Principles of Economics

Elasticity

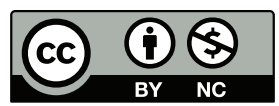
Jiaming Mao

Xiamen University

This version: Fall 2018

Contact: jmao@xmu.edu.cn

Course homepage: jiamingmao.github.io/principles-of-economics



Elasticity

- Until now,we've been talking about the direction in which quantities change.
  - A downward-sloping demand: price $\uparrow \rightarrow$ quantity demanded $\downarrow$
- In real life it is quite important to know the **intensity** of the change.
  - By how much will the demand for my product decrease if I increase the price by 10%?

Elasticity

- **Elasticity:** a measure of the responsiveness of quantity demanded or quantity supplied to a change in one of their determinants
- **Price elasticity of demand** measure show much quantity demanded changes in response to a change in price.

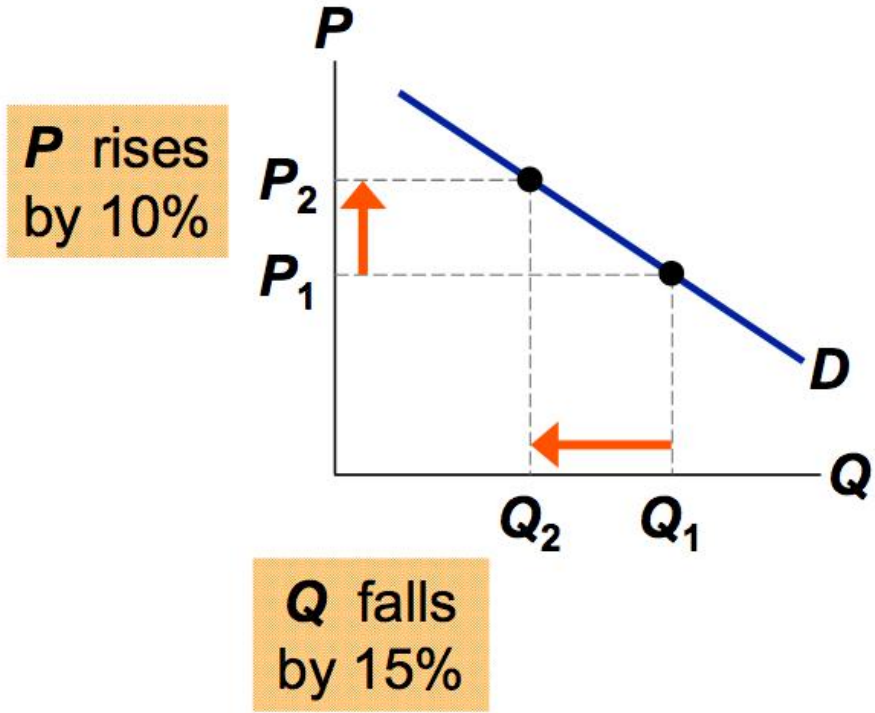
Price Elasticity of Demand

- Price elasticity of demand $\epsilon_{d,p} = \left| \frac{\%\Delta Q^d}{\%\Delta P} \right|$

Example:

Price elasticity of demand equals

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



Price Elasticity of Demand

- Elasticity gives a convenient measure of responsiveness to price.
  - Instead of saying: "a $1,000 change in the price of new Fords leads to 30,000 more cars being sold," it's more meaningful to say: "a 5% change in the price of a Ford leads to a 20% increase in the Ford's sales".
- Elasticity is *unit free*: allows comparison of price sensitivity across markets.
  - Car market and shoe market
  - HK market and China market

Price Elasticity of Demand

- Point elasticity:

$$\begin{aligned} \epsilon_{d,p} &= -\frac{dQ/Q}{dP/P} = \left|\frac{dQ/Q}{dP/P}\right| = \left|\frac{d\ln Q}{d\ln P}\right| \\ &= \frac{1}{|\text{slope}|} \times \frac{P}{Q} \end{aligned}$$

  , where slope is the slope of the demand curve[1].

- Arc elasticity[2]:

$$\epsilon_{d,p} = \left|\frac{(Q_2 - Q_1) \Big/ \frac{Q_1+Q_2}{2}}{(P_2 - P_1) \Big/ \frac{P_1+P_2}{2}}\right|$$

[1] drawn with P on the vertical axis and Q on the horizontal axis.

[2] The **arc percent change** between two points, x and y, is defined as $(x-y) \Big/ \frac{x+y}{2}$. This is also called the **mid-point method** for calculating percentage changes. It has the virtue of being *symmetric*.

"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:

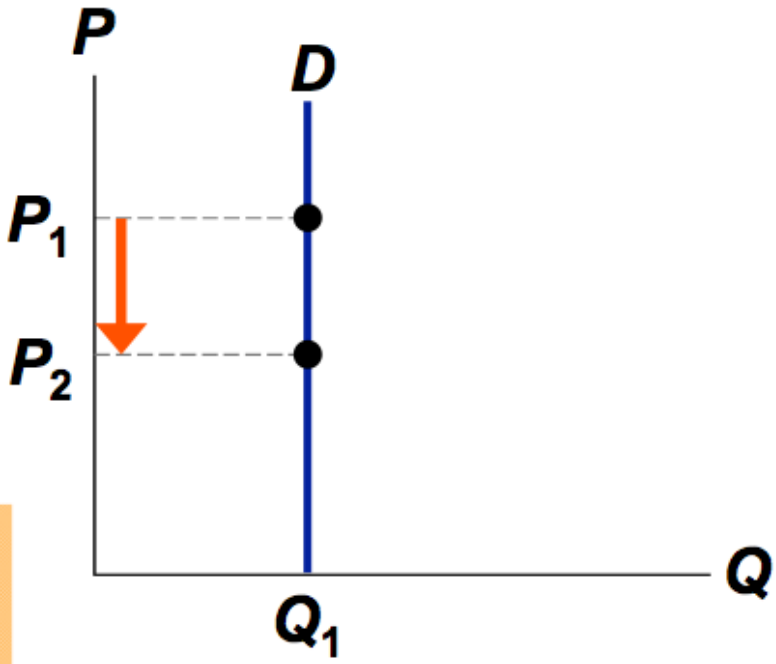
vertical

Consumers' price sensitivity:

none

Elasticity:

0



P falls by 10%

Q changes by 0%

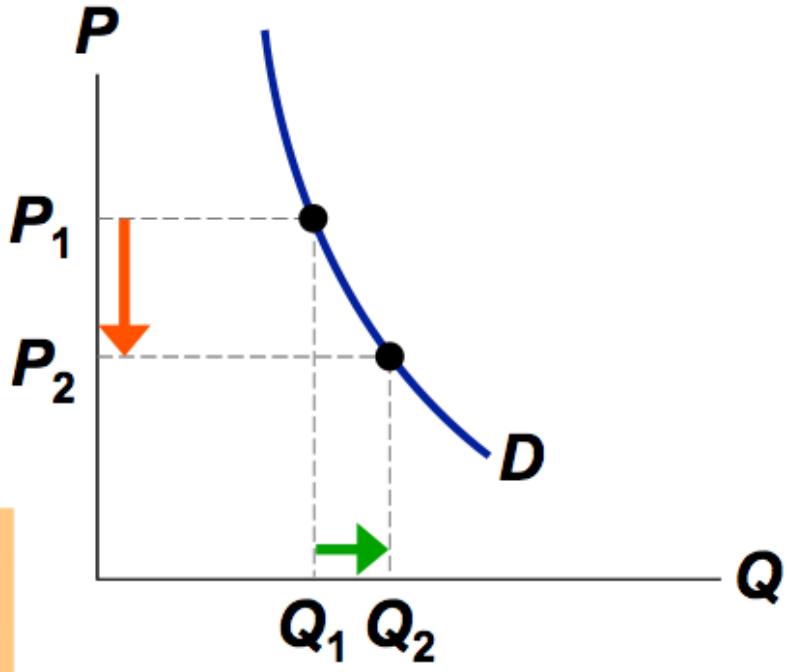
"Inelastic demand"

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

D curve:
relatively steep

Consumers' price sensitivity:
relatively low

Elasticity:
< 1



P falls by 10%

Q rises less than 10%

"Unit elastic demand"

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

D curve:

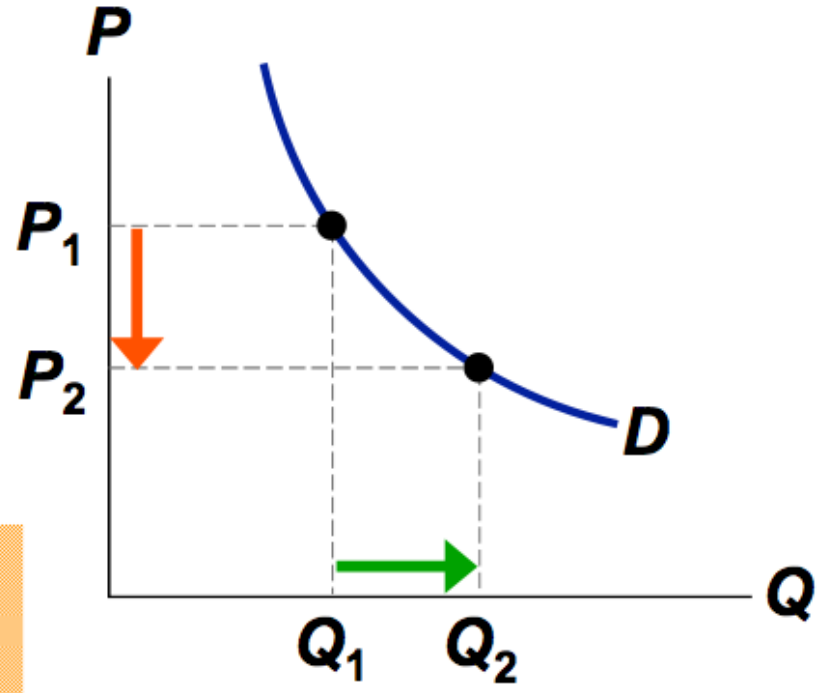
intermediate slope

Consumers' price sensitivity:

intermediate

Elasticity:

1



P falls by 10%

Q rises by 10%

"Elastic demand"

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

D curve:

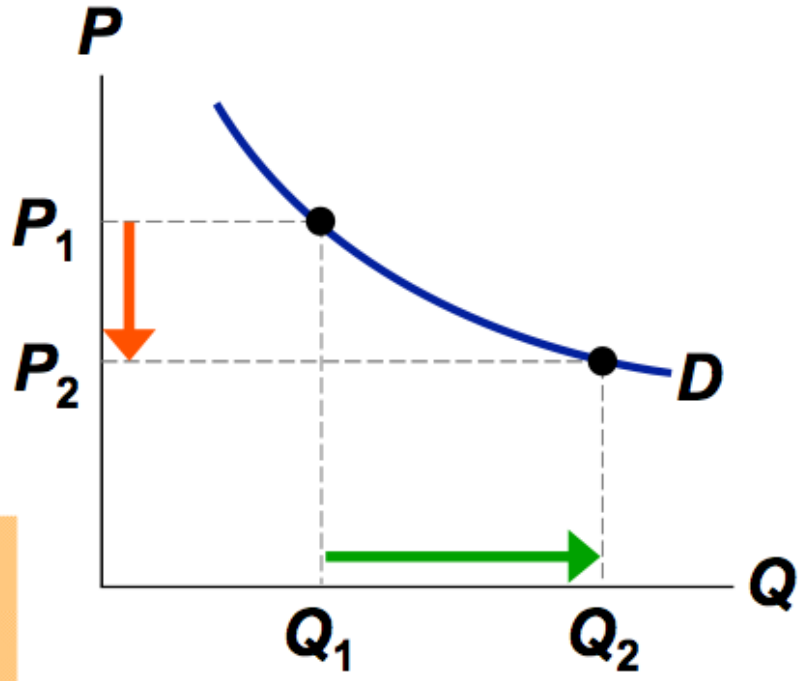
relatively flat

Consumers' price sensitivity:

relatively high

Elasticity:

> 1



P falls by 10%

Q rises more than 10%

"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:

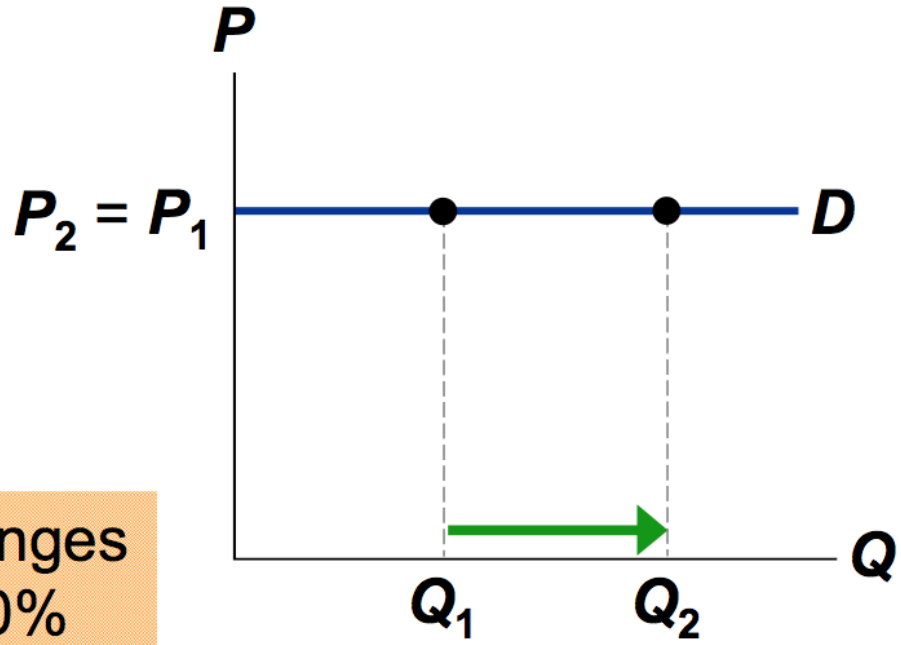
horizontal

Consumers' price sensitivity:

extreme

Elasticity:

infinity



P changes by 0%

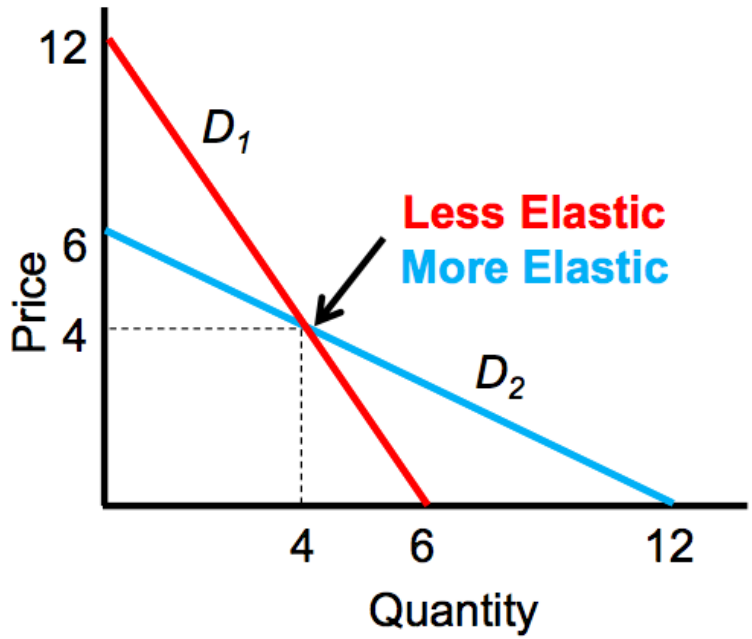
Q changes by any %

Price Elasticity of Demand

$\epsilon > 1$	Elastic
$\epsilon < 1$	Inelastic
$\epsilon = 1$	Unit elastic
$\epsilon = 0$	Perfectly inelastic
$\epsilon \to \infty$	Perfectly elastic

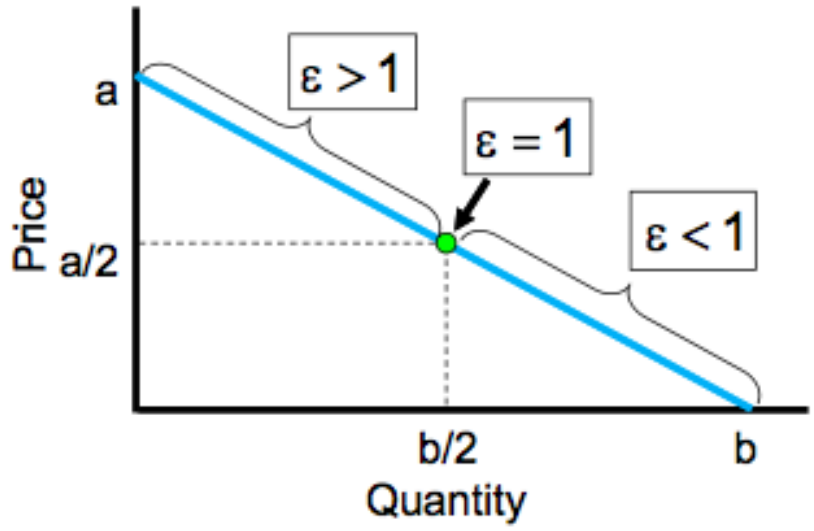
Price Elasticity of Demand

- When two demand curves cross:
  - P/Q is the same for both curves
  - (1/slope) is smaller for the steeper curve
- At the common point, demand is less elastic for the steeper curve.



Price Elasticity along a Linear Demand Curve

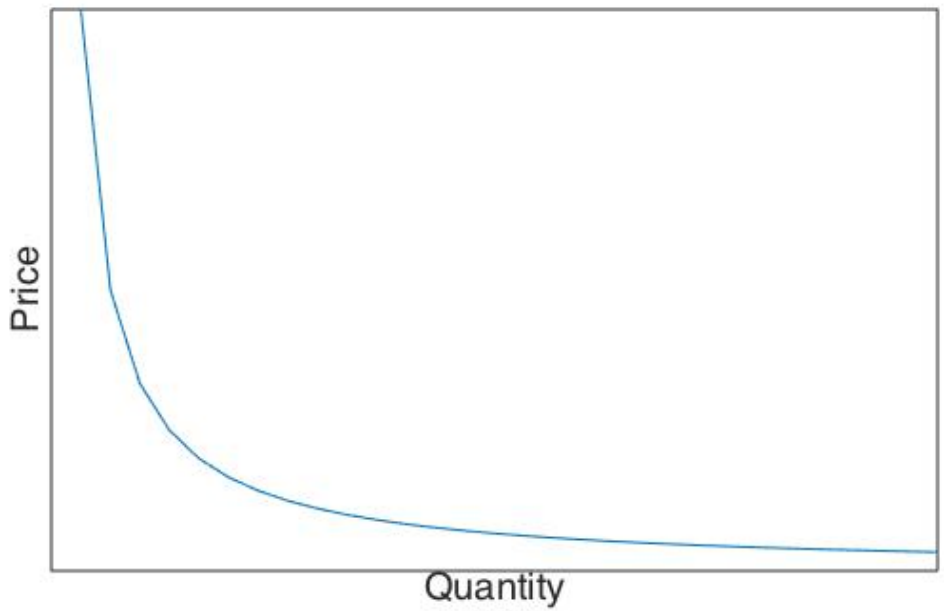
- At the midpoint, demand is *unit elastic*
- At high P and low Q, demand is *elastic*
- At low P and high Q, demand is *inelastic*



Unit Elastic Demand Curve

A demand curve that is unit elastic everywhere:

$$Q^d = P^{-1}$$



Determinants of Price Elasticity of Demand

- Availability of close substitutes
  - "McDonalds cheeseburgers" vs. "Hubble telescopes"
  - Price elasticity is higher when there exist close substitutes.

Determinants of Price Elasticity of Demand

- Availability of close substitutes
- Necessities vs. luxuries
  - "Insulin" vs. "Caribbean cruise"
  - Necessities are more price inelastic. Luxuries are more price elastic.

Determinants of Price Elasticity of Demand

- Availability of close substitutes
- Necessities vs. luxuries
- Definition of the market
  - "Macbook Air" vs. "Laptop computers"
  - Price elasticity is higher for narrowly defined goods than more broadly defined ones.

Determinants of Price Elasticity of Demand

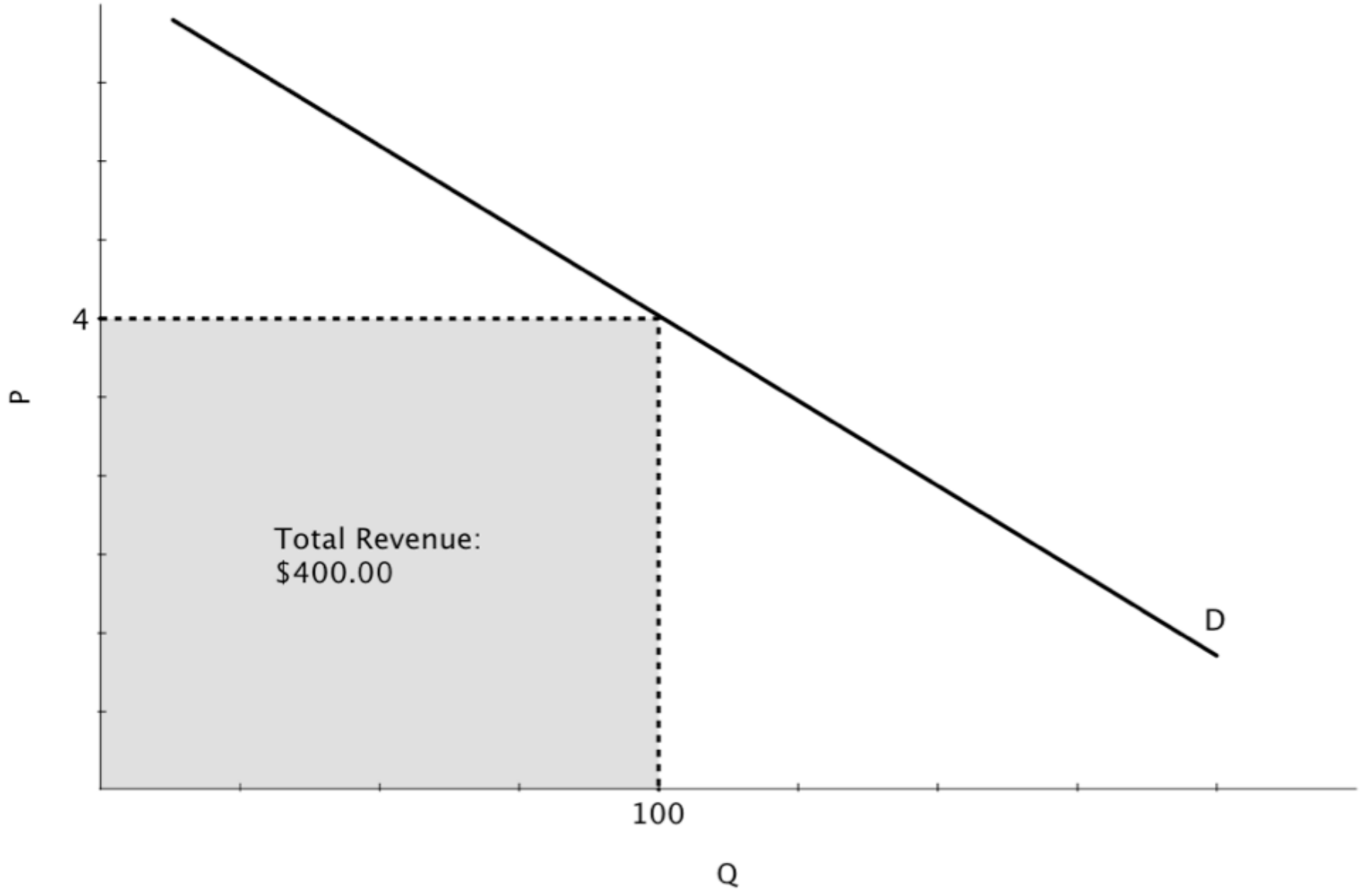
- Availability of close substitutes
- Necessities vs. luxuries
- Definition of the market
- Time horizon
  - “Gasoline in the short run" vs. “Gasoline in the long run"
  - Price elasticity is higher in the long run than in the short run.

Price Elasticity and Total Revenue

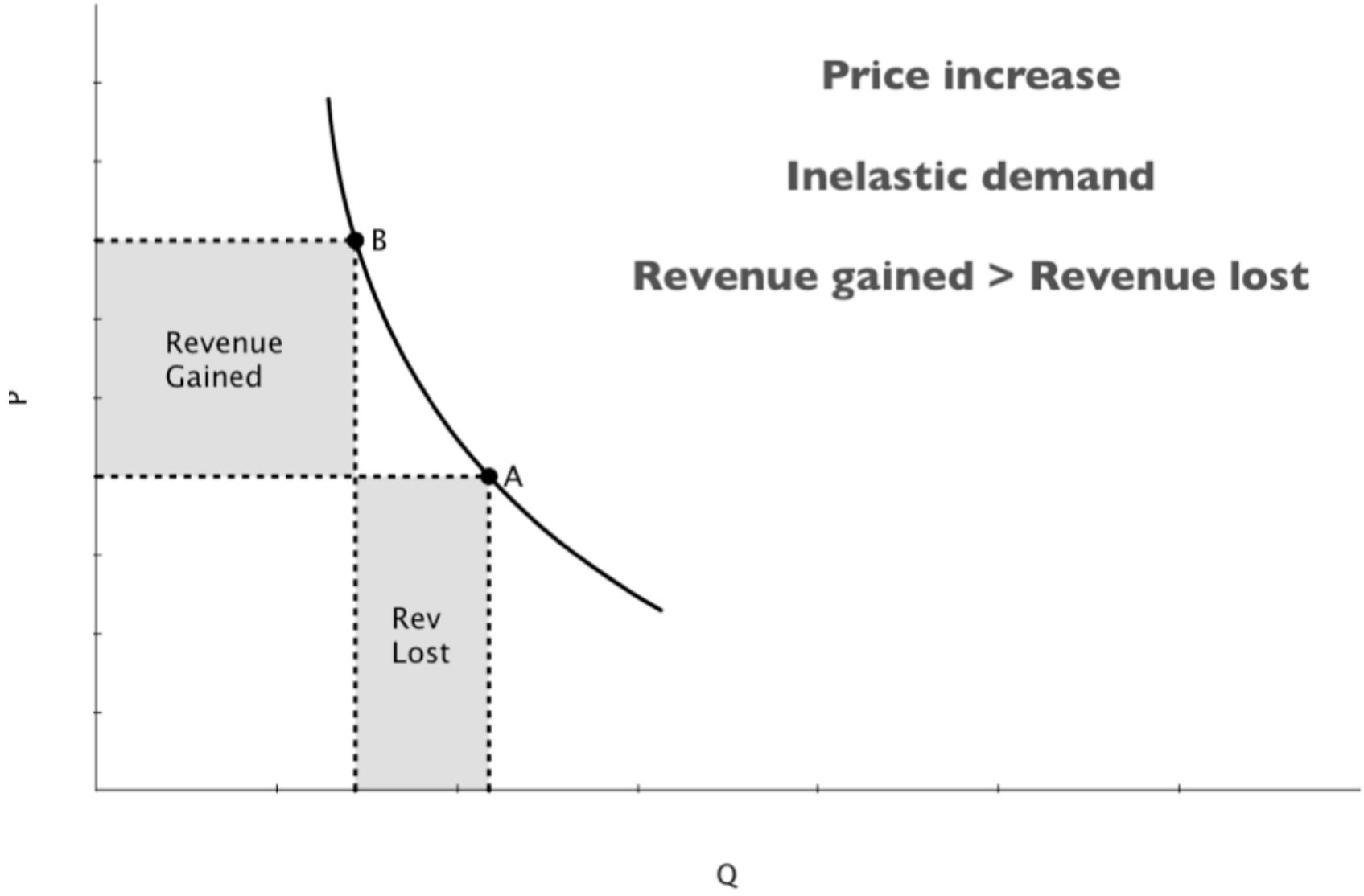
Question

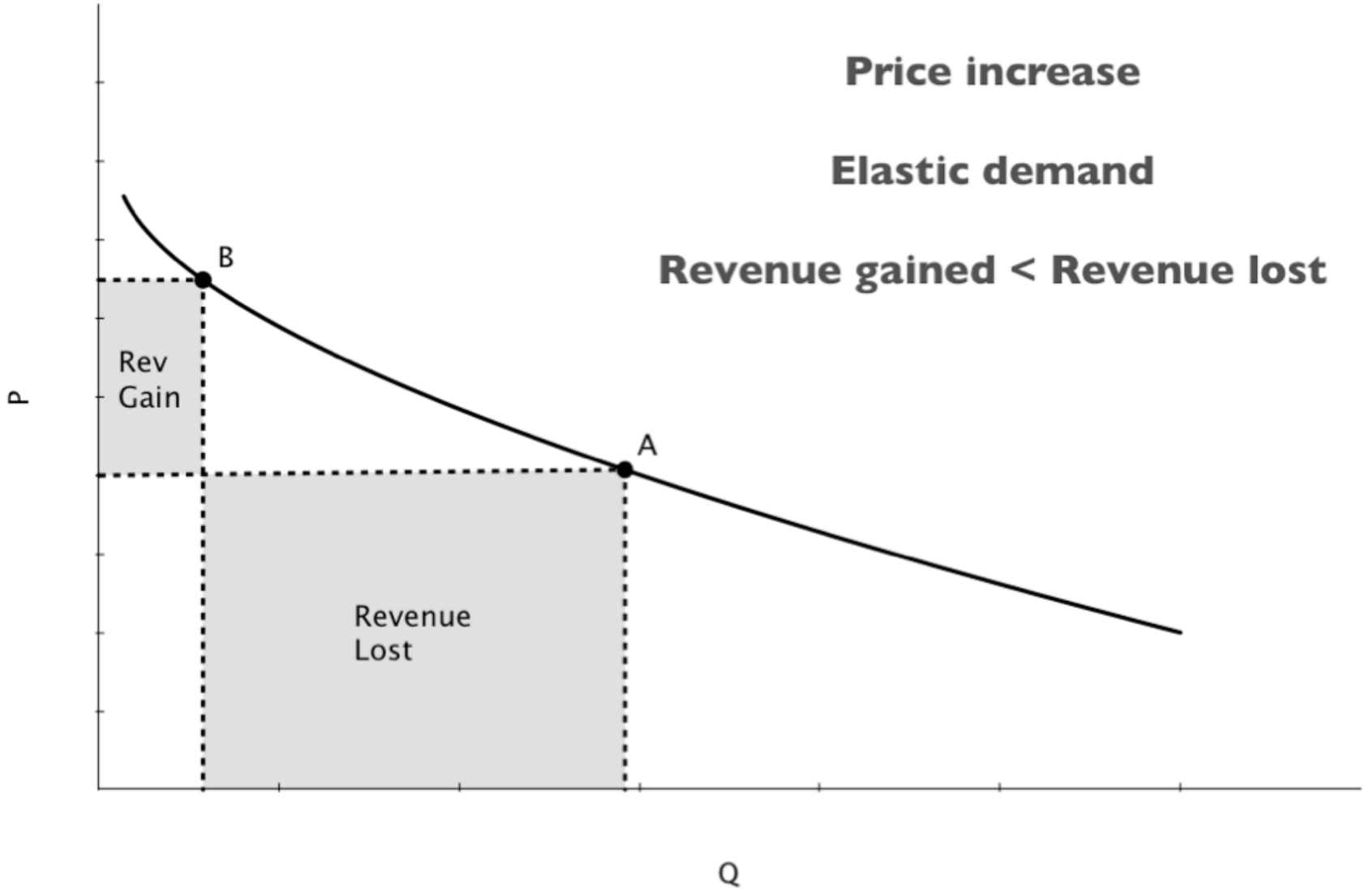
If price goes up, would total revenue rise or fall?

- P $\times$ Q = sellers' total revenue or buyers' total expenditure.
- A price increase has two effects on revenue:
  - Higher P means more revenue on each unit
  - But you sell fewer units (lower Q), due to the law of demand
- Which of these two effects is bigger depends on the price elasticity of demand.



j. mao


Price increase
Inelastic demand
Revenue gained > Revenue lost
B
A
Revenue
Gained
Rev
Lost
P
Q


Price increase
Elastic demand
Revenue gained < Revenue lost
B
A
Rev
Gain
Revenue
Lost
P
Q

How total Revenue is affected by a change in price

$$\frac{d(\text{Total Revenue})}{dP} = \frac{d(Q \times P)}{dP} = \frac{dQ}{dP}P + Q$$

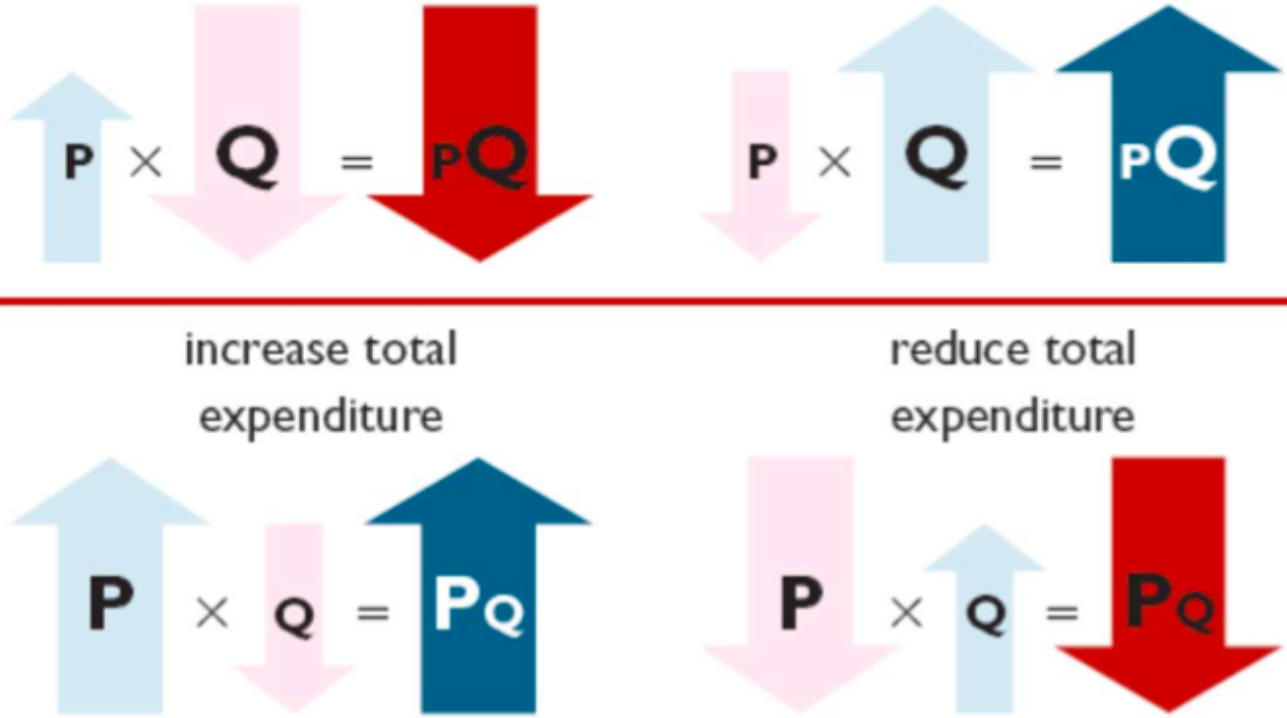
Therefore,

$$\frac{d(\text{Total Revenue})}{dP} > 0 \Leftrightarrow \frac{dQ}{dP}\frac{P}{Q} > -1 \Leftrightarrow \epsilon_{d,p} < 1$$

$$\frac{d(\text{Total Revenue})}{dP} < 0 \Leftrightarrow \frac{dQ}{dP}\frac{P}{Q} < -1 \Leftrightarrow \epsilon_{d,p} > 1$$

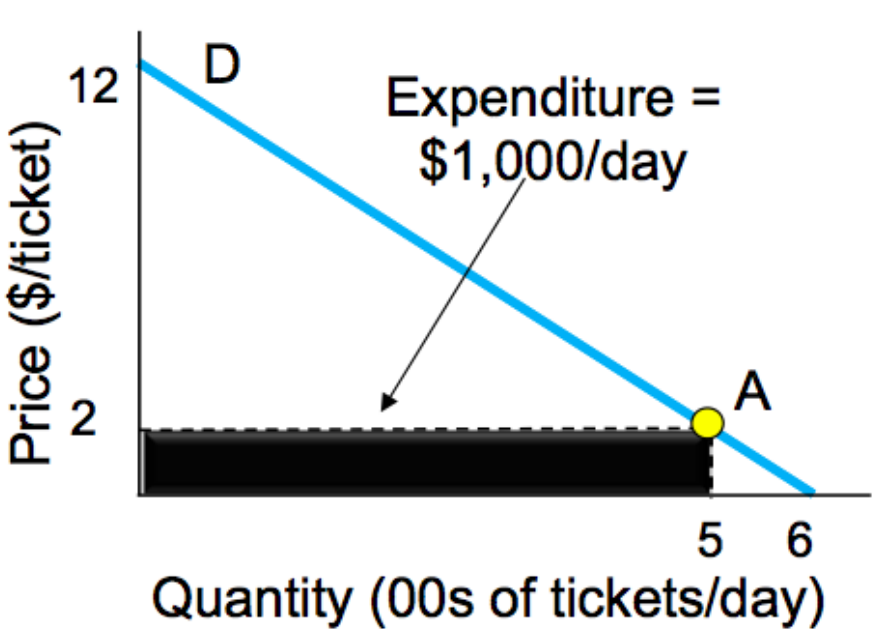
How Total Revenue is affected by a change in price

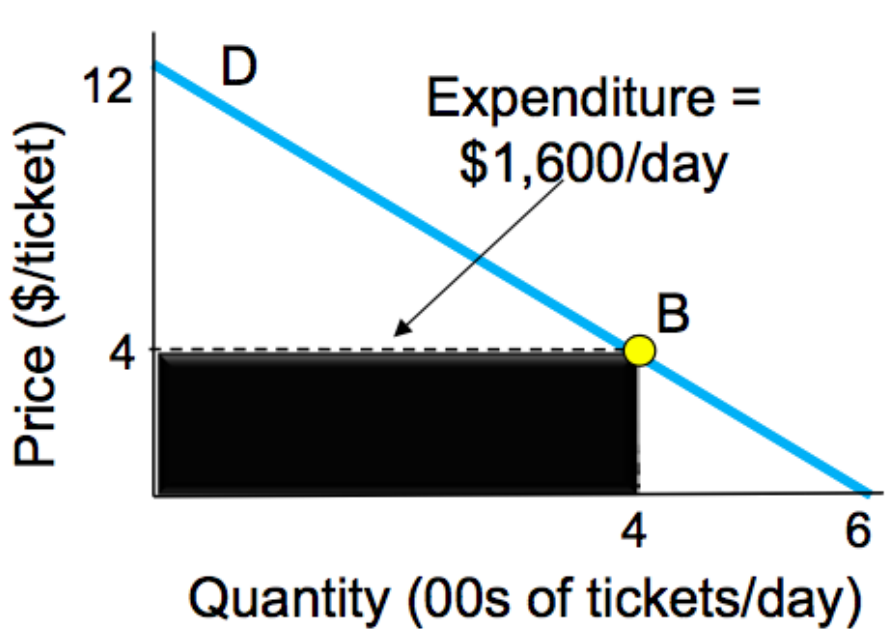
If demands is...	A price increase will...	A price reduction will...
elastic ($\epsilon > 1$)	reduce total expenditure	increase total expenditure
inelastic ($\epsilon < 1$)	increase total expenditure	reduce total expenditure



Price Elasticity and Total Revenue

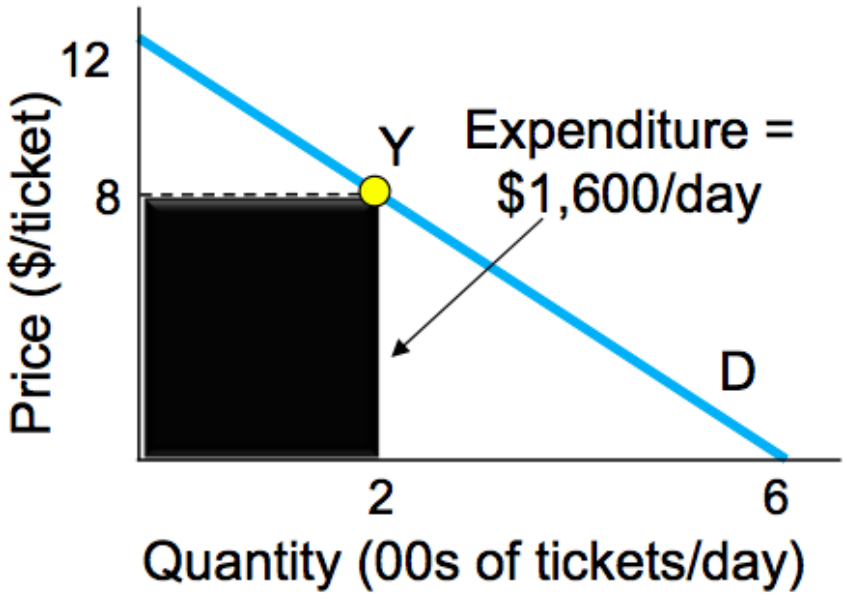
- Movie ticket price increases from \$2 to \$4
  - A and B are both below the midpoint of the curve
  - Inelastic portion of the demand curve
- Total revenue increases when price increases

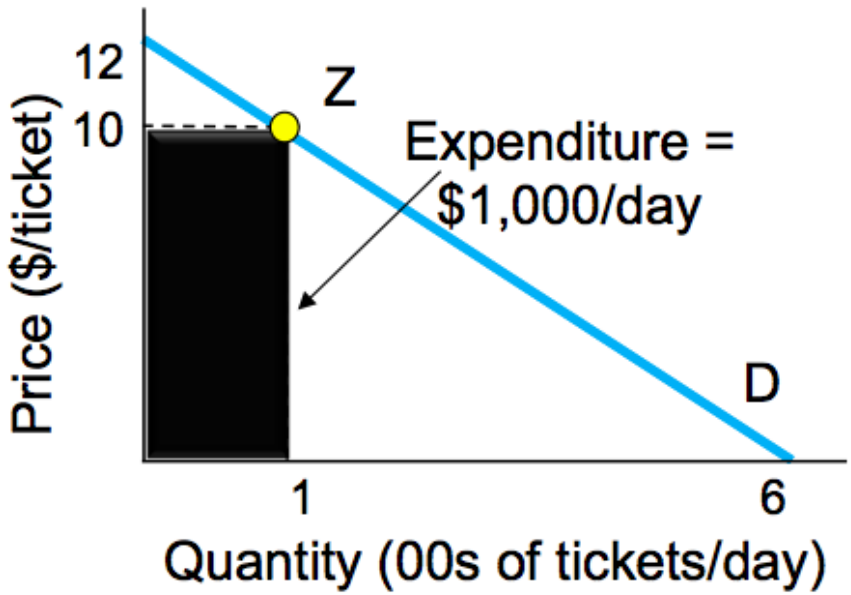




Price Elasticity and Total Revenue

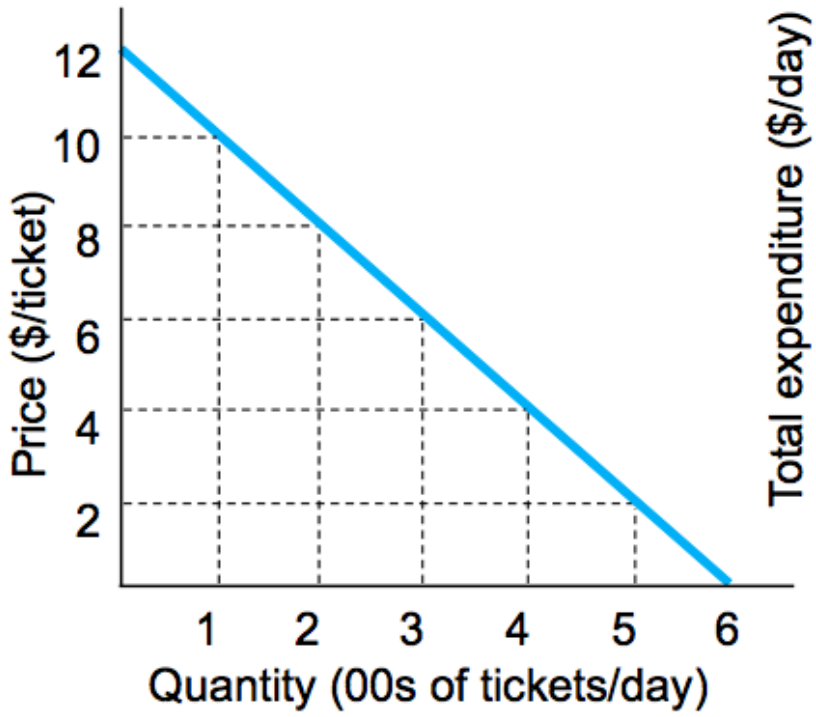
- Movie ticket price increases from \$8 to \$10
  - Prices are both above the midpoint of the curve
  - Elastic portion of the demand curve
- Total revenue decreases when price increases

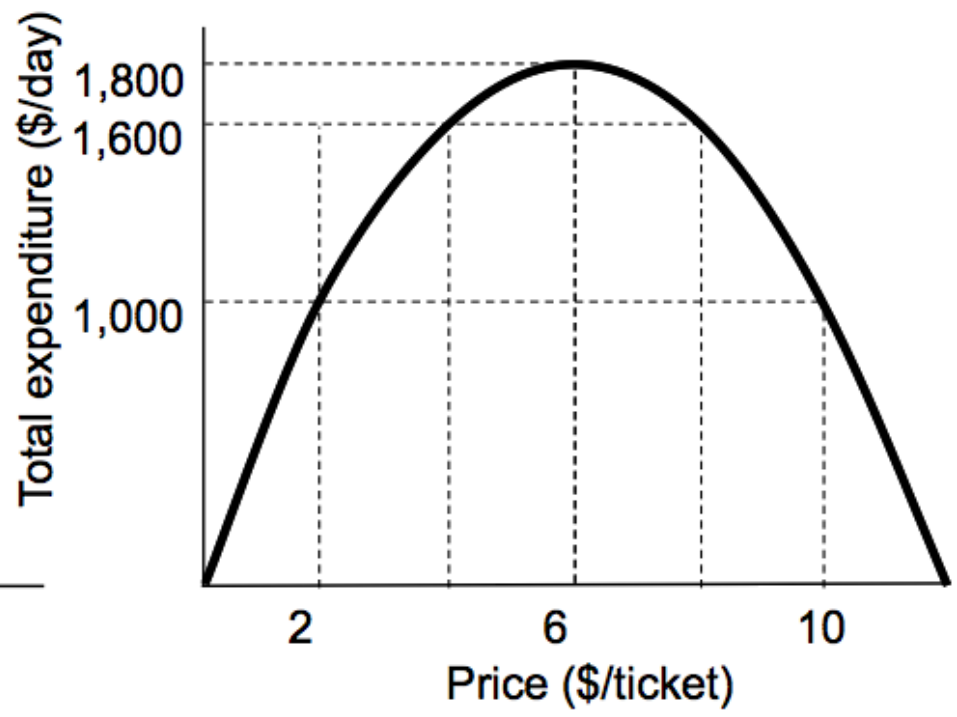




Total Revenue along a Linear Demand Curve

Price	$12	$10	$8	$6	$4	$2	$0
Quantity	0	1,000	2,000	3,000	4,000	5,000	6,000
Expenditure	$0	$1,000	$1,600	$1,800	$1,600	$1,000	$0





Estimating Elasticities

- As in estimating the shape of the demand curve, when estimating the price elasticity of demand, we need to hold fixed other determinants of demand in order to isolate the impact of price change on quantity demanded.
  - In other words, we want to estimate the percent change in quantity demanded in response to a percent change in price, when the price change is caused by supply shift rather than demand shift.

Gasoline Market in the US
June 2007 and June 2008

Time Period	Per Capita Daily Consumption of Motor Gasoline	Average Price Per Gallon in Dollars
June 2007	1.32	3.05
June 2008	1.26	4.07
Δ	–.06	1.02
Average of Both Years	1.29	3.56
%Δ	–.05	.28

Estimating Elasticities

- $\epsilon_{d,p}$ of gas demand?
- Elastic or inelastic?
- As prices go up, should total spending increase or decrease? r
- Is this short-run elasticity or long-run elasticity?

Estimating Elasticities

- Is the price change due to supply shift or demand shift or both?
  - Consumer tastes
    - ★ Tastes for driving higher in summer than winter.
    - ★ So comparing June to June
  - Number of buyers
    - ★ Population grows about 1% a year
    - ★ Not significant. Also comparing per capita
  - Income
    - ★ Income in June 2007 and June 2008 about the same (financial crisis led to income decrease after summer 2008)
  - Prices of substitutes and complements
    - ★ Didn't change much over the one year period
  - Expectations?

Estimating Long-run Elasticities

- One way to estimate long-run elasticity is to compare cases where prices have been different a long time.
- "Fuel Consumption in Europe and the U.S."
  - Europe has long taxed gasoline.
  - If taxes on gasoline are high for a long time, like in Europe, consumers will shift to fuel-efficient cars. People will move closer to where they work, etc. All these adjustments take time.

Country	Average Price $US per Gallon	Consumption Per Capita Gallons Per Day
United States	2.80	1.29
Selected Countries in Europe		
Norway	7.00*	.30
United Kingdom	6.90	.28
Germany	6.88	.25
France	6.37	.15
Spain	5.13	.15
Italy	6.50	.21
Some Other Countries		
Japan	4.49	.33
Mexico	2.45	.29
China	2.29	.04

Country	Per Capita GDP ($1,000)
United States	45.5
Selected Countries in Europe	
Norway	51.9
United Kingdom	35.7
Germany	34.3
France	32.7
Spain	31.6
Italy	30.4
Some Other Countries	
Japan	33.6
Mexico	14.0
China	5.3

Table 3: Price and Per Capita Quantit
Consumed of Gasoline
The United States and Norway in 200

Time Period	Per Capita Daily Consumption of Motor Gasoline	Average Price Per Gallon in Dollars
United States	1.29	2.80
Norway	.30	7.00
Δ	-.99	4.20
Average of Both Years	.80	4.90
%Δ	-1.24	.86

Estimating Long-run Elasticities

- Is the supply curve shifting between the two countries?
- Is the demand curve staying fixed?
  - Income
  - Price of substitutes/complements
    - ⋆ Can be a big problem. Public transit is much better in Norway than in the U.S. So there are really two main differences: (1) gas prices are higher and (2) public transit options are better. Both contribute to the lower consumption of gas in Norway.
  - Other factors
    - ⋆ Population density impacts gasoline demand
    - ⋆ Any other factors that make the demand curve in Norway and the U.S. different

Price Elasticity and Total Revenue

Concept Check

The price of a pair of running shoes rises from \$100 to \$150, while the quantity demanded falls from 1200 to 900

- Assumptions needed to calculate price elasticity of demand
- Calculate the price elasticity of demand
- Is demand elastic, unit elastic, or inelastic
- Calculate total revenue before and after the price increase
- By how much would the quantity demanded change if price rises another 5%? (and what further assumptions are needed to answer this question)

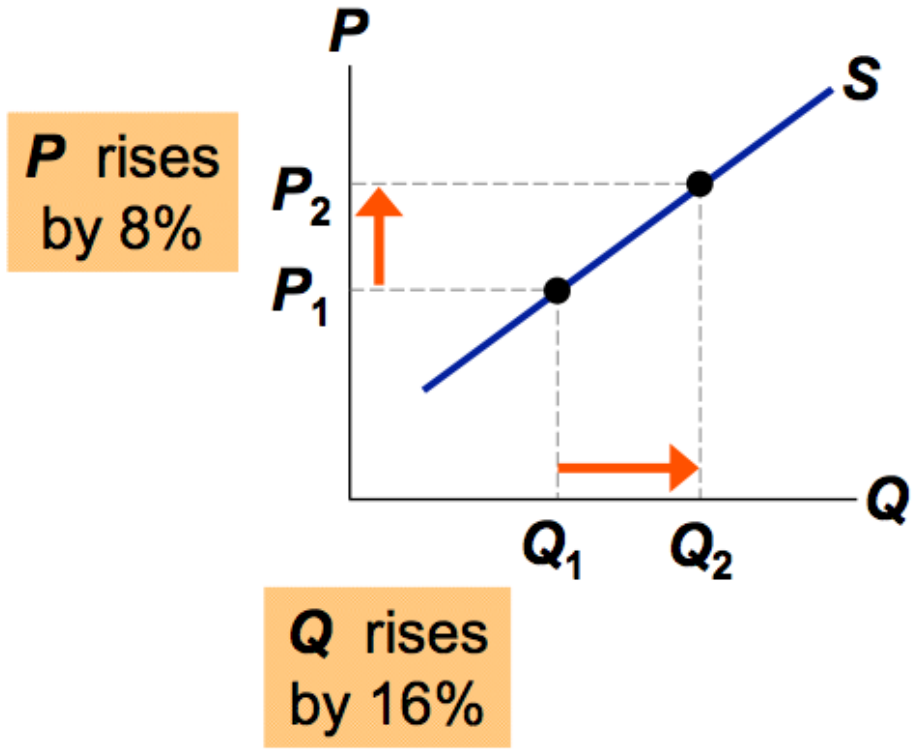
Price Elasticity of Supply

- Price elasticity of supply $\epsilon_{s,p} = \frac{\%\Delta Q^s}{\%\Delta P}$

Example:

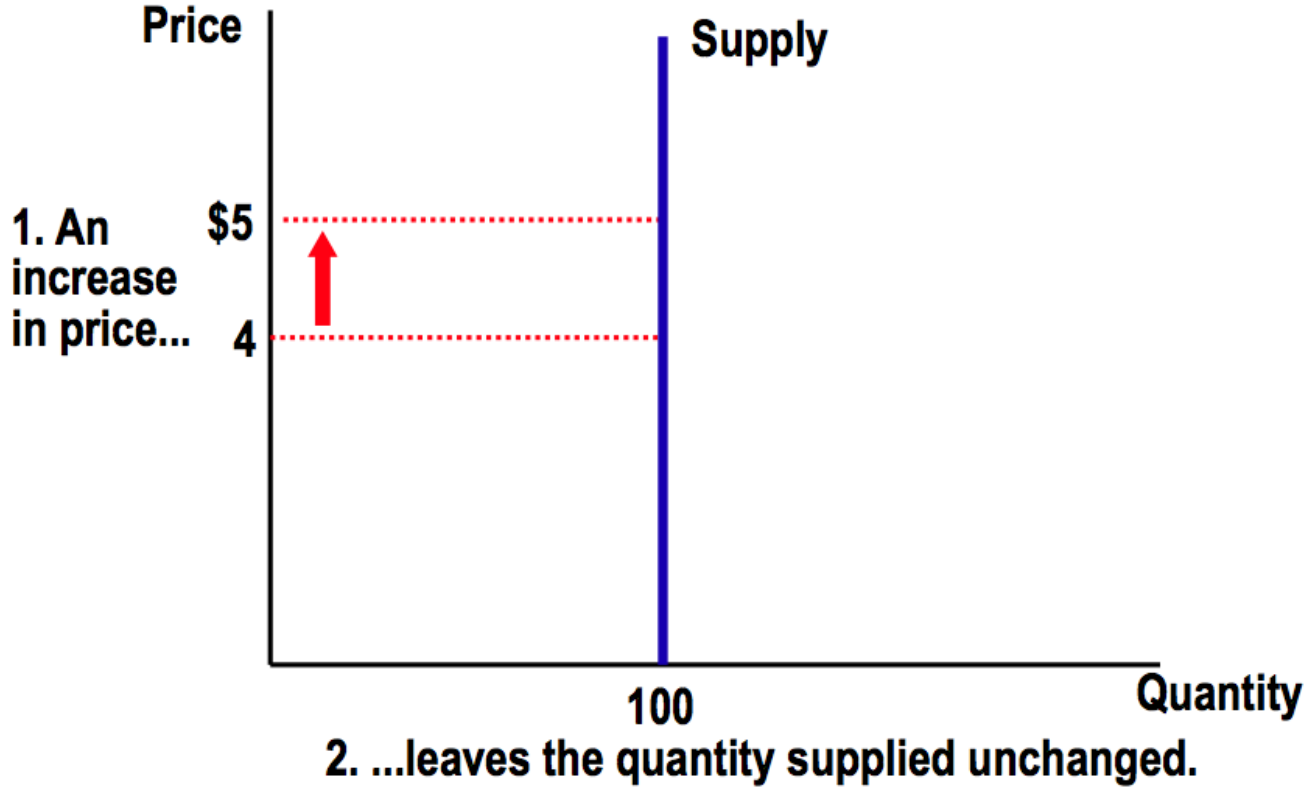
Price elasticity of supply equals

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



Perfectly Inelastic Supply

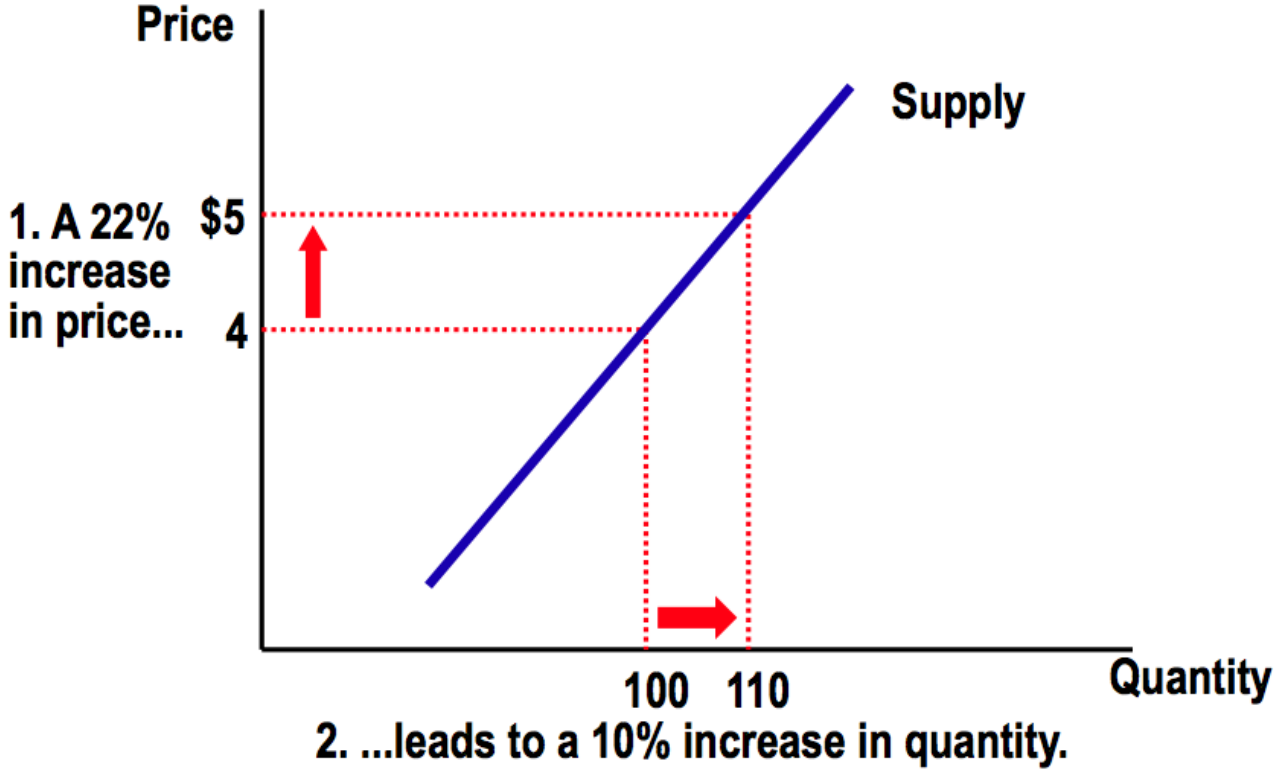
- Elasticity equals 0



Example: land on manhattan, Mona Lisa

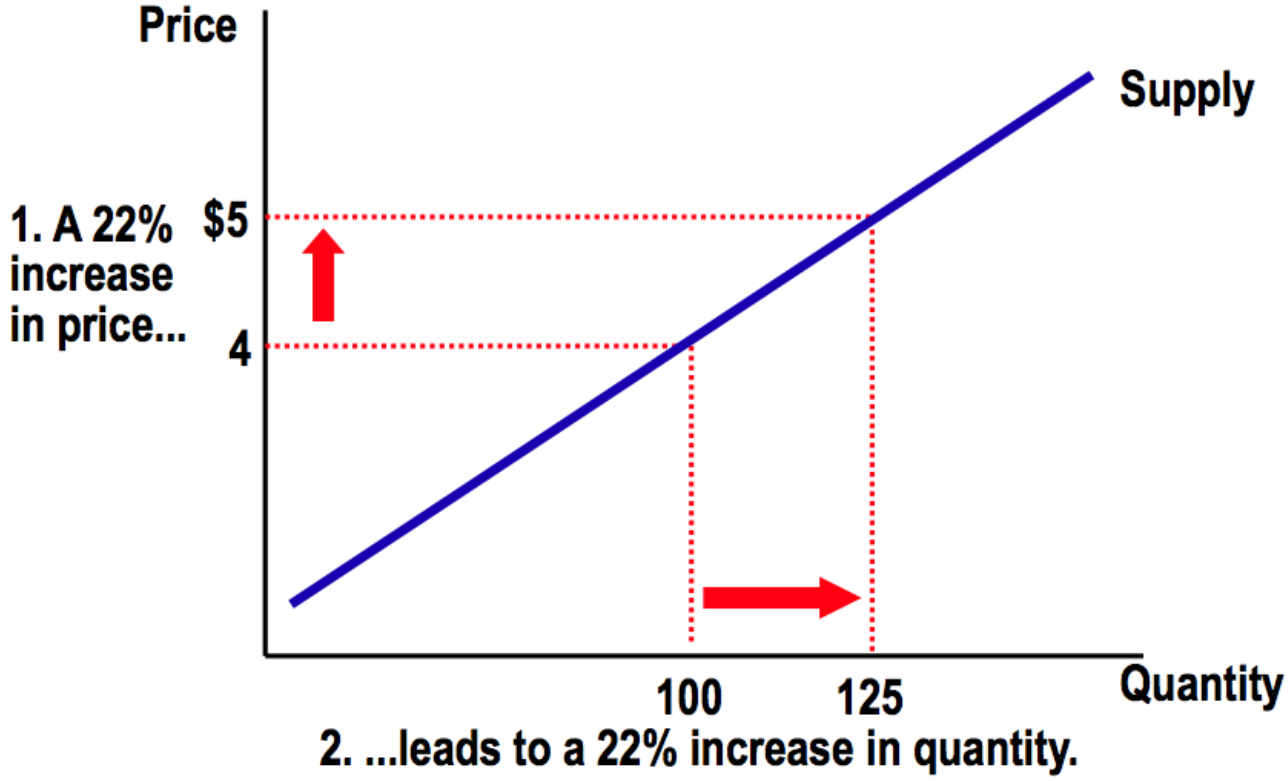
Inelastic Supply

- Elasticity is less than 1



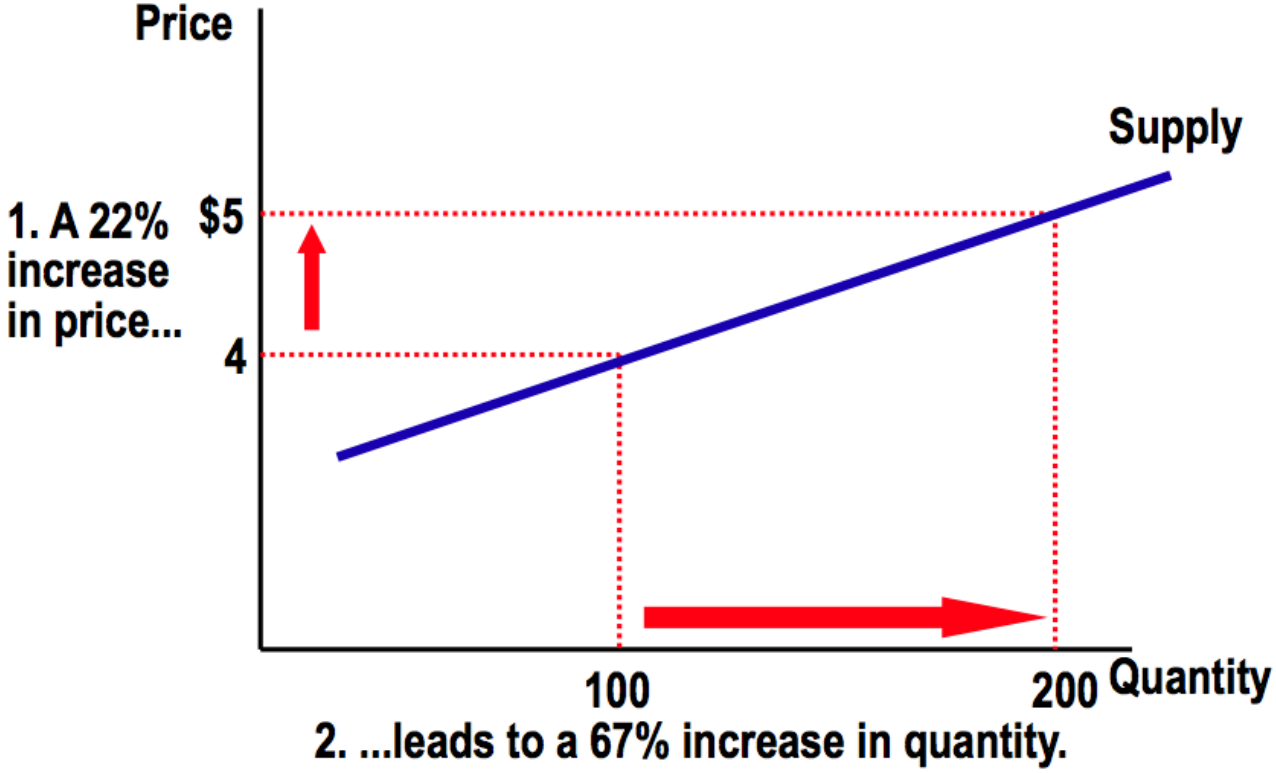
Unit Elastic Supply

- Elasticity equals 1



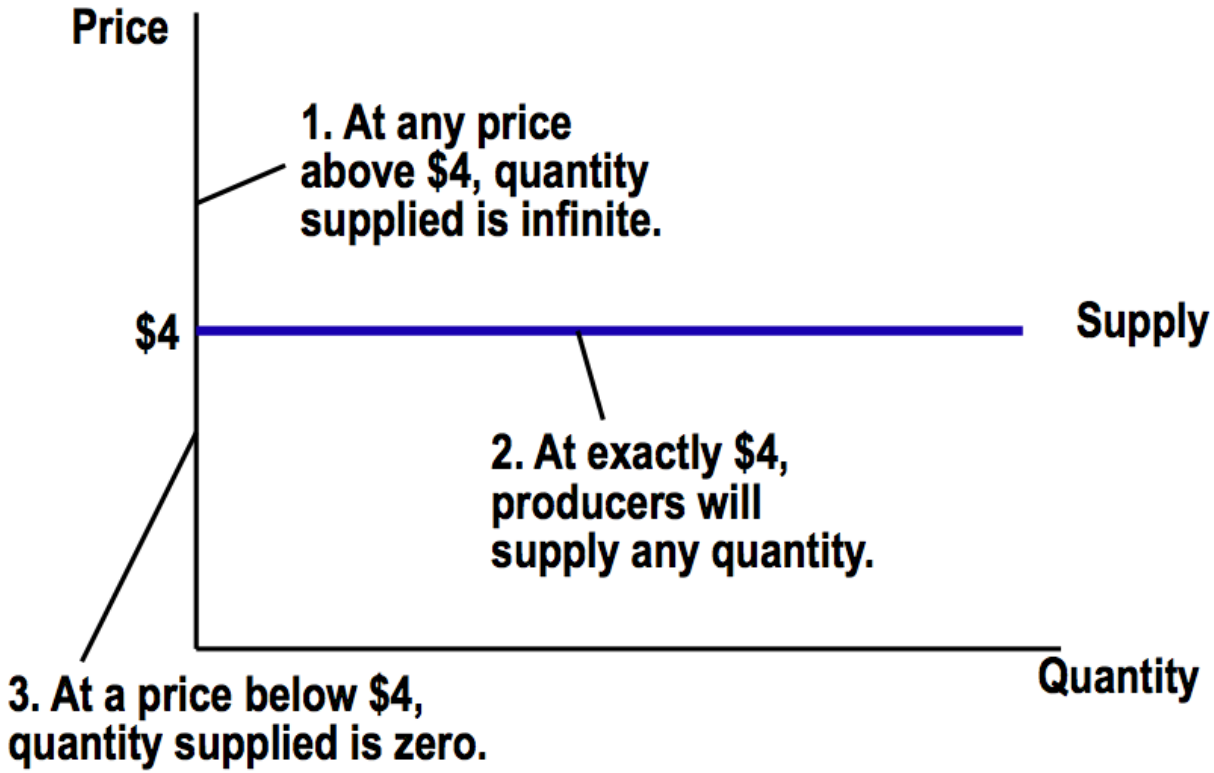
Elastic Supply

- Elasticity is greater than 1



Perfectly Elastic Supply

- Elasticity equals infinity



Example: the supply of Budweiser in a small town

Price Elasticity of Supply

- If the supply curve is linear, then

$$\epsilon_{s,p} = \frac{dQ}{dP} \times \frac{P}{Q} = \frac{1}{b} \times \left(\frac{a}{Q} + b \right) = 1 + \frac{a}{b \times Q}$$

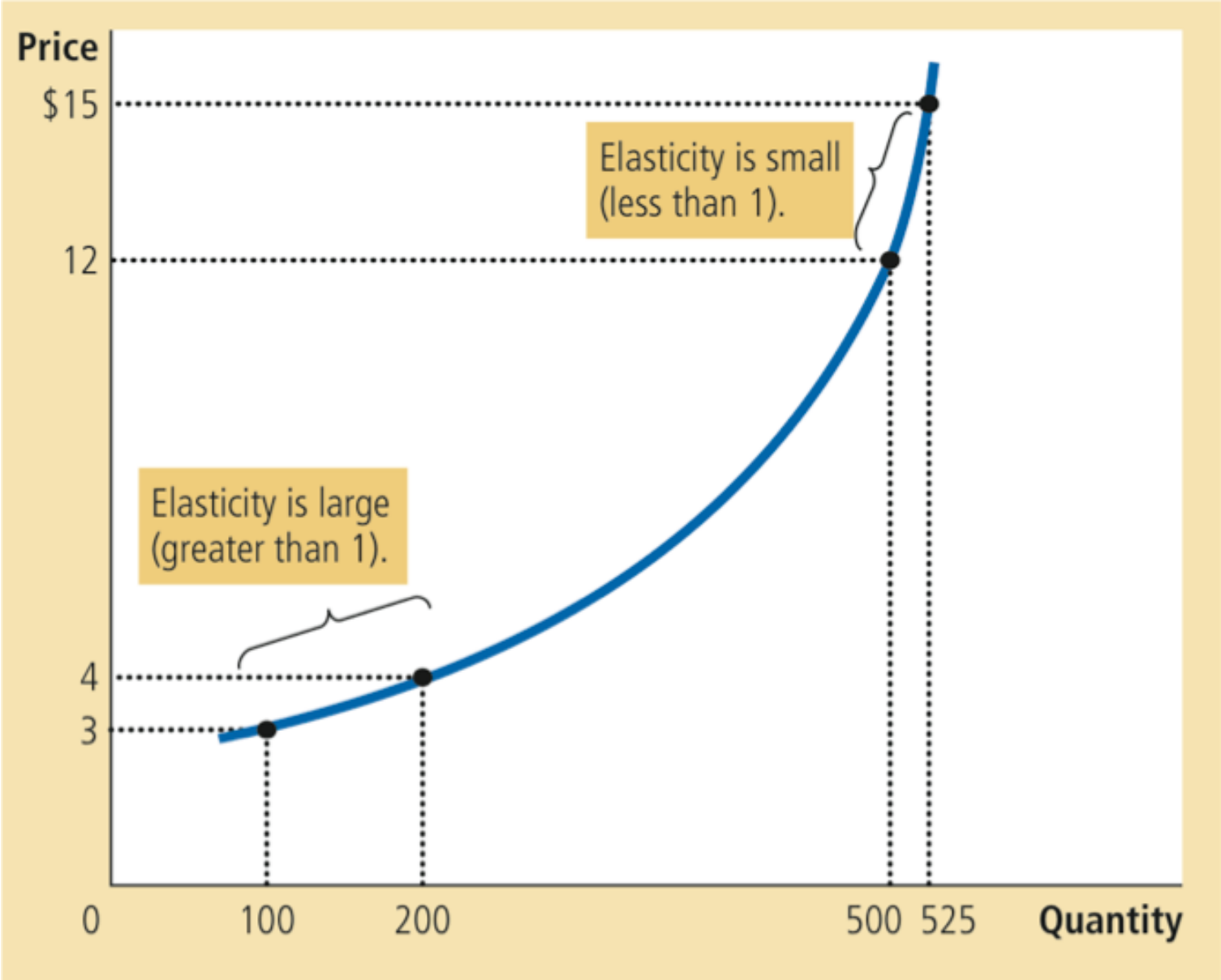
, where we assume $P = a + b \times Q$.

  - If the linear supply curve has a zero intercept, then $\epsilon_{s,p} = 1$
  - If the linear supply curve has a positive intercept, then $\epsilon_{s,p} > 1$ and $Q \uparrow \rightarrow \epsilon_{s,p} \searrow 1$
  - If the linear supply curve has a negative intercept, then $\epsilon_{s,p} < 1$ and $Q \uparrow \rightarrow \epsilon_{s,p} \nearrow 1$

Price Elasticity of Supply

- In general, price elasticity can vary over the supply curve.
- Consider an industry in which firms have factories with a limited capacity for production.
- For low levels of quantity supplied, firms can use idle capacity to respond to changes in the price.
- As the quantity supplied rises,firms begin to reach capacity.
- Once capacity is fully used, increasing production further requires the construction of new plants. To induce firms to incur this extra expense, the price must rise substantially.

Price Elasticity of Supply



j. mao

Determinants of Supply Elasticity

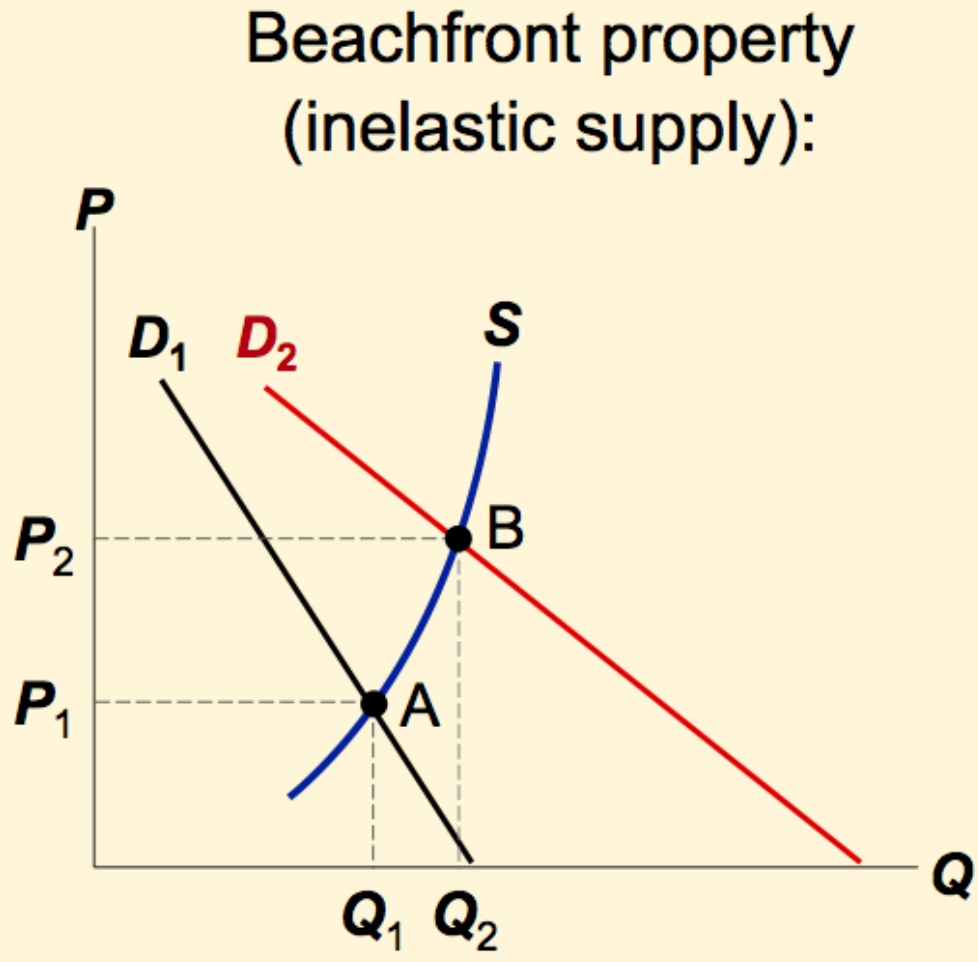
- The more easily sellers can change the quantity they produce, the greater the price elasticity of supply.
  - Example: Supply of beach front property is harder to vary and thus less elastic than supply of new cars.
- For many goods, price elasticity of supply is greater in the long run than in the short run.
  - Firms can build factories.
  - New firms may enter the market.

Supply Elasticity and Equilibrium Change

- The supply of beachfront property is inelastic. The supply of new cars is elastic.
- Suppose population growth causes the demand for both goods to double.
- For which product will P change the most?
- For which product will Q change the most?

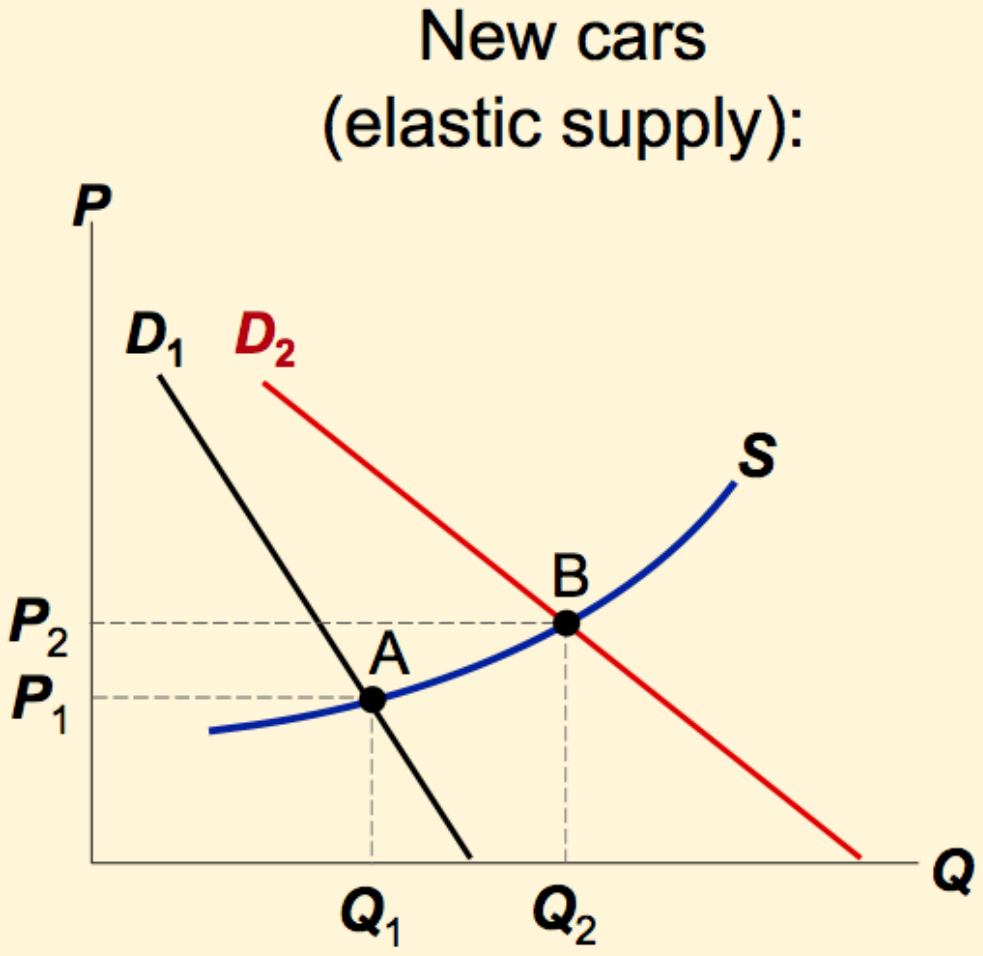
Supply Elasticity and Equilibrium Change

When supply is *inelastic*, an increase in demand has a bigger impact on price than on quantity.



Supply Elasticity and Equilibrium Change

When supply is *elastic*, an increase in demand has a bigger impact on quantity than on price.

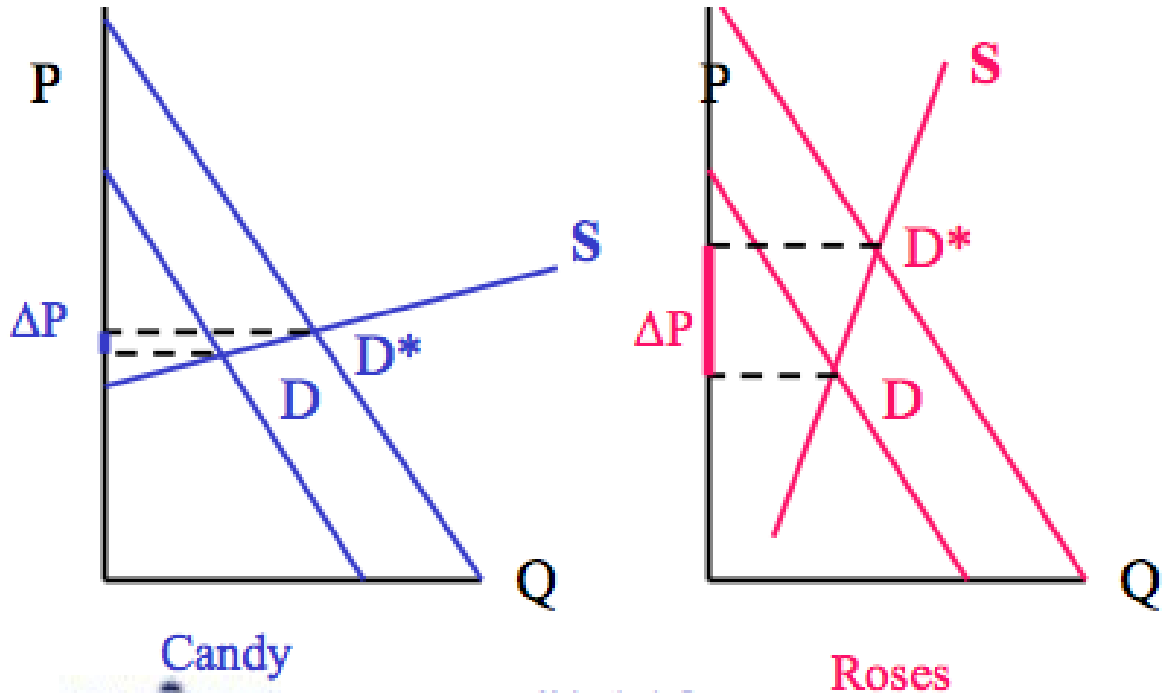


Valentine's Day

- Both chocolate and roses cost more on Valentine's Day. However, Roses cost a lot more, while chocolate costs a little more.

- Difference: chocolate candies are storable while roses are not. The supply of roses is more inelastic.

Valentine's Day



Others Elasticities

- **Income Elasticity of Demand**

$$\epsilon_{d,i} = \frac{\text{Percent change in quantity demanded}}{\text{Percent change in income}} = \frac{\%\Delta Q^d}{\%\Delta I}$$

  - Normal goods: $\epsilon_{d,i} > 0$
  - Inferior goods: $\epsilon_{d,i} < 0$

- **Cross-price Elasticity of Demand**

$$\epsilon_{d,xy} = \frac{\text{Percent change in quantity demanded of good x}}{\text{Percent change in the price of good y}} = \frac{\%\Delta Q_x^d}{\%\Delta P_y}$$

  - Substitutes: $\epsilon_{d,xy} > 0$
  - Complements: $\epsilon_{d,xy} < 0$

Cross-price Elasticity of Demand

- Suppose the quantity demanded of good X decreased 25% while the price of good Y increased by 50%
- What is the cross-price elasticity of demand for X and Y? Are X and Y substitutes or complements?
  - What assumptions do we need to answer these questions?

Can Good News for Farming be Bad News for Farmers?

- Scientific discovery of new wheat hybrid that can raise yield per acre by 20%
  - Q↑,P↓
- Change in total revenue depends on price elasticity of demand
  - Demand for wheat is usually inelastic
  - P↓ → total revenue↓ (inelastic demand)
- If the new hybrid hurts farmers, why would they adopt it?
  - In competitive markets, each farmer is a price taker: it's better for each to sell more at given market price
  - When all farmers do this, the supply of wheat increases, the price falls, and farmers are worse off.

Acknowledgement

Part of this lecture is adapted from the following sources:

- Mankiw, N. G. (2017). *Principles of Economics* (8th ed.). Boston, MA: Cengage Learning.