

# Elasticity and Its Applications

EE 211

- What is the definition of elasticity?
- What is the meaning and importance of
  - price elasticity of demand?
  - income elasticity of demand
  - price elasticity of supply?
- What factors influence the size of these various elasticities?
- How the cross-price elasticity of demand measures the responsiveness of demand for one good to changes in the price of another good

## Elasticity

- measures how much one variable responds to changes in another variable.
  - One type of elasticity measures how much demand for your websites will fall if you raise your price.
- is a numerical measure of the responsiveness of  $Q^d$  or  $Q^s$  to one of its determinants.

## Price Elasticity of Demand

- is the ratio of the percent change in the quantity demanded to the percent change in the price as we move along the demand curve (dropping the minus sign).

$$\text{Price elasticity of demand} = \frac{\text{Percentage change in } Q^d}{\text{Percentage change in } P}$$

**Price elasticity of demand** measures how much  $Q^d$  responds to a change in  $P$ .

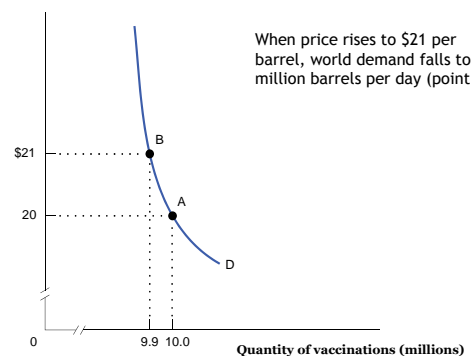
$$\% \text{ change in quantity demanded} = \frac{\text{Change in quantity demanded}}{\text{Initial quantity demanded}} \times 100$$

$$\% \text{ change in price} = \frac{\text{Change in price}}{\text{Initial price}} \times 100$$

$$\text{Price elasticity of demand} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}}$$

## Demand for Vaccinations

Price of vaccination



## Calculating the Price Elasticity of Demand

$$\% \text{ change in quantity demanded} = \frac{-0.1 \text{ million vaccinations}}{10 \text{ million vaccinations}} \times 100 = -1\%$$

$$\% \text{ change in price} = \frac{\$1}{\$20} \times 100 = 5\%$$

$$\text{Price elasticity of demand} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}}$$

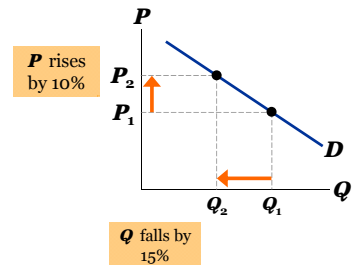
$$\text{Price elasticity of demand} = \frac{1\%}{5\%} = 0.2$$

## Price Elasticity of Demand

$$\text{Price elasticity of demand} = \frac{\text{Percentage change in } Q^d}{\text{Percentage change in } P}$$

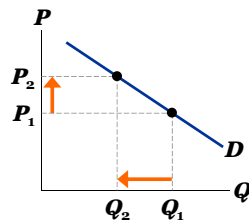
Price elasticity of demand equals

$$\frac{15\%}{10\%} = 1.5$$

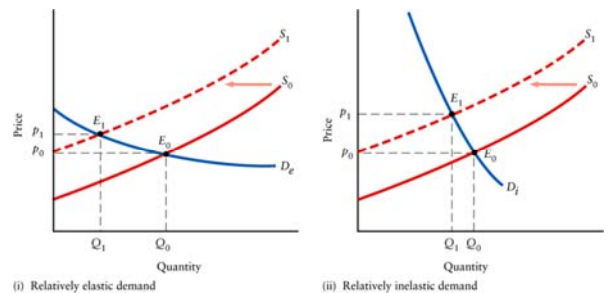


Along a  $D$  curve,  $P$  and  $Q$  move in opposite directions, which would make price elasticity negative.

We will drop the minus sign and report all price elasticities as positive numbers.



## The Effects of a Supply Shift with Two Different Demand Curves



- Both curves are drawn on the same scale
- The initial equilibrium prices and quantities were the same
- If the initial prices and quantities are the same in both cases, the larger absolute change is also the larger percentage change
- However, when we wish to deal with different initial price quantity equilibria, we need to decide whether we are interested in absolute or percentage changes

An alternative way to calculate elasticities:

the Midpoint Method

## The Midpoint Method

The midpoint method is a technique for calculating the percent change. In this approach, we calculate changes in a variable compared with the average, or midpoint, of the starting and final values.

## Example

Suppose you were trying to estimate the price elasticity of demand for gasoline by comparing gasoline prices and consumption in different countries

Because of high taxes, gasoline usually costs about three times as much per gallon in Europe as it does in the United States

A good way to avoid computing different elasticities for rising and falling prices is to use the midpoint method

$$\% \text{ change in } X = \frac{\text{Change in } X}{\text{Average value of } X} \times 100$$

$$\text{Average value of } X = \frac{\text{Starting value of } X + \text{final value of } X}{2}$$

$$\text{Price elasticity of demand} = \frac{\frac{Q_2 - Q_1}{(Q_1 + Q_2)/2}}{\frac{P_2 - P_1}{(P_1 + P_2)/2}}$$

## Using the Midpoint Method to Calculate Elasticities

|                    | Price  | Quantity demanded |
|--------------------|--------|-------------------|
| <b>Situation A</b> | \$0.90 | 1,100             |
| <b>Situation B</b> | \$1.10 | 900               |

$$\% \text{ change in quantity demanded} = \frac{-200}{(1,100 + 900)/2} \times 100 = \frac{-200}{1,000} \times 100 = -20\%$$

$$\% \text{ change in price} = \frac{\$0.20}{(\$0.90 + \$1.10)/2} \times 100 = \frac{\$0.20}{\$1.00} \times 100 = 20\%$$

$$\text{Price elasticity of demand} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}} = \frac{20\%}{20\%} = 1$$

## Example

Price reductions and corresponding increases in quantity demanded for three products

| Commodity  | Reduction in price | Increase in Quantity demanded (per month) |
|------------|--------------------|---|
| Cheese     | \$2 per pound      | 7,500 pounds                              |
| T-Shirts   | \$2 per shirt      | 25,000 shirts                             |
| CD players | \$2 per CD player  | 500 CD players                            |

## Price and Quantity information

| Product    | Unit   | Original price(\$) | New price (\$) | Average price (\$) | Original quantity | New quantity | Average quantity |
|------------|--------|--------------------|----------------|--------------------|-------------------|--------------|------------------|
| Cheese     | Pound  | 5                  | 3              | 4                  | 116,250           | 123,750      | 120,000          |
| T-Shirts   | Shirt  | 17                 | 15             | 16                 | 187,500           | 212,500      | 200,000          |
| CD players | player | 81                 | 79             | 80                 | 9,750             | 10,250       | 10,000           |

## Calculation of demand elasticities

| Product    | (1) Percentage decrease in price | (2) Percentage increase in quantity | (3) Elasticity of demand (2)/(1) |
|------------|----------------------------------|-------------------------------------|----------------------------------|
| Cheese     | 50                               | 6.25                                | 0.125                            |
| T-Shirts   | 12.5                             | 12.5                                | 1.0                              |
| CD players | 2.5                              | 5.0                                 | 2.0                              |

## Price Elasticity of Demand

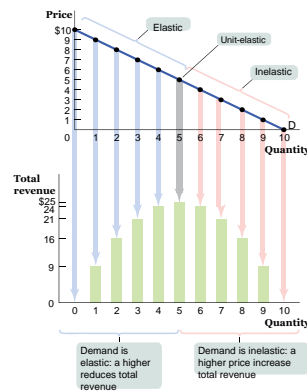
## Price Elasticity of Demand

Demand is elastic when quantity demanded is relatively responsive to a change in the product's own price.

Demand is inelastic if quantity demanded is relatively unresponsive to changes in price.

Elasticity is related to the slope of the demand curve, but it is not exactly the same.

## Price elasticity along the demand curve



| Price | Quantity demanded | Total Revenue |
|-------|-------------------|---------------|
| \$0   | 10                | \$0           |
| 1     | 9                 | 9             |
| 2     | 8                 | 16            |
| 3     | 7                 | 21            |
| 4     | 6                 | 24            |
| 5     | 5                 | 25            |
| 6     | 4                 | 24            |
| 7     | 3                 | 21            |
| 8     | 2                 | 16            |
| 9     | 1                 | 9             |
| 10    | 0                 | 0             |

The price elasticity of demand changes along the demand curve

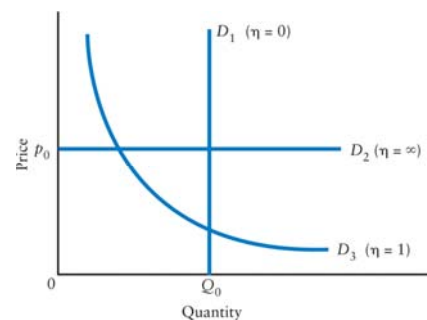
## Interpreting Numerical Elasticities

Inelastic Demand ( $<1$ ):  
A given % change in  $p$  results in a smaller % change in  $Q^D$ .

Elastic Demand ( $>1$ ):  
A given % change in  $p$  results in a larger % change in  $Q^D$ .

Unit elastic Demand ( $=1$ ):  
A given % change in  $p$  results in the same % change in  $Q^D$ .

## Three Demand Curves with Constant Elasticity



## Two Extreme Cases of Price Elasticity of Demand

Demand is perfectly inelastic when the quantity demanded does not respond at all to changes in the price. When demand is perfectly inelastic, the demand curve is a vertical line.

Demand is perfectly elastic when any price increase will cause the quantity demanded to drop to zero. When demand is perfectly elastic, the demand curve is a horizontal line.

## Unit-Elastic Demand, Inelastic Demand, and Elastic Demand

Demand is elastic if the price elasticity of demand is greater than 1

Demand is inelastic if the price elasticity of demand is less than 1

Demand is unit-elastic if the price elasticity of demand is exactly 1.

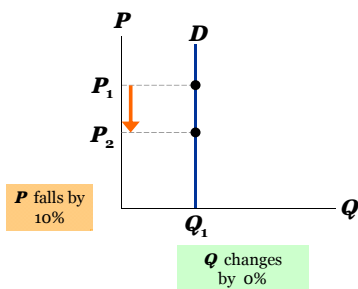
### “Perfectly inelastic demand” (one extreme case)

$$\text{Price elasticity of demand} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{0\%}{10\%} = 0$$

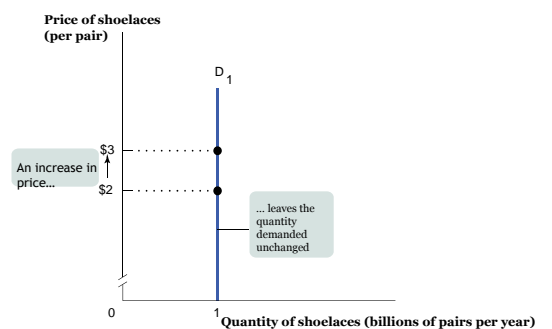
D curve:  
vertical

Consumers' price sensitivity:  
none

Elasticity:  
0



### Perfectly Inelastic Demand: Price Elasticity of Demand = 0



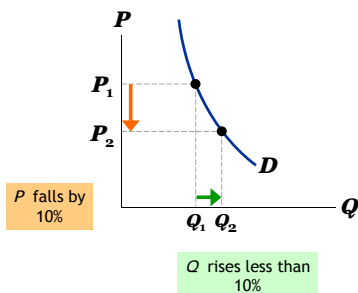
### “Inelastic demand”

$$\text{Price elasticity of demand} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{< 10\%}{10\%} < 1$$

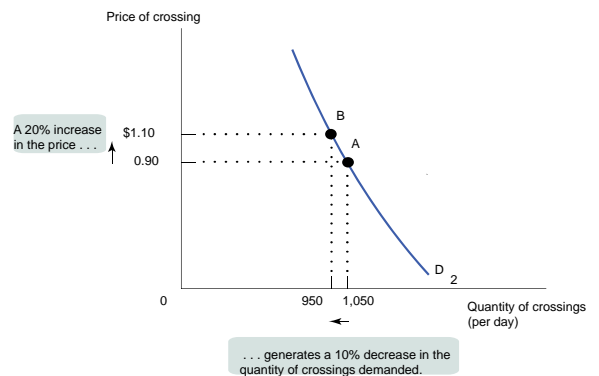
D curve:  
relatively steep

Consumers' price sensitivity:  
relatively low

Elasticity:  
< 1



### Inelastic Demand: Price Elasticity of Demand = 0.5



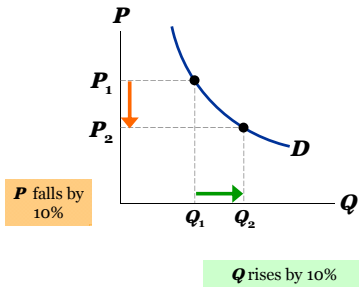
### “Unit elastic demand”

$$\text{Price elasticity of demand} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{10\%}{10\%} = 1$$

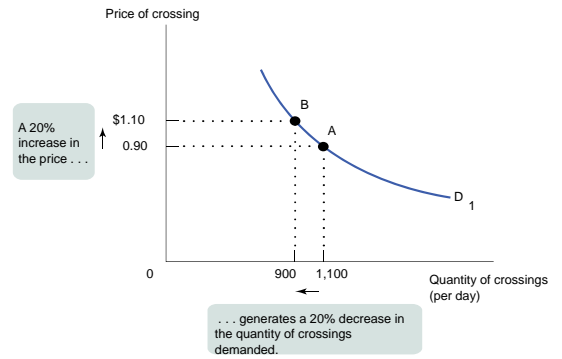
D curve:  
intermediate slope

Consumers' price sensitivity:  
intermediate

Elasticity:  
1



### Unit-Elastic Demand: Price Elasticity of Demand = 1



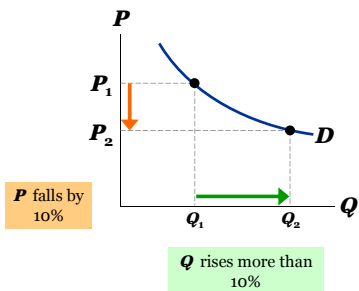
### “Elastic demand”

$$\text{Price elasticity of demand} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{> 10\%}{10\%} > 1$$

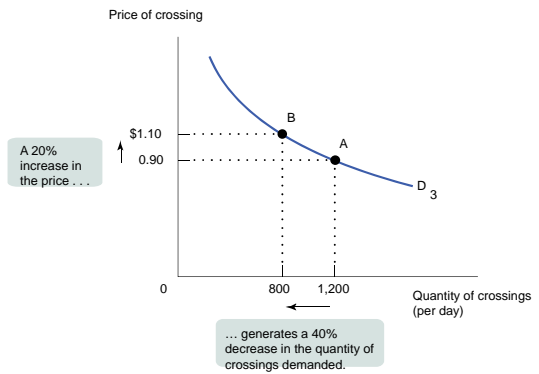
D curve:  
relatively flat

Consumers' price sensitivity:  
relatively high

Elasticity:  
> 1



### Elastic Demand: Price Elasticity of Demand = 2



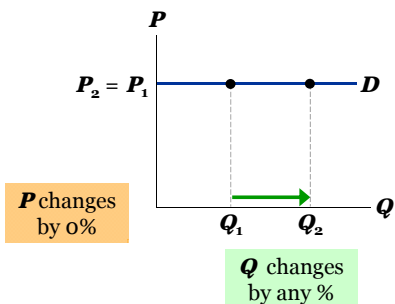
### “Perfectly elastic demand” (the other extreme)

$$\text{Price elasticity of demand} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{\text{any } \%}{0\%} = \text{infinity}$$

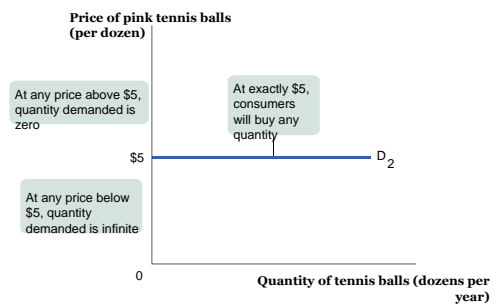
D curve:  
horizontal

Consumers' price sensitivity:  
extreme

Elasticity:  
infinity



### Price Elastic Demand: Price Elasticity of Demand = ∞



## Some Estimated Price Elasticities of Demand

| Good                    | Price elasticity |                                |
|-------------------------|------------------|--------------------------------|
| <i>Inelastic demand</i> |                  |                                |
| • Eggs                  | 0.1              | Price elasticity of demand < 1 |
| • Beef                  | 0.4              |                                |
| • Stationery            | 0.5              |                                |
| • Gasoline              | 0.5              |                                |
| <i>Elastic demand</i>   |                  |                                |
| • Housing               | 1.2              | Price elasticity of demand > 1 |
| • Restaurant meals      | 2.3              |                                |
| • Airline travel        |                  |                                |
| • Foreign travel        | 4.1              |                                |

## What Determines Elasticity of Demand?

Demand elasticity tends to be high when there are many close substitutes.

The availability of substitutes is determined by:

- how specifically the product is defined
- whether the good is a necessity or a luxury
- the length of the time interval (short run vs. long run)

### EXAMPLE 1:

#### Breakfast Cereal vs. Sunscreen

- The prices of both of these goods rise by 20%. For which good does  $Q^d$  drop the most? Why?
  - Breakfast cereal has close substitutes (e.g., pancakes, Eggo waffles, leftover pizza), so buyers can easily switch if the price rises.
  - Sunscreen has no close substitutes, so consumers would probably not buy much less if its price rises.
- Lesson: *Price elasticity is higher when close substitutes are available.*

### EXAMPLE 2:

#### Insulin vs. Caribbean Cruises

- The prices of both of these goods rise by 20%. For which good does  $Q^d$  drop the most? Why?
  - To millions of diabetics, insulin is a necessity. A rise in its price would cause little or no decrease in demand.
  - A cruise is a luxury. If the price rises, some people will forego it.
- Lesson: *Price elasticity is higher for luxuries than for necessities.*

### EXAMPLE 3:

#### Gasoline in the Short Run vs. Gasoline in the Long Run

- The price of gasoline rises 20%. Does  $Q^d$  drop more in the short run or the long run? Why?
  - There's not much people can do in the short run, other than ride the bus or carpool.
  - In the long run, people can buy smaller cars or live closer to where they work.
- Lesson: *Price elasticity is higher in the long run than the short run.*

## The Determinants of Price Elasticity: A Summary

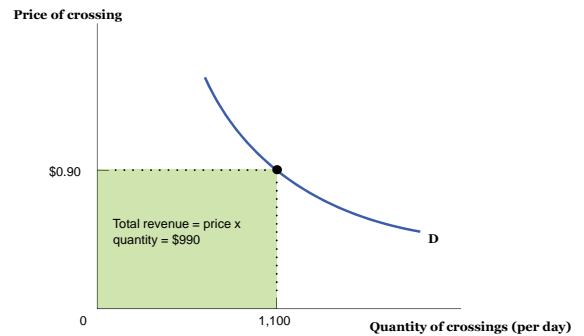
The price elasticity of demand depends on:

- the extent to which close substitutes are available
- whether the good is a necessity or a luxury
- how broadly or narrowly the good is defined
- the time horizon—elasticity is higher in the long run than the short run

Why does it matter whether demand is unit-elastic, inelastic, or elastic?

- Because this classification predicts how changes in the price of a good will affect the *total revenue* earned by producers from the sale of that good.
- The total revenue is defined as the total value of sales of a good or service, i.e.
- Total Revenue = Price × Quantity Sold

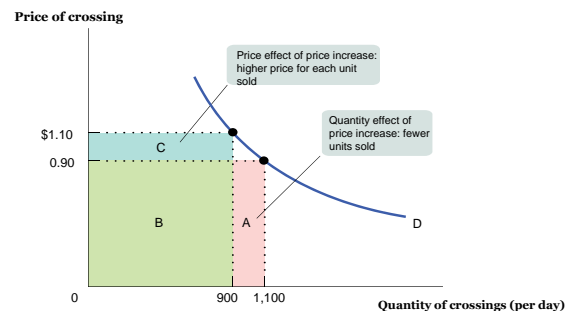
## Total Revenue by Area



## Elasticity and Total Revenue

- When a seller raises the price of a good, there are two countervailing effects in action (except in the rare case of a good with perfectly elastic or perfectly inelastic demand):
  - *A price effect:* After a price increase, each unit sold sells at a higher price, which tends to raise revenue.
  - *A quantity effect:* After a price increase, fewer units are sold, which tends to lower revenue.

## Effect of a Price Increase on Total Revenue



## Price Elasticity and Total Revenue

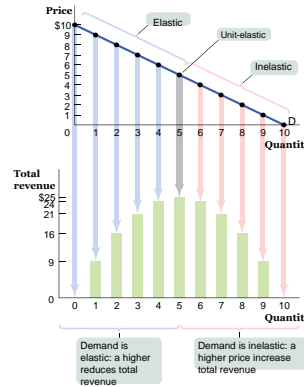
- Continuing our scenario, if you raise your price from \$200 to \$250, would your revenue rise or fall?  
Revenue =  $P \times Q$
- A price increase has two effects on revenue:
  - Higher  $P$  means more revenue on each unit you sell.
  - But you sell fewer units (lower  $Q$ ), due to law of demand.
- Which of these two effects is bigger?  
It depends on the price elasticity of demand.

- If demand for a good is *elastic* (the price elasticity of demand is greater than 1), an increase in price reduces total revenue. In this case, the quantity effect is stronger than the price effect.
- If demand for a good is *inelastic* (the price elasticity of demand is less than 1), a higher price increases total revenue. In this case, the price effect is stronger than the quantity effect.
- If demand for a good is *unit-elastic* (the price elasticity of demand is 1), an increase in price does not change total revenue. In this case, the sales effect and the price effect exactly offset each other.

## Price Elasticity of Demand and Total Revenue

|   | Price of crossing<br>= \$0.90 | Price of crossing<br>= \$1.10 |
|---|-------------------------------|-------------------------------|
| <b>Unit-elastic demand</b> (price elasticity of demand = 1) |                               |                               |
| Quantity demanded   | 1,100                         | 900                           |
| Total revenue   | \$990                         | \$990                         |
| <b>Inelastic demand</b> (price elasticity of demand = 0.5)  |                               |                               |
| Quantity demanded   | 1,050                         | 950                           |
| Total revenue   | \$945                         | \$1,045                       |
| <b>Elastic demand</b> (price elasticity of demand = 2)      |                               |                               |
| Quantity demanded   | 1,200                         | 800                           |
| Total revenue   | \$1,080                       | \$880                         |

## Demand Schedule and Total Revenue

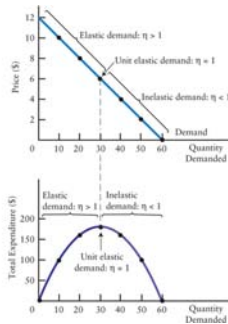


| Price | Quantity demanded | Total Revenue |
|-------|-------------------|---------------|
| \$0   | 10                | \$0           |
| 1     | 9                 | 9             |
| 2     | 8                 | 16            |
| 3     | 7                 | 21            |
| 4     | 6                 | 24            |
| 5     | 5                 | 25            |
| 6     | 4                 | 24            |
| 7     | 3                 | 21            |
| 8     | 2                 | 16            |
| 9     | 1                 | 9             |
| 10    | 0                 | 0             |

The price elasticity of demand changes along the demand curve

## Total Expenditure and Quantity Demanded

| Price (\$) | Quantity Demanded | Expenditure (\$) |
|------------|-------------------|------------------|
| 12         | 0                 | 0                |
| 10         | 10                | 100              |
| 8          | 20                | 160              |
| 6          | 30                | 180              |
| 4          | 40                | 160              |
| 2          | 50                | 100              |
| 0          | 60                | 0                |



## Price Elasticity and Total Revenue

$$\text{Price elasticity of demand} = \frac{\text{Percentage change in } Q}{\text{Percentage change in } P}$$

$$\text{Revenue} = P \times Q$$

- If demand is elastic, then price elasticity of demand > 1  
% change in Q > % change in P
- The fall in revenue from lower Q is greater than the increase in revenue from higher P, so revenue falls.

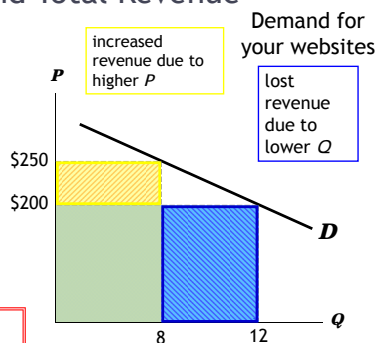
## Price Elasticity and Total Revenue

Elastic demand (elasticity = 1.8)

If  $P = \$200$ ,  $Q = 12$  and revenue = \$2400.

If  $P = \$250$ ,  $Q = 8$  and revenue = \$2000.

When  $D$  is elastic, a price increase causes revenue to fall.



## Price Elasticity and Total Revenue

$$\text{Price elasticity of demand} = \frac{\text{Percentage change in } Q}{\text{Percentage change in } P}$$

$$\text{Revenue} = P \times Q$$

- If demand is inelastic, then price elasticity of demand < 1  
% change in Q < % change in P
- The fall in revenue from lower Q is smaller than the increase in revenue from higher P, so revenue rises.
- In our example, suppose that Q only falls to 10 (instead of 8) when you raise your price to \$250.

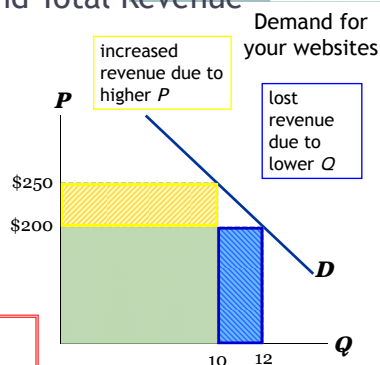
## Price Elasticity and Total Revenue

Now, demand is inelastic:  
elasticity = 0.82

If  $P = \$200$ ,  
 $Q = 12$  and revenue  
= \$2400.

If  $P = \$250$ ,  
 $Q = 10$  and  
revenue = \$2500.

When  $D$  is inelastic,  
a price increase  
causes revenue to rise.



Demand for  
your websites

## What Factors Determine the Price Elasticity of Demand?

- Whether Close Substitutes Are Available
- Whether the Good Is a Necessity or a Luxury
- Share of Income spent on the Good
- Time

## APPLICATION: Does Drug Interdiction Increase or Decrease Drug-Related Crime?

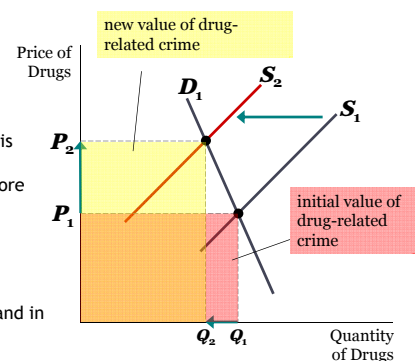
- One side effect of illegal drug use is crime: Users often turn to crime to finance their habit.
- We examine two policies designed to reduce illegal drug use and see what effects they have on drug-related crime.
- For simplicity, we assume the total dollar value of drug-related crime equals total expenditure on drugs.
- Demand for illegal drugs is inelastic, due to addiction issues.

## Policy 1: Interdiction

Interdiction reduces  
the supply of drugs.

Since demand for drugs is  
inelastic,  
 $P$  rises proportionally more  
than  $Q$  falls.

Result: an increase in  
total spending on drugs, and in  
drug-related crime

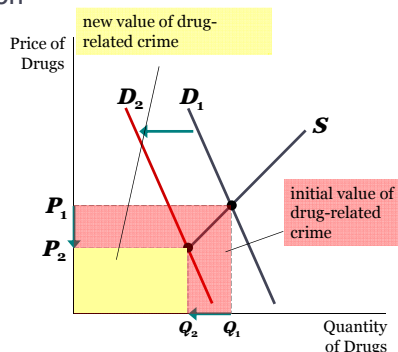


## Policy 2: Education

Education reduces  
the demand for  
drugs.

$P$  and  $Q$  fall.

Result:  
A decrease in total  
spending on drugs, and  
in drug-related crime.



## Other Demand Elasticities: Cross-Price Elasticity

- The cross-price elasticity of demand between two goods measures the effect of the change in one good's price on the quantity demanded of the other good. It is equal to the percent change in the quantity demanded of one good divided by the percent change in the other good's price.

The Cross-Price Elasticity of Demand Between Goods A and B:

$$= \frac{\% \text{ change in quantity of A demanded}}{\% \text{ change in price of B}}$$

$$\eta_{XY} = \frac{\text{percentage change in quantity demanded of good X}}{\text{percentage change in price of good Y}}$$

If  $\eta_{XY} > 0$ , then X and Y are substitutes.

If  $\eta_{XY} < 0$ , then X and Y are complements.

## Cross-Price Elasticity

- Goods are substitutes when the *cross-price elasticity of demand* is positive.
- Goods are complements when the cross-price elasticity of demand is negative.

- For substitutes, cross-price elasticity  $> 0$  (e.g., an increase in price of beef causes an increase in demand for chicken)
- For complements, cross-price elasticity  $< 0$  (e.g., an increase in price of computers causes decrease in demand for software)

## The Income Elasticity of Demand

is the percent change in the quantity of a good demanded when a consumer's income changes divided by the percent change in the consumer's income.

$$\text{Income elasticity of demand} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in income}}$$

## Income Elasticity of Demand

$$\eta_Y = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}}$$

If  $\eta_Y > 0$ , the good is said to be normal.

If  $\eta_Y < 0$ , the good is said to be inferior.

## Normal Goods and Inferior Goods

- When the income elasticity of demand is positive, the good is a *normal good* - that is, the quantity demanded at any given price increases as income increases.
- When the income elasticity of demand is negative, the good is an *inferior good* - that is, the quantity demanded at any given price decreases as income increases.

## Measuring the Price Elasticity of Supply

is a measure of the responsiveness of the quantity of a good supplied to the price of that good. It is the ratio of the percent change in the quantity supplied to the percent change in the price as we move along the supply curve.

$$\text{Price elasticity of supply} = \frac{\% \text{ change in quantity supplied}}{\% \text{ change in price}}$$

## Price Elasticity of Supply

Price elasticity of supply measures the responsiveness of the quantity supplied to a change in the product's own price.

It is denoted by  $\eta_s$  and is defined as:

$$\eta_s = \frac{\text{percentage change in quantity supplied}}{\text{percentage change in price}}$$

$$\eta_s = \frac{\Delta Q^S / \bar{Q}^S}{\Delta p / \bar{p}}$$

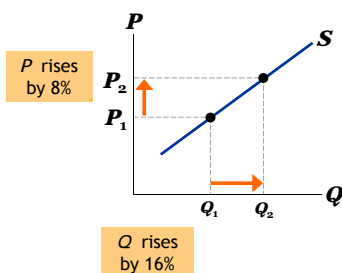
## Price Elasticity of Supply

$$\text{Price elasticity of supply} = \frac{\text{Percentage change in } Q^S}{\text{Percentage change in } P}$$

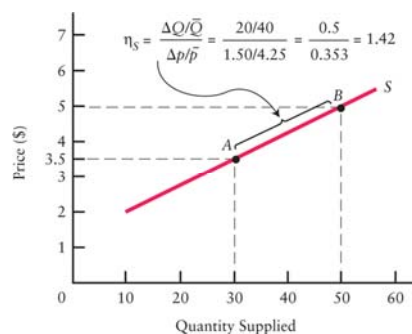
**Example:**

Price elasticity of supply equals

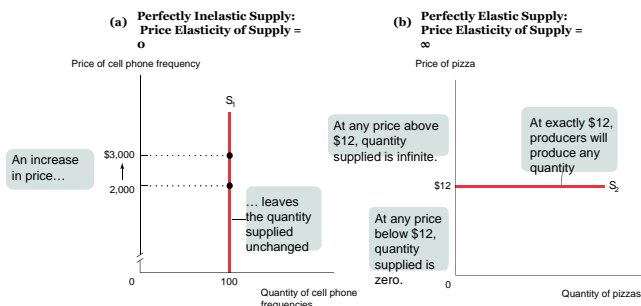
$$\frac{16\%}{8\%} = 2.0$$



## Computing Price Elasticity of Supply



## Two Extreme Cases of Price Elasticity of Supply



## Two Extreme Cases of Price Elasticity of Supply

- There is perfectly inelastic supply when the price elasticity of supply is zero, so that changes in the price of the good have no effect on the quantity supplied. A perfectly inelastic supply curve is a vertical line.

- There is perfectly elastic supply when even a tiny increase or reduction in the price will lead to very large changes in the quantity supplied, so that the price elasticity of supply is infinite. A perfectly elastic supply curve is a horizontal line.

## What Factors Determine the Price Elasticity of Supply?

- **The Availability of Inputs:** The price elasticity of supply tends to be large when inputs are readily available and can be shifted into and out of production at a relatively low cost. It tends to be small when inputs are difficult to obtain.
- **Time:** The price elasticity of supply tends to grow larger as producers have more time to respond to a price change. This means that the long-run price elasticity of supply is often higher than the short-run elasticity.

## The Variety of Supply Curves

- The slope of the supply curve is closely related to price elasticity of supply.
- Rule of thumb:  
The flatter the curve, the bigger the elasticity.  
The steeper the curve, the smaller the elasticity.

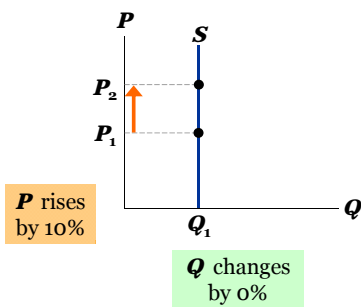
### “Perfectly inelastic” (one extreme)

$$\text{Price elasticity of supply} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{0\%}{10\%} = 0$$

S curve:  
vertical

Sellers' price sensitivity:  
none

Elasticity:  
0



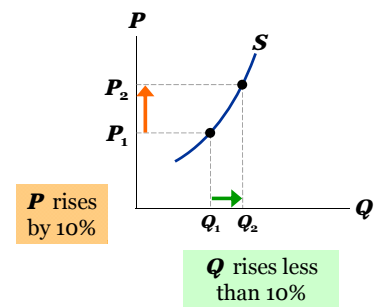
### “Inelastic”

$$\text{Price elasticity of supply} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{< 10\%}{10\%} < 1$$

S curve:  
relatively steep

Sellers' price sensitivity:  
relatively low

Elasticity:  
< 1



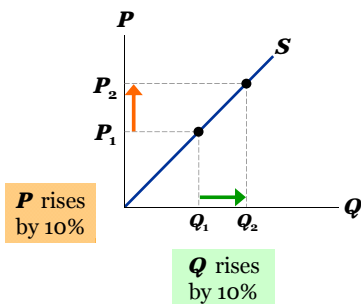
### “Unit elastic”

$$\text{Price elasticity of supply} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{10\%}{10\%} = 1$$

S curve:  
intermediate slope

Sellers' price sensitivity:  
intermediate

Elasticity:  
= 1



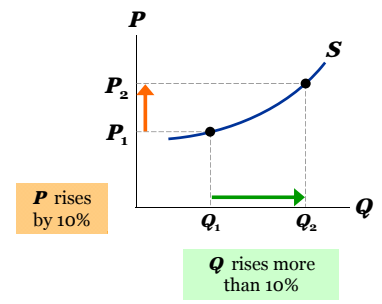
### “Elastic”

$$\text{Price elasticity of supply} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{> 10\%}{10\%} > 1$$

S curve:  
relatively flat

Sellers' price sensitivity:  
relatively high

Elasticity:  
> 1



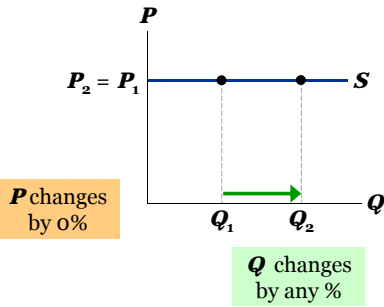
## “Perfectly elastic” (the other extreme)

$$\text{Price elasticity of supply} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{\text{any } \%}{0\%} = \text{infinity}$$

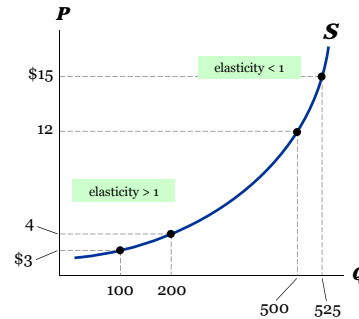
S curve:  
horizontal

Sellers' price sensitivity:  
extreme

Elasticity:  
infinity



## How the Price Elasticity of Supply Can Vary



Supply often becomes less elastic as  $Q$  rises, due to capacity limits.

| Name  | Possible values                    | Significance   |
|---|------------------------------------|--|
| <b>Price elasticity of demand</b> = $\frac{\% \text{ change in quantity demanded}}{\% \text{ change in price}}$ (dropping the minus sign) |                                    |  |
| Perfectly inelastic demand  | 0                                  | Price has no effect on quantity demanded (vertical demand curve).  |
| Inelastic demand  | Between 0 and 1                    | A rise in price increases total revenue.   |
| Unit-elastic demand   | Exactly 1                          | Changes in price have no effect on total revenue.  |
| Elastic demand  | Greater than 1, less than $\infty$ | A rise in price reduces total revenue.   |
| Perfectly elastic demand  | $\infty$                           | A rise in price causes quantity demanded to fall to 0. A fall in price leads to an infinite quantity demanded (horizontal demand curve). |

$$\text{Cross-price elasticity of demand} = \frac{\% \text{ change in quantity of one good demanded}}{\% \text{ change in price of another good}}$$

Complements Negative Quantity demanded of one good falls when the price of another rises.

Substitutes Positive Quantity demanded of one good rises when the price of another rises.

$$\text{Income elasticity of demand} = \frac{\% \text{ change in quantity demanded}}{\% \text{ change in income}}$$

Inferior good Negative Quantity demanded falls when income rises.

Normal good, income-inelastic Positive, less than 1 Quantity demanded rises when income rises, but not as rapidly as income.

Normal good, income-elastic Greater than 1 Quantity demanded rises when income rises, and more rapidly than income.

$$\text{Price elasticity of supply} = \frac{\% \text{ change in quantity supplied}}{\% \text{ change in price}}$$

Perfectly inelastic supply 0 Price has no effect on quantity supplied (vertical supply curve).

Greater than 0, less than  $\infty$  Ordinary upward-sloping supply curve.

Perfectly elastic supply  $\infty$  Any fall in price causes quantity supplied to fall to 0. Any rise in price elicits an infinite quantity supplied (horizontal supply curve).

## Sources:

- Krugman, P. and Robin Wells (2008)
- Mankiw, N.G. (2012)
- Lipsey, Ragan, and Storer (2008)