anna's utility maximizing choice

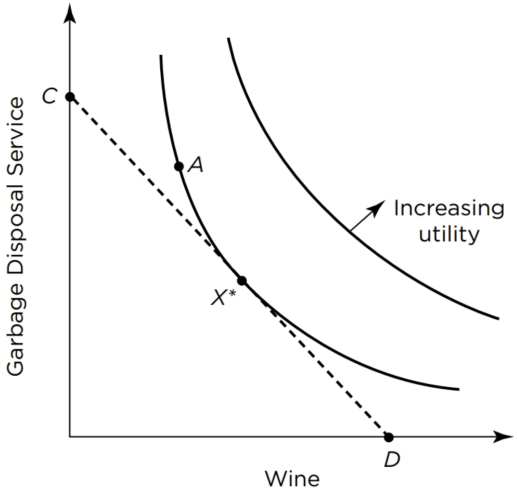


FIGURE 4.2 Utility maximizing choice

- Budget line

Anna's utility maximizing choice

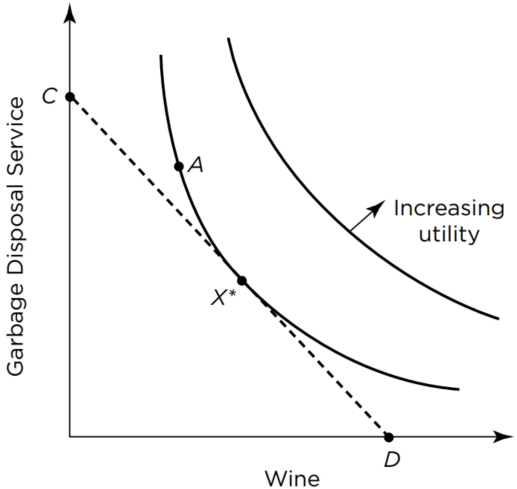
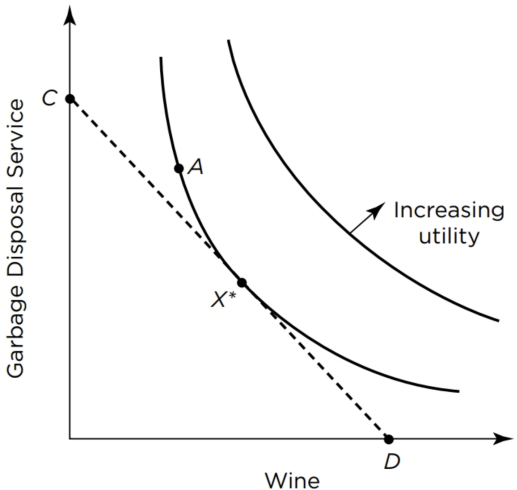


FIGURE 4.2 Utility maximizing choice

- Budget line
  - Dashed line CD
- Indifference curves
  - Which curve has a higher utility?
- Marginal rate of substitution (MRS)

Anna's utility maximizing choice



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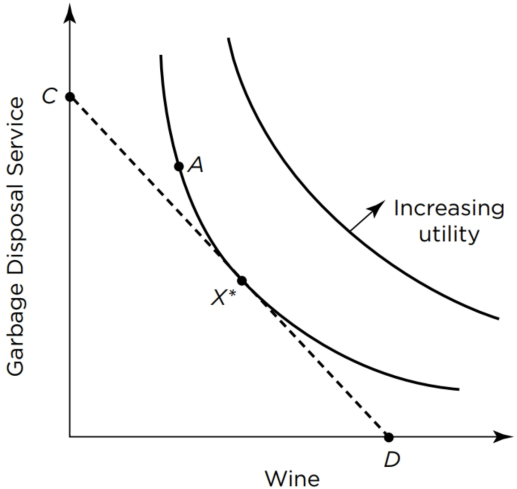
  - How much wine consumption would need to increase to offset a one unit drop in garbage disposal consumption to keep utility constant?
- Which allocation could maximize the utility?

Anna's utility maximizing choice



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- Which allocation could maximize the utility?
  - X^*: MRS $=$ Budget line slope

Could a trade make Anna and Brewster better off?

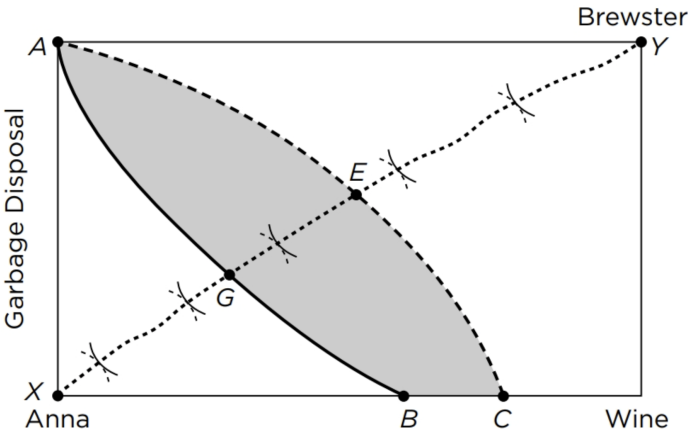
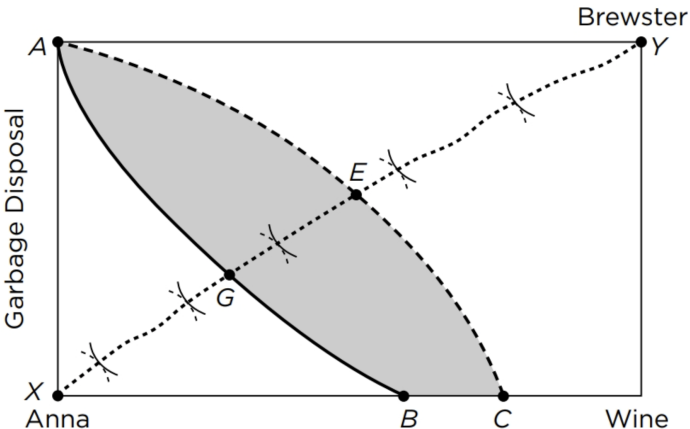


FIGURE 4.3 Edgeworth box characterization

- Edgeworth box
  - Plot Brewster's indifference curves from the upper right corner
- Suppose A to be the initial endowment
  - Anna with all garbage disposal services
  - Brewster with all wine
- Pareto improvement?

Could a trade make Anna and Brewster better off?



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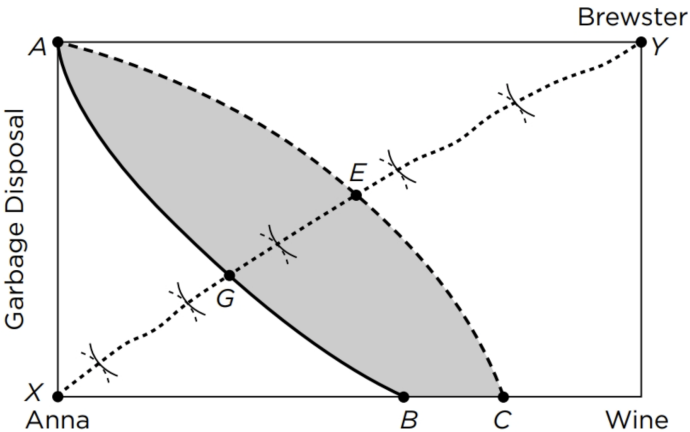
  - Shaded lens ACB

Contract curve



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- Contract curve: Points where Anna and Brewster's indifference curves are tangent form the contract curve.
  - One person can improve utility only by decreasing the other's utility.

Contract curve

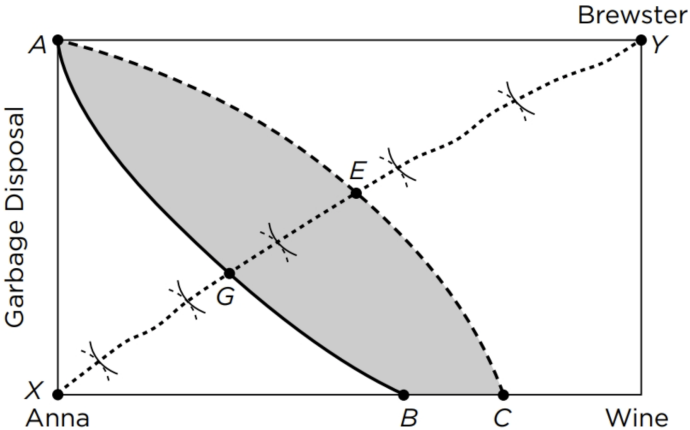

FIGURE 4.3 Edgeworth box characterization

- Contract curve: Points where Anna and Brewster's indifference curves are tangent form the contract curve.
  - One person can improve utility only by decreasing the other's utility.
    – Pareto frontier
- Free exchange leads to the Pareto optimum.
  - MRS should be the same for all individuals.

Markets and exchange: What happens with money or prices?

- Suppose the prices are given (Anna and Brewster are price-takers)
  - Garbage disposal service: $p_G = \$20$
  - Wine: $p_W = \$10$
- Anna's initial endowment
  - Garbage disposal service: $G_0 = 0$ (None)
  - Wine: $W_0 = 100$ (All)
- Anna's budget balancing requires any allocation (G, W) to satisfy

$$p_G G_0 + p_W W_0 = p_G G + p_W W \iff G = -0.5W + 1000$$

  - Anna's budget line has a slope of the price ratio $-p_W/p_G = -0.5$

Market equilibrium: Which allocation would the market realize?

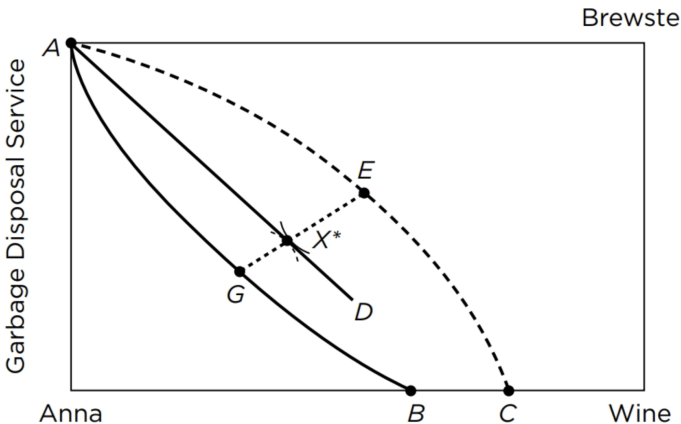

FIGURE 4.4 Market equilibrium

Both individuals must be satisfied with the equilibrium allocation.

1. The budget line must pass through the initial endowment.
2. There must be some allocation at which the indifference curves of both parties are tangent to the budget line.
   - MRS = price ratio

The initial endowment determines the equilibrium allocation

- What about other points on the contract curve? Can we achieve those allocations in an equilibrium?
- Any allocations on the contract curve are possible by adjusting the initial endowment.

Supply side

- Suppose there is a firm that has a fixed amount of land and labor to produce wine or dispose of garbage.
  - Production possibilities frontier: the maximum possible production combinations of wine and garbage disposal
  - Marginal rate of transformation (MRT): how much garbage disposal can be increased when wine production is decreased by one unit

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  - Production possibilities frontier: the maximum possible production combinations of wine and garbage disposal
  - Marginal rate of transformation (MRT): how much garbage disposal can be increased when wine production is decreased by one unit
    $\rightarrow$ Slope of the production possibilities frontier
  - Fixed total cost of $C = \$500$

- Suppose the prices are given (Firm is a price-taker)
  - Garbage disposal service: $p_G = \$20$; Wine: $p_W = \$10$

- Firm's profit π for an allocation (G, W) is

$$\pi = p_G G + p_W W - C \iff G = -0.5W + (\pi + 500)/20$$

  - Indifference curve for the firm; slope of the price ratio $p_W/p_G = 0.5$

Efficiency in production

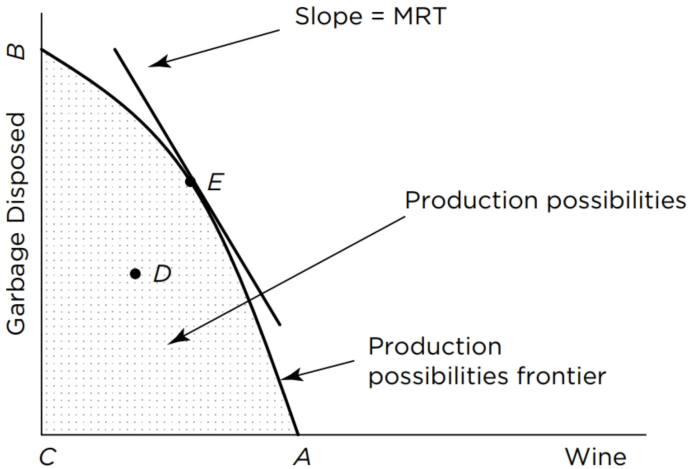


FIGURE 4.5 Efficiency in production

How could the firm maximize its profit?

Efficiency in production

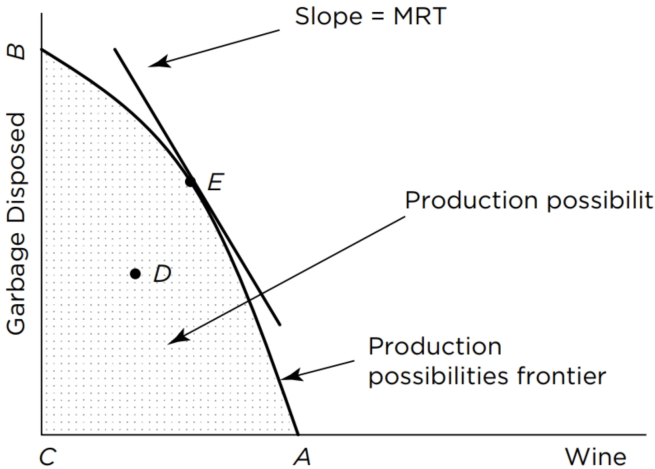


FIGURE 4.5 Efficiency in production

How could the firm maximize its profit?
$\rightarrow$ MRT = price ratio

Equimarginal principle

- If there are multiple producers of wine and garbage disposal, for efficiency to hold, the MRT between wine and garbage must be the same for all producers.
- In the context of Environmental Economics: If more than one firm is generating emissions, then efficiency calls for the equality among those firms of the MRT between pollution emissions and goods output.
- More generally: The marginal cost of emissions control should be equal for all polluters emitting the same pollutant.
  - "Same pollutant": the marginal damage from a unit of pollution is the same, regardless of which polluter it comes from.

Equimarginal principle example: low- and high–control cost firm

- Suppose two firms are emitting SO_2 at different marginal costs of pollution control.
- We can reduce total costs without affecting the overall emissions of SO_2 simply by moving some of the responsibility for pollution control to the low-control cost firm, away from the high–control cost firm.
- This is a potential Pareto improvement and thus the original situation was not efficient.

Equimarginal principle example: Kyoto Protocol

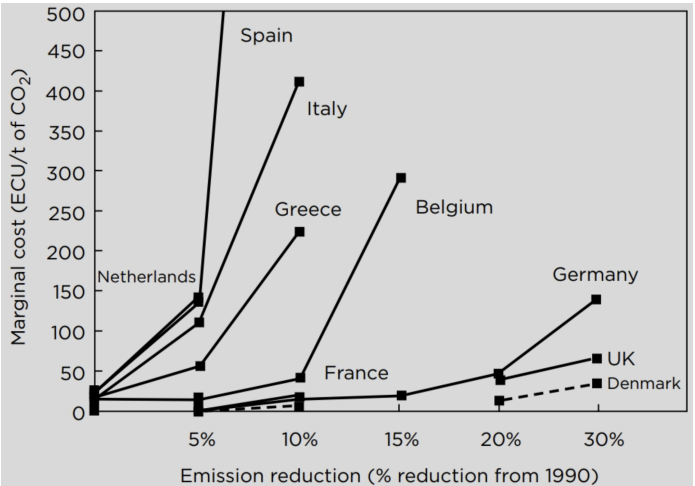


FIGURE 4.6 Marginal costs of emission reductions

- The Protocol calls for countries to reduce emissions by a certain percentage.
- 7% target for the EU as a whole.
- Potential differences in control costs among different countries.
- EU not satisfying the equimarginal principle.

Efficiency without markets

Efficiency requires

1. MRS = MRT
2. The same MRS across individuals.
3. The same MRT across firms.

without markets (or prices)

Efficiency with markets

In *competitive* markets,

1. MRS = MRT
2. The same MRS across individuals.
3. The same MRT across firms.

will automatically hold in the market equilibrium.

Two Theorems of Welfare Economics

1. First Theorem of Welfare Economics
   - In a competitive economy, a market equilibrium is Pareto Optimal.

2. Second Theorem of Welfare Economics
   - In a competitive economy, any Pareto optimum can be achieved by market forces, provided the resources of the economy are appropriately distributed before the market is allowed to operate.

$\rightarrow$ Why not let the market operate to solve environmental issues?

Devil lies in the characteristics of “competitive markets”

1. Complete property rights
2. Atomistic participants
3. Complete information
4. No transaction costs

Supply, demand, and efficiency

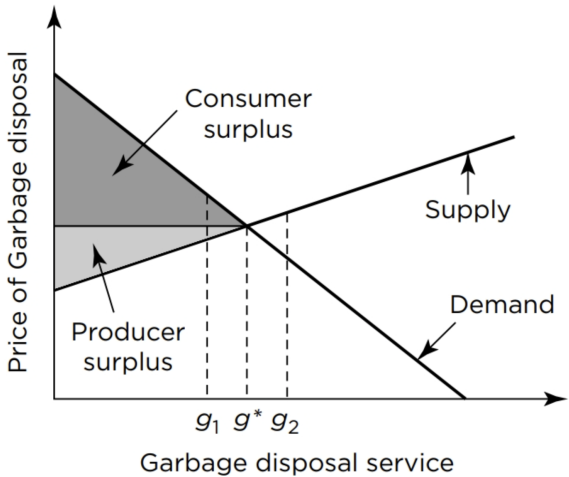


FIGURE 4.7 Supply, demand, and surplus measures

Demand and willingness to pay

- A conventional demand curve shows quantity demanded as a function of price.
  - For any price, how much will be demanded?
- Without market prices, a demand curve is the answer to the following question:
  - If there were a price of $\$p$ for this good, how much would you want, taking into account your budget and the prices of other goods?
  - It asks about the *marginal willingness to pay*.

A market equilibrium is Pareto optimal

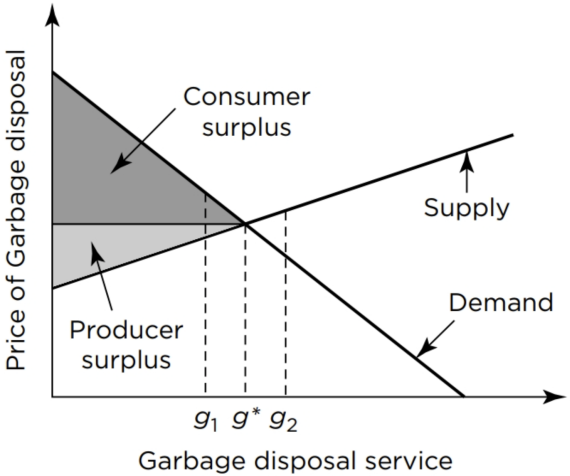


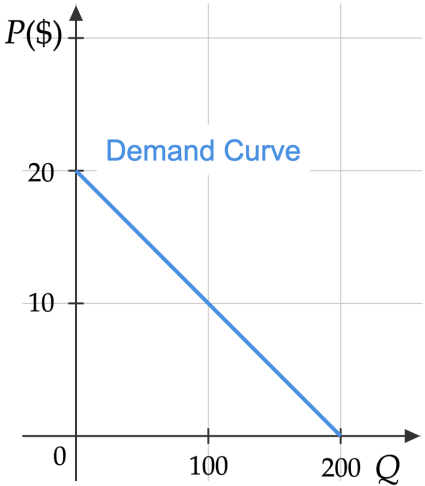
FIGURE 4.7 Supply, demand, and surplus measures

- g^* is Pareto optimal
- g^* is a Pareto improvement from g_1?
  - At g_1, additional garbage disposal services could be supplied to our consumer at a cost less than the willingness-to-pay for the garbage disposal services.
- g^* is a Pareto improvement from g_2?
  - At g_2, the last bit of wine is worth less to the consumer than it costs to produce it.

Measuring consumer welfare

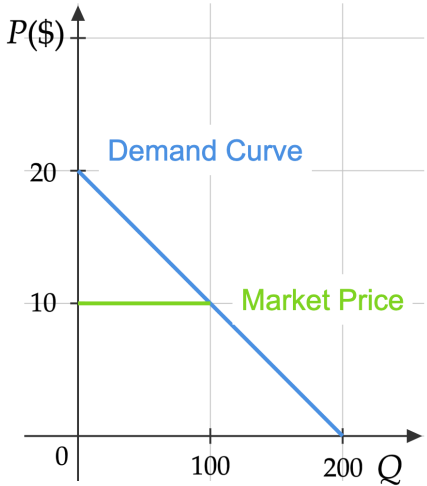
- We use the *consumer surplus* to measure changes in consumer welfare.
- The consumer surplus measures the net benefit a consumer enjoys from being able to purchase a good or service.
- It is computed as the difference between what the consumer is willing to pay and what the consumer actually pays for each unit consumed.

Consumer surplus calculation



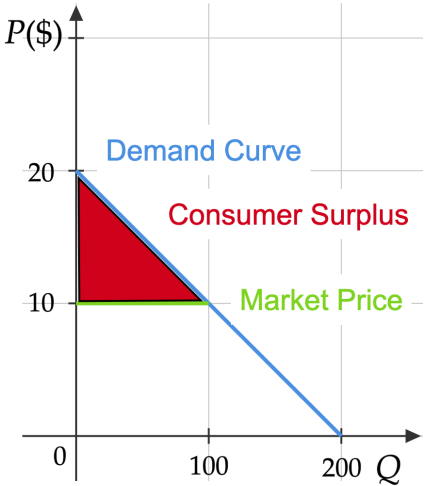
- Start from the demand curve.

Consumer surplus calculation



- Start from the demand curve.
- Price is determined by the market.
  - Supply-demand model
  - Policy intervention

Consumer surplus calculation



- Start from the demand curve.
- Price is determined by the market.
  - Supply-demand model
  - Policy intervention
- Consumer surplus is the area between the demand curve and the market price line:

$$\frac{1}{2} \times 100 \times (20 - 10) = 500.$$

Consumer and producer surplus

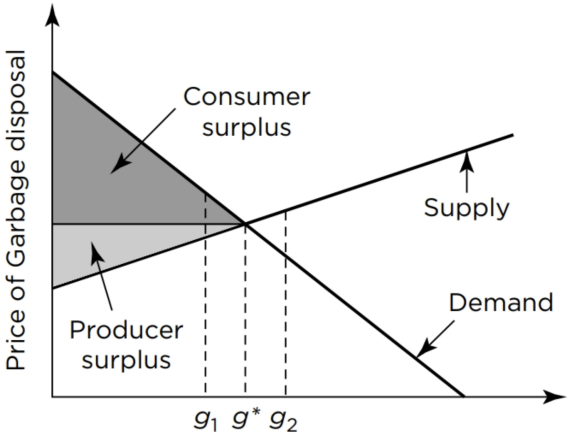


FIGURE 4.7 Supply, demand, and surplus measures

- Consumer surplus =

Consumer and producer surplus

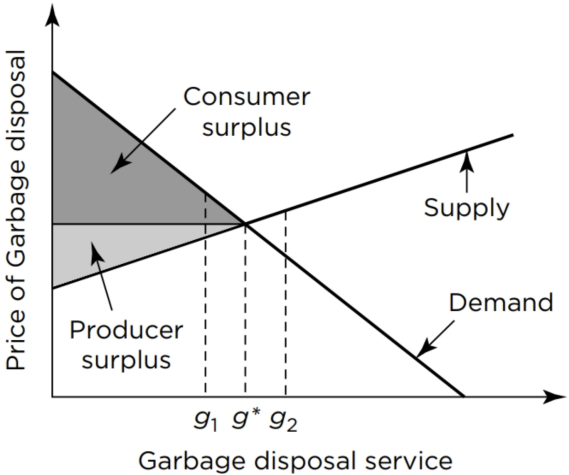
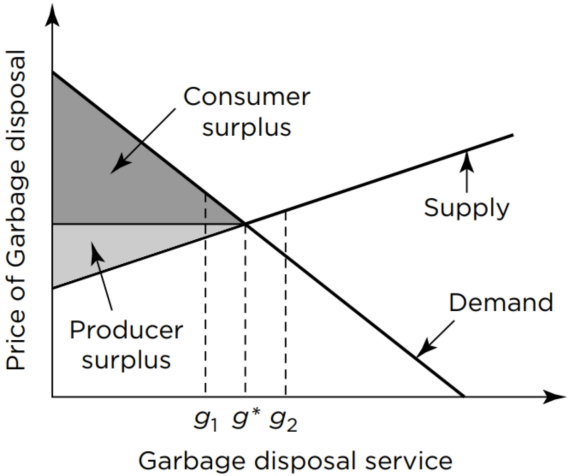


FIGURE 4.7 Supply, demand, and surplus measures

- Consumer surplus = willingness-to-pay − amount paid
- Producer surplus =

Consumer and producer surplus



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- Producer surplus = revenue − cost
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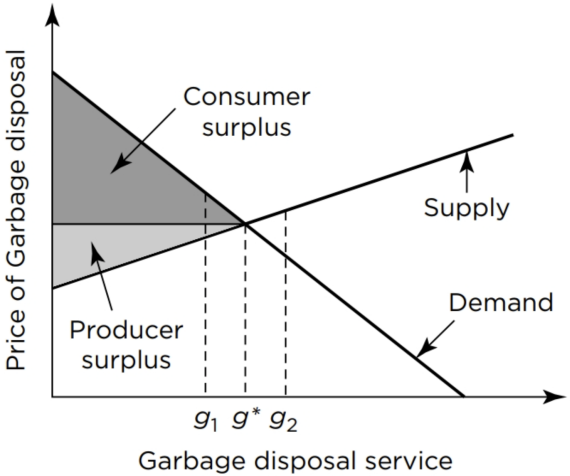

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- Consumer surplus = willingness-to-pay − amount paid
- Producer surplus = revenue − cost
- Total surplus = consumer surplus + producer surplus
- Total surplus is maximized at the market equilibrium.
  - g^* (equilibrium) vs g_1 (too little)?
  - g^* (equilibrium) vs g_2 (too much)?