Supply and Demand

Lecture 1

Reading: Perloff Chapter 2 A

July 2017

Introduction

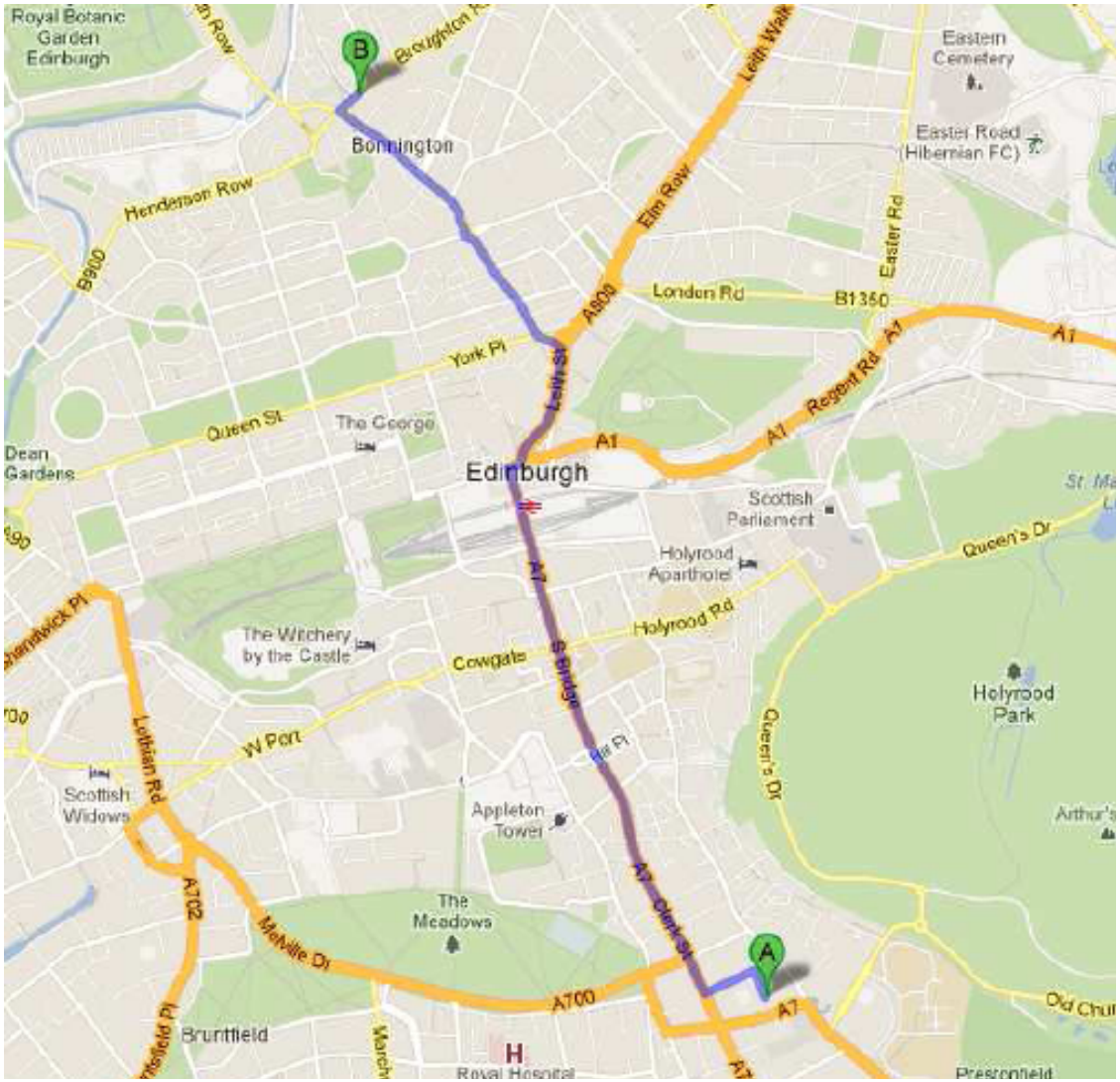
On Exactitude in Science . . . "In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast Map was Useless, and not without some Pitilessness was it, that they delivered it up to the Inclemencies of Sun and Winters. In the Deserts of the West, still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars; in all the Land there is no other Relic of the Disciplines of Geography." - Jorge Luis Borges

Introduction

- How do I get from my flat to Tesco?
- This map is realistic, but it is useless.

Introduction

- This is an abstraction from reality, but it is useful for what we want to know.



Introduction

- **Macroeconomics** models the economy as a whole.
- **Microeconomics** models the decisions of individual consumers and individual firms.
- If economics were a watch, microeconomics would be inside... all the gears and tiny parts.
- Macroeconomics is the outside of the watch, it is a result of all the interactions of the small pieces.

Introduction

- The simplest model, but perhaps the most useful, in microeconomics is **supply and demand.**
- Supply and demand is a model of how consumers and producers interact to determine the quantity of a particular good sold, and the price at which it will be sold at.

Introduction

- Among many other things, it provides answers to such questions as
  - How does an import quota affect the price of steel?
  - Does the minimum wage increase unemployment?
  - Are consumers or producers more affected by cigarette taxes?

Outline

- **Demand** - What determines how much of a good or service consumers wish to buy?
- **Supply** - What determines how much of a good or service firms wish to sell?
- **Equilibrium** - We can find the resulting price and quantity by putting supply and demand together.
- **Comparative Statics** - What happens to our equilibrium when something changes?
- **Policies** - How can government intervention affect the market?

Demand

- Many things affect how much of a particular item people wish to buy
  - The price of the good
  - Tastes
  - Information
  - The price of other goods
  - Income
  - Government policy

Demand

- The **demand function** shows the relationship between how much a good is demanded and all factors that influence the purchase of it.
- **Quantity demanded** is the amount of a good that consumers are *willing* to buy at a given price during some specified time holding everything but the price constant.

Demand

- Economists have estimated the demand function for pork in Canada as

$$Q = 171 - 20p + 20p_b + 3p_c + 2Y$$

- Where Q is quantity demand of pork, p is price of pork, p_b is the price of beef (a substitute), p_c is the price of chicken (a substitute), and Y is income in \$1000s.

Demand

- But in the model of supply and demand, only price and quantity are **endogenous**...
- We want to know the price of pork and the quantity of pork for given values of everything else.
  - Let's use the average values for everything but the price.
  - $p_b = \$4 \ per \ kg$, $p_c = \$3\frac{1}{3} \ per \ kg$, and $Y = 12.5$.
- Plugging these values in, we get

$$Q^d = 286 - 20p.$$

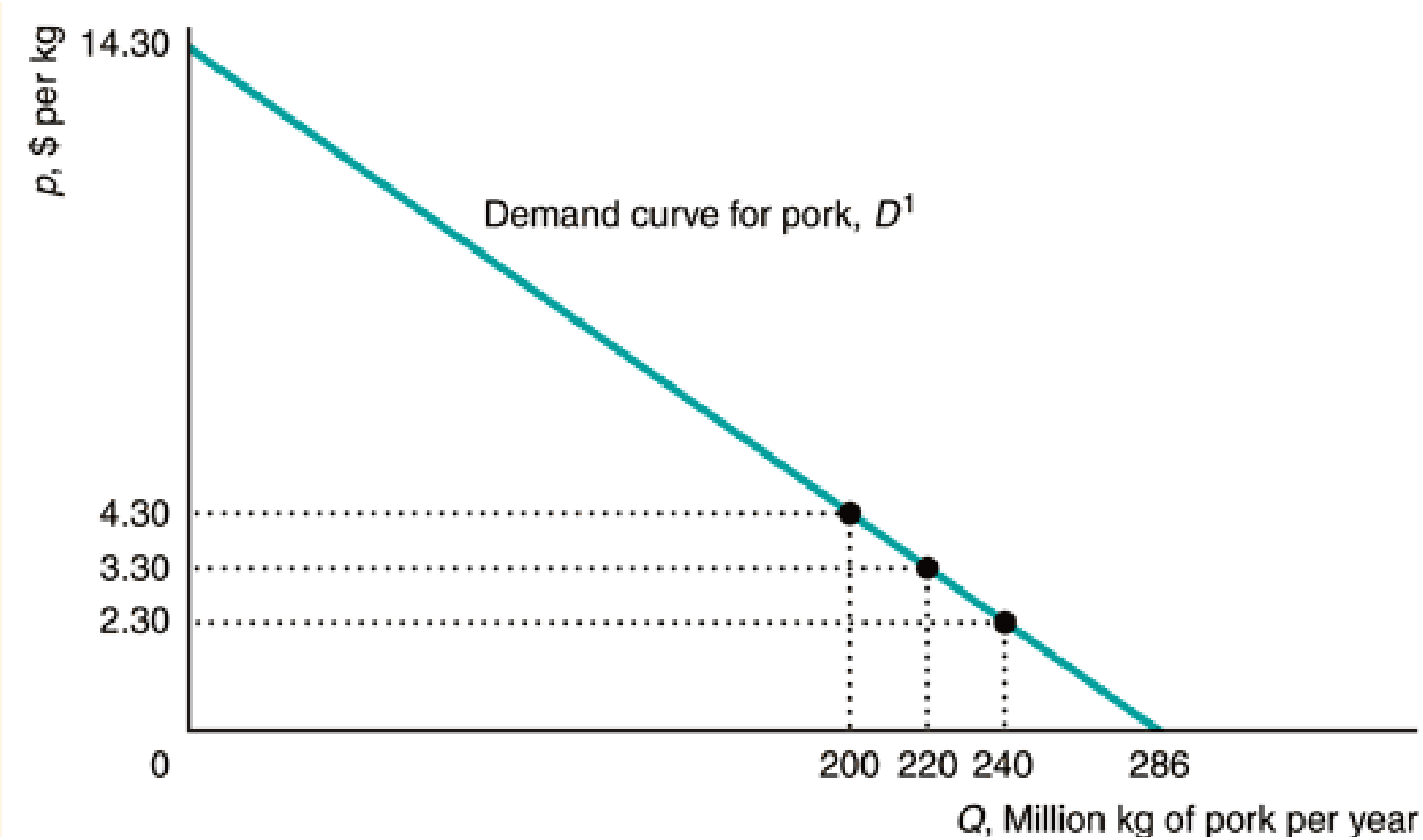
- This is the **demand curve**, it shows quantity demanded for every possible price, holding everything else constant.

Demand

$$\frac{dQ^d}{dp} = -20.$$

- If we increase the price by one unit, quantity demanded will fall by 20 units
- This is the **Law of Demand,** which states that when the price goes up, quantity demanded falls.
- Can you think of why the law of demand might not hold?

Demand


p, $ per kg
14.30
Demand curve for pork, D^1
4.30
3.30
2.30
0
200
220
240
286
Q, Million kg of pork per year

EXAMPLE

- Lets draw the demand curve for big macs if the demand function is

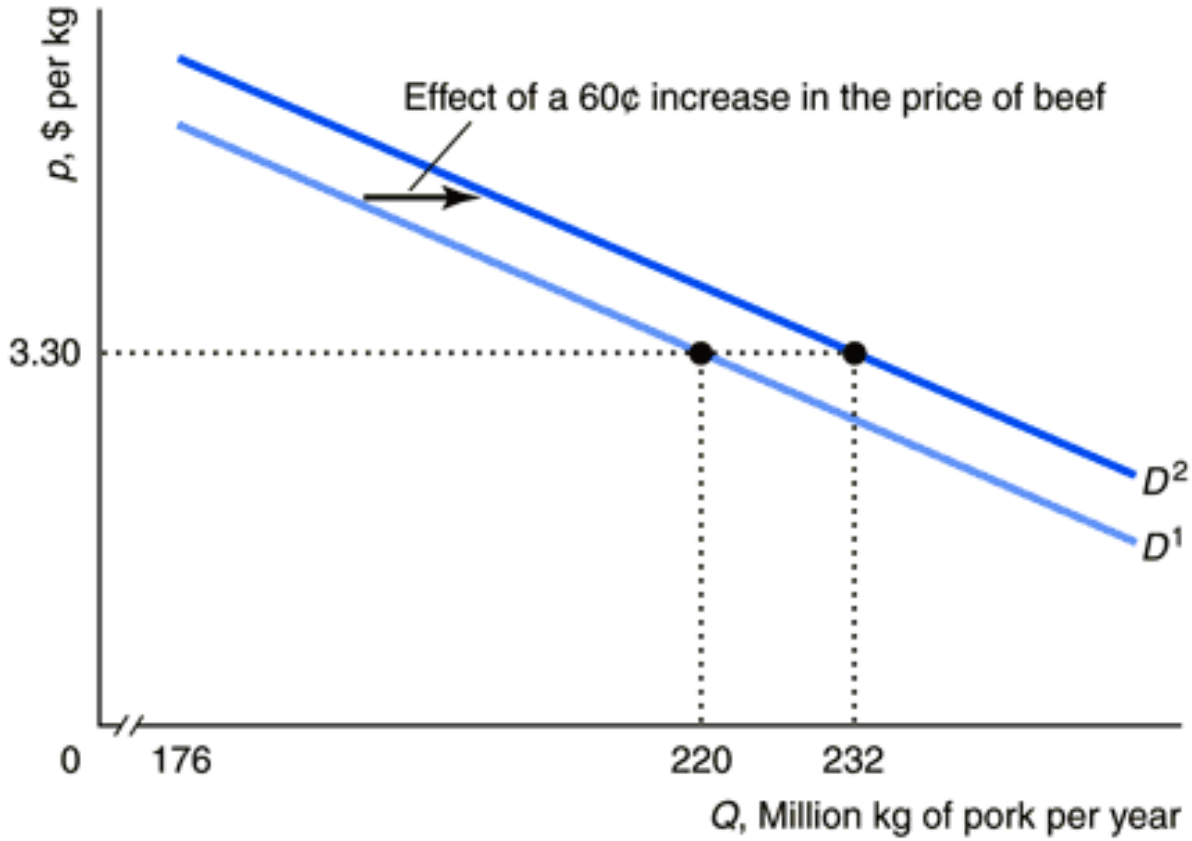
$$Q^D = 2p^{bk} + Y - p^{bm}$$

- Where Q^D is quantity demanded of big macs, p^{bm} is the price of big macs, $p^{bk} = 5$ is the price of Burger King and $Y = 30$ is income.
- What is the slope of this demand curve?

Demand

- Changes in price will represent movements along the demand curve.
- Anything that changes quantity demanded other than the price will represent a shift in the demand curve.
- Example: suppose the price of beef increases from \$4.00 to \$4.60. The demand curve becomes $Q^d = 298 - 20p$.
    - The demand curve will shift to the right because for any given price, quantity demanded is now higher.

Demand


p, $ per kg
Effect of a 60¢ increase in the price of beef
3.30
D2
D1
0
176
220
232
Q, Million kg of pork per year

Demand

- If you know the demand curve of individuals, it is easy to find the demand curve in the market.
- Just add all the individual demand curves together by quantity demanded.
- Suppose you have two people in the market.
  - Sean wants 10 big macs when the price of a big mac is £4 and Anna wants 5 big macs when the price is £4
  - The market demand for big macs when the price is £4 is just 10+5=15

Supply

- Now that we know much consumers wish to buy of a good, all that is left is to find how much producers wish to sell. Important factors that affect supply are
  - The market price of the good
  - Costs of production
  - Government policy

Supply

- The **supply function** tells us the relationship between quantity supplied and all the factors that influence the number of units offered for sale.
- **Quantity supplied** is the amount of a good firms wish to sell at a given price holding everything else in the world constant.

Supply

- Economists have estimated the supply curve for pork as follows

$$Q^s = 178 + 40p - 60p_h$$

- where Q^s quantity supplied, p is the price of pork and p_h is the price of hogs (an input).

Supply

- Once again, we hold the price of everything else constant so let's use the average price of hogs $p_h = \$1.50 \; per \; kg$ to find

$$Q^s = 88 + 40p$$

- This is the **supply curve**, which shows quantity supplied at every price holding everything else constant.

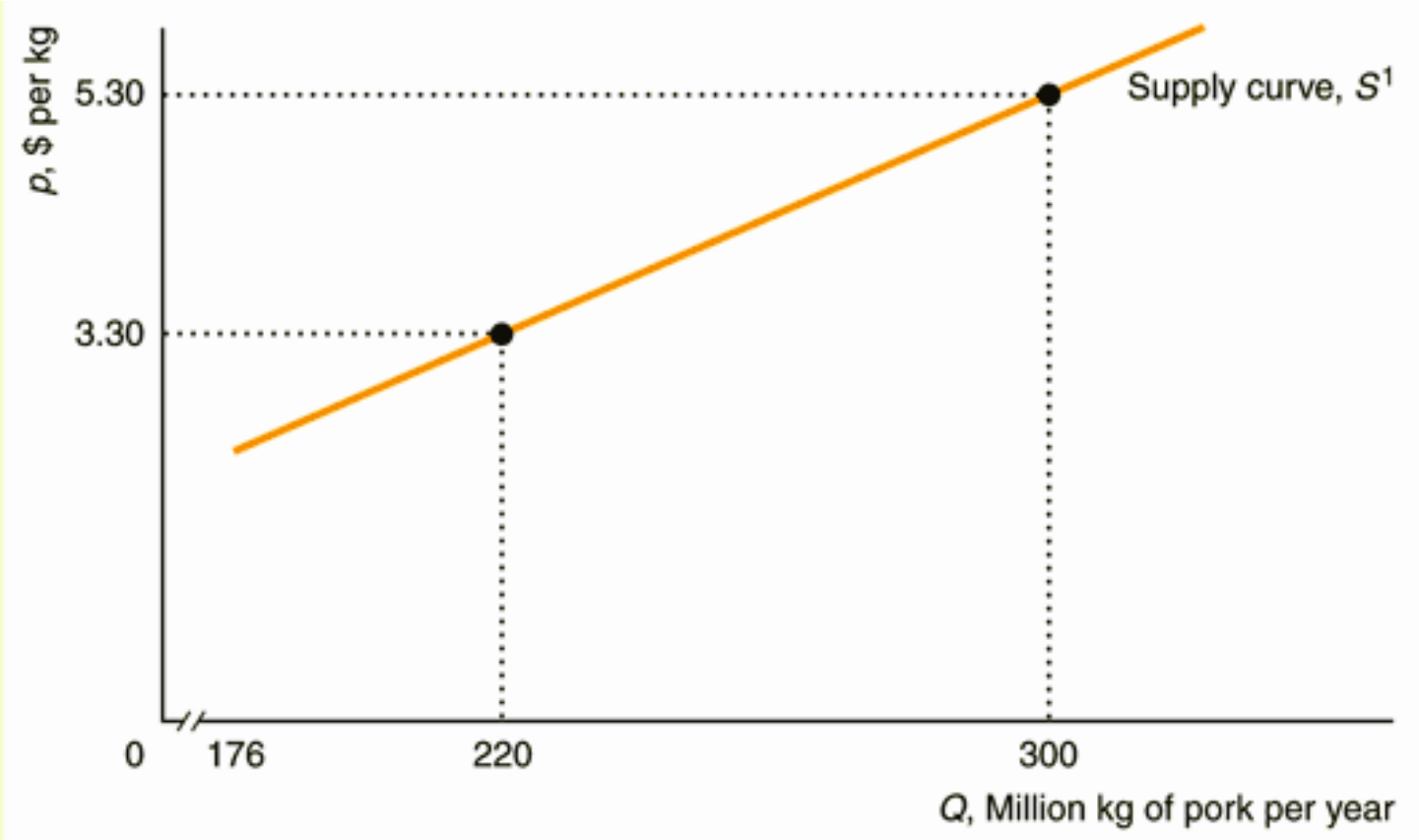
Supply

- We can find the slope of the supply curve by taking the derivative $w.r.t$ p

$$\frac{dQ}{dp} = 40$$

- There is no such thing as the law of supply

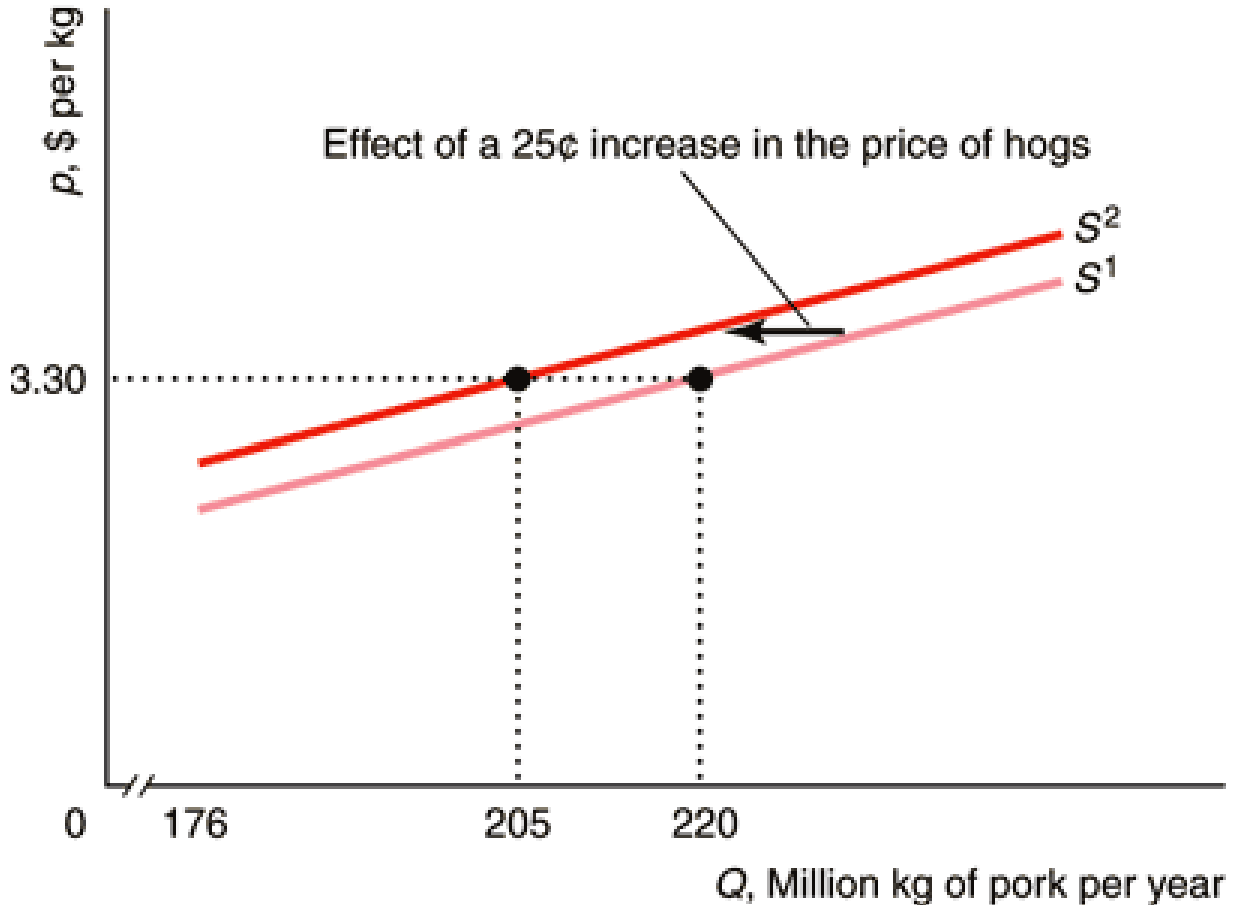
Supply


p, $ per kg
5.30
3.30
0
176
220
300
Q, Million kg of pork per year
Supply curve, S^1

Supply

- Changes in the price of pork represent movements along the supply curve
- Anything that changes quantity supplied of pork other than the price of pork represents a shift in the supply curve
- Example: The price of hogs increases by \$.25, the new supply function becomes $Q^s = 73 + 40p$
    - At any price, quantity supplied is now lower

Supply


p, $ per kg
Effect of a 25¢ increase in the price of hogs
S^2
S^1
3.30
0
176
205
220
Q, Million kg of pork per year

Supply

- If we want to find the supply curve of a number of firms, we just take the horizontal sum.
- We add quantity supplied of each firm for each particular price.

Equilibrium

- What is an **equilibrium?**
- In the context of economics, an equilibrium occurs when nobody wants to change their behavior.
- For example... it is an equilibrium in the UK for everybody to drive their cars on the left and it is an equilibrium in the US for everybody to drive their cars on the right.
- Generally, it is when our endogenous variables do not change unless there is an exogenous shock to the system.

Equilibrium

- In the supply and demand model, we are in equilibrium when no consumer wishes to buy more or less at the current market price, and no producer wishes to sell more or less at the current market price.
- Lets call P^* the equilibrium price and Q^* the equilibrium quantity.
- When there is no pressure for P and Q to change, we are in equilibrium.

Equilibrium

- When quantity demanded exactly equals quantity supplied, we have our equilibrium price and quantity.
- Neither side of the market wishes to change their behavior.
- To find this, all you do is set $Q^s = Q^d$

Equilibrium

$$
\begin{aligned}
Q^d &= 286 - 20p \\
Q^s &= 88 + 40p \\
Q^d &= Q^s \\
286 - 20p &= 88 + 40p \\
P^* &= \$3.30 \\
Q^* &= 220
\end{aligned}
$$

EXAMPLE

Demand curve for shotguns is

$$Q^d = 500 - 4P$$

Supply curve for shotguns is

$$Q^S = -100 + 2P$$

What is the equilibrium price and quantity?

Equilibrium

- What if the price is different than the equilibrium price?
- When we aren't in equilibrium, people have an incentive to change their behavior
- We go to equilibrium without any explicit coordination

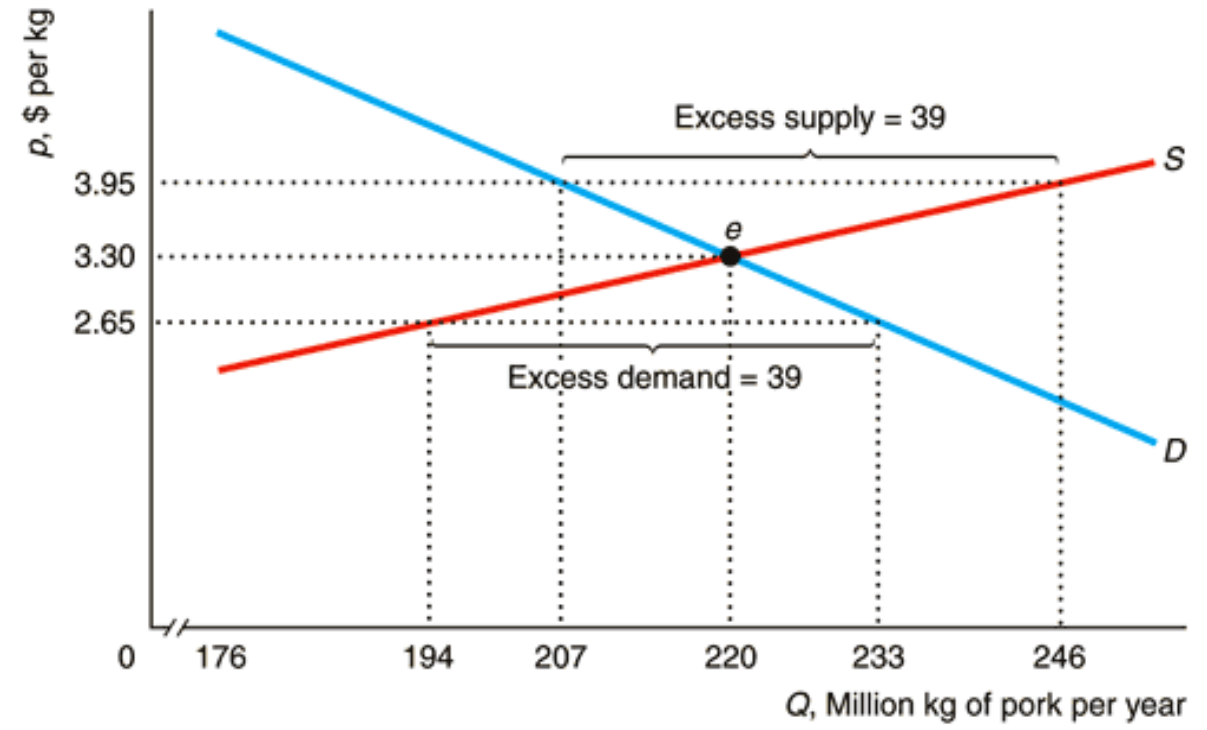
Equilibrium

- Suppose the price is \$2.65, firms will want to supply 194 million *kg* of pork, but consumers will wish to purchase 233 million *kg*.
- There is **excess demand**, and we are not in equilibrium.
  - Only 194 *million kg* of pork is produced, but consumers want more
  - There is an upward pressure on the price
  - Firms know this, so they will start producing more.

Equilibrium

- Suppose the price is \$3.95, firms want to sell 246 million kg, but buyers only want to purchase 207 million kg
  - There is **excess supply**
  - firms aren't selling all they produced, so they will start lowering the price and producing less.

Equilibrium



EXAMPLE

- If the price of shotguns is £85, what will happen?

Comparative Statics

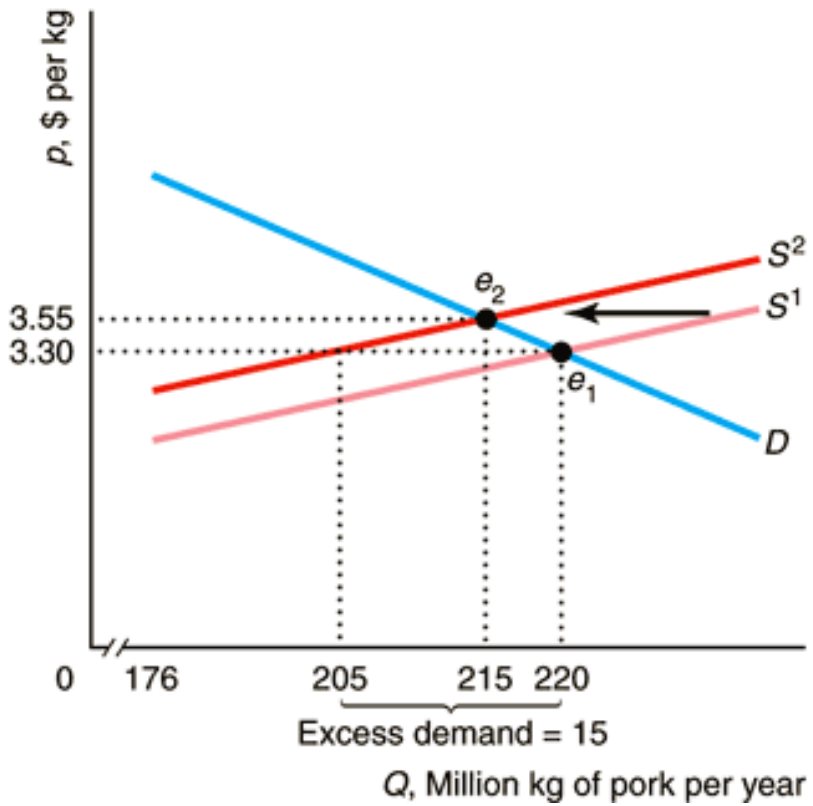
- Suppose we are at some equilibrium where all our endogenous variables are happy where they are
- If we shock the system (change one of the exogenous variables) we will go to a new equilibrium.

Comparative Statics

- **Comparative statics** compares one equilibrium with another as a result of a shock to an exogenous variable
- It is a before and after picture.
- Of course there is a dynamic adjustment process (that is important), but this is not comparative statics.
- We will first talk about big shocks and then we will talk about little shocks.

Comparative Statics

- Suppose price of hogs goes up by \$.25



- The equilibrium price goes up by \$0.25, the equilibrium quantity goes down by 5.

EXAMPLE

- Draw the supply and demand curve for sandwiches.
  - The cost of bread goes up.
  - The price of paninis goes down.
  - The price of sandwiches goes up.

Comparative Statics

- What happens to the equilibrium price and quantity of pork if we change the price of hogs by a tiny amount?
- Call a is the price of hogs
  - The price of pork is implicitly a function of a so lets write p as $p(a)$.
- Demand is $Q^d = D(p(a))$
- Supply is $Q^s = S(p(a), a)$

Comparative Statics

- We know in equilibrium $D(p(a)) = S(p(a), a)$
- To find the effect on the equilibrium, just differentiate this with respect to a.
- We need the chain rule... so lets revise that really quick.

Diversion - Chain Rule

- Suppose you have some function $y = f(x)$.
- The value of y depends on the value of x.
- But suppose x depends on some other thing z.
- We can write this as $y = f(x(z))$.
- z affects x and x affects y.

Diversion - Chain Rule

- The chain rule lets us find how z affects y.

$$\frac{dy}{dz} = \frac{dy}{dx} * \frac{dx}{dz}$$

Diversion - Chain Rule

- Suppose $y = f(x(z))$ where z is the minimum wage, x is unemployment and y is crime.
- A 1% increase in the minimum wage (z) increases unemployment (x) by $\frac{1}{5}\%$
- A 1% increase in unemployment (x) increases crime (y) by 10%
- What is the effect of the minimum wage on crime?

$$\begin{aligned} \frac{dy}{dz} &= \frac{dy}{dx} * \frac{dx}{dz} \\ \frac{dy}{dz} &= (10\%) * \left(\frac{1}{5}\%\right) = 2\% \end{aligned}$$

Diversion - Chain Rule

- What if we have $y = f(x, w)$ where both x and w are affected by z.
- That is, $y = f(x(z), w(z))$
- What is the effect of a change in z on y?
- z affects y through two channels now

Diversion - Chain Rule

- We just add these two effects together to get the total effect.

$$\frac{dy}{dz} = \frac{dy}{dx}\frac{dx}{dz} + \frac{dy}{dw}\frac{dw}{dz}$$

Comparative Statics

- We know in equilibrium $D(p(a)) = S(p(a), a)$
- To find the effect on the equilibrium, just differentiate this with respect to a.

$$\frac{dQ^d(p(a))}{dp}\frac{dp}{da} = \frac{\partial Q^s(p(a), a)}{\partial p}\frac{dp}{da} + \frac{\partial Q^s(p(a), a)}{\partial a}$$

- Solve that for $\frac{dp}{da}$

$$\frac{dp}{da} = \frac{\frac{\partial Q^s(p(a),a)}{\partial a}}{\frac{dQ^d(p(a))}{dp} - \frac{\partial Q^s(p(a),a)}{\partial p}}$$

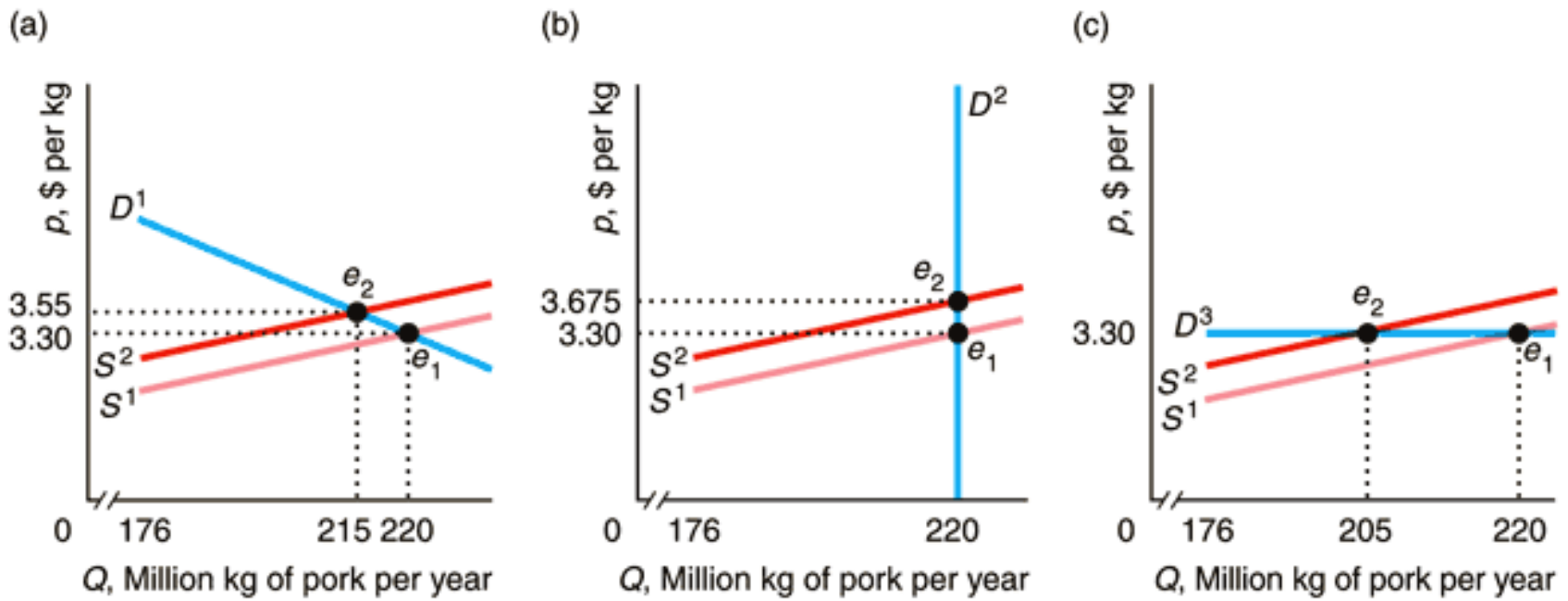
Comparative Statics

- To find the effect of a change in a on equilibrium quantity, take the derivative of either Q^s or Q^d w.r.t. a

$$\frac{dQ^d}{da} = \frac{dQ^d}{dp}\frac{dp}{da}$$

Comparative Statics

- The slopes of supply and demand really matter when we shock the system.



Elasticities

- **Elasticities** simply measure the percentage change in one variable with respect to a percentage change in another all else constant.
- Example:
  - The elasticity of my mood with respect to my sleep is the percentage change in my mood that results from a percentage change in my sleep.

Elasticities

- Let g be a variable which measures how happy I am, and z be a variable that measures how much sleep I got.
- $\%\Delta g = \frac{\Delta g}{g}$
- So the elasticity of how happy I am with respect to how much sleep I got is

$$E = \frac{\%\ change\ in\ g}{\%\ change\ in\ z} = \frac{\frac{\Delta g}{g}}{\frac{\Delta z}{z}} = \frac{\Delta g}{\Delta z}\frac{z}{g}$$

- If we look at infinitesimally small changes (which we normally do) this becomes

$$E = \frac{dg}{dz}\frac{z}{g}$$

Elasticities

- An important elasticity is the **price elasticity of demand**
- This tells us how responsive demand is to the price... it is the percentage change in Q^d with respect to a percentage change in p.

$$\begin{aligned} \varepsilon &= \frac{\frac{\Delta Q}{Q}}{\frac{\Delta p}{p}} = \frac{\Delta Q}{\Delta p}\frac{p}{Q} \\ \lim_{\Delta \to 0} &= \frac{\partial Q}{\partial p}\frac{p}{Q} \end{aligned}$$

Elasticities

- For example suppose our demand curve is

$$Q = a - bP$$

- $\frac{dQ}{dP} = -b$ so the price elasticity of demand is

$$-b\frac{P}{Q}$$

EXAMPLE

- Suppose our demand curve is

$$Q = 1000 - 10P$$

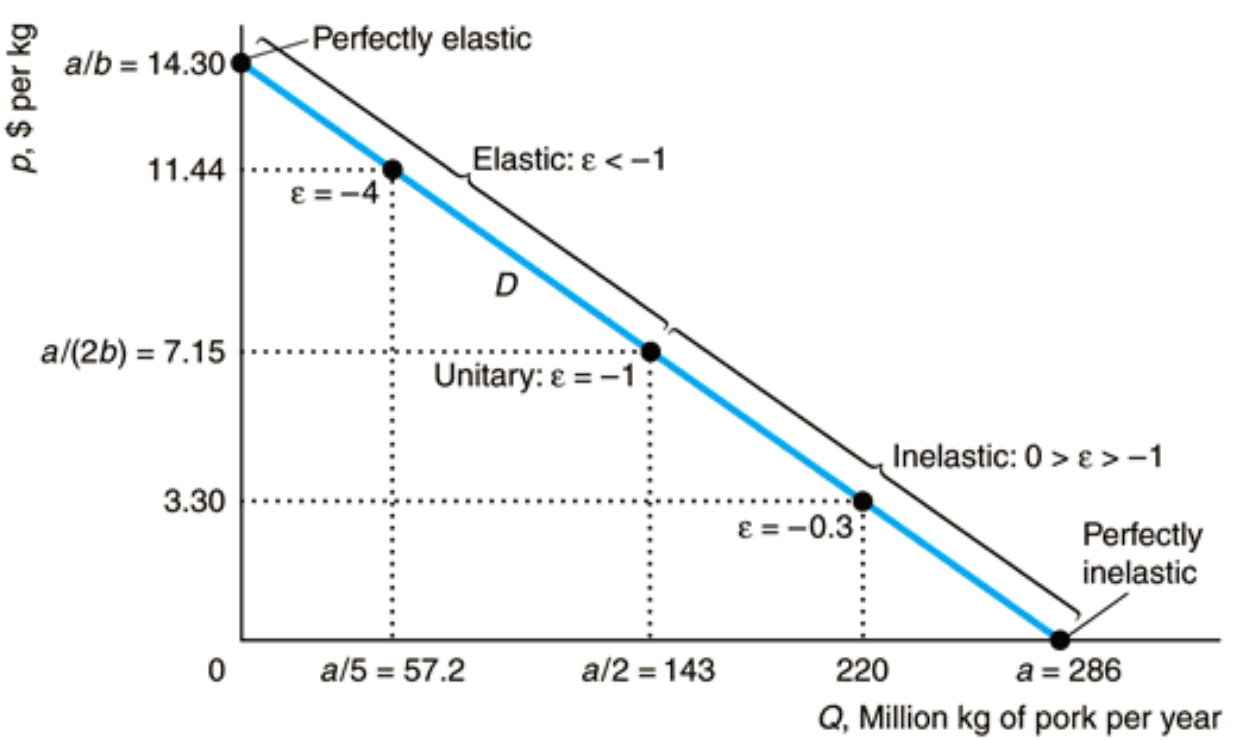
- What is the price elasticity of demand when the price is 10 and the quantity is 900?
- If the price increases by 1% how much does quantity demanded fall by?

Elasticities

- $\varepsilon > 1$ demand is **elastic ....** A 1% change in price leads to a >1% change in quantity
- $\varepsilon < 1$ demand is **inelastic ....** A 1% change in price leads to a <1% change in quantity
- $\varepsilon = 1$ demand is **unitary elastic ....** A 1% change in price leads to a 1% change in quantity
- $\varepsilon = \infty$ demand is **perfectly elastic ....** A 1% change in price causes quantity to go to infinity or zero
- $\varepsilon = 0$ demand is **perfectly inelastic ....** No matter how much price changes, quantity is the same

Elasticities

- On most demand curves, the elasticity of demand is not constant



Elasticities

- For some curves, elasticity is constant.
  - Vertical curves ($\varepsilon = 0$ everywhere)
  - Horizontal curves ($\varepsilon = \infty$ everywhere)
  - Constant elasticity demand curves, which take the form

$$Q = Ap^{\varepsilon}$$

- Lets prove this together.

Elasticities

- Income elasticity of demand

$$\xi = \frac{\partial Q}{\partial Y}\frac{Y}{Q}$$

- Cross-price elasticity of demand

$$\varepsilon_{Q^a p^b} = \frac{\partial Q_a^d}{\partial p_b}\frac{p_b}{Q_a^d}$$

- Price elasticity of supply

$$\eta = \frac{\partial Q}{\partial p}\frac{p}{Q}$$

Elasticities

- The time horizon makes a big deal when talking about elasticities
- Demand might be more or less elastic in the long run
  - Easier to change purchasing decisions in the long run $\rightarrow$more elastic in LR
  - Durable goods be *less* elastic in LR

Elasticities

- Supply will always be more elastic in the long run.
- Firms are relatively constrained in the short run
  - can hire more or less workers quickly, but can't build new factories quickly
  - price elasticity of supply is greater in the LR.

Sales Taxes

- What happens to supply and demand if the government intervenes?
- The most common type of intervention is through taxation.
- There are two types of taxes
- Ad valorem
  - government keeps a fraction of the amount spent by consumers (20% in the UK)
- Unit tax
  - tax on units sold (e.g. 56p tax per litre of petrol)

Sales Taxes

- Lets look at the pork market again and suppose the government imposes a specific tax of \$1.05 on producers

$$\begin{aligned} Q^s &= 88 + 40p \\ Q^d &= 286 - 20p \end{aligned}$$

- If we were directly taxing consumers, the result would be the same.

Sales Taxes

- This tax creates a wedge
  - Consumers must pay \$1.05 more than what producers receive
  - if p^S is how much producers receive and p^D is how much consumers pay, $p^S = p^D - 1.05$
- This will shift the supply curve up

Sales Taxes

- Lets find the new equilibrium
- The new supply curve is $Q^s = 88 + 40(p^D - 1.05) = 46 + 40p^D$
- Set this equal to the original demand curve

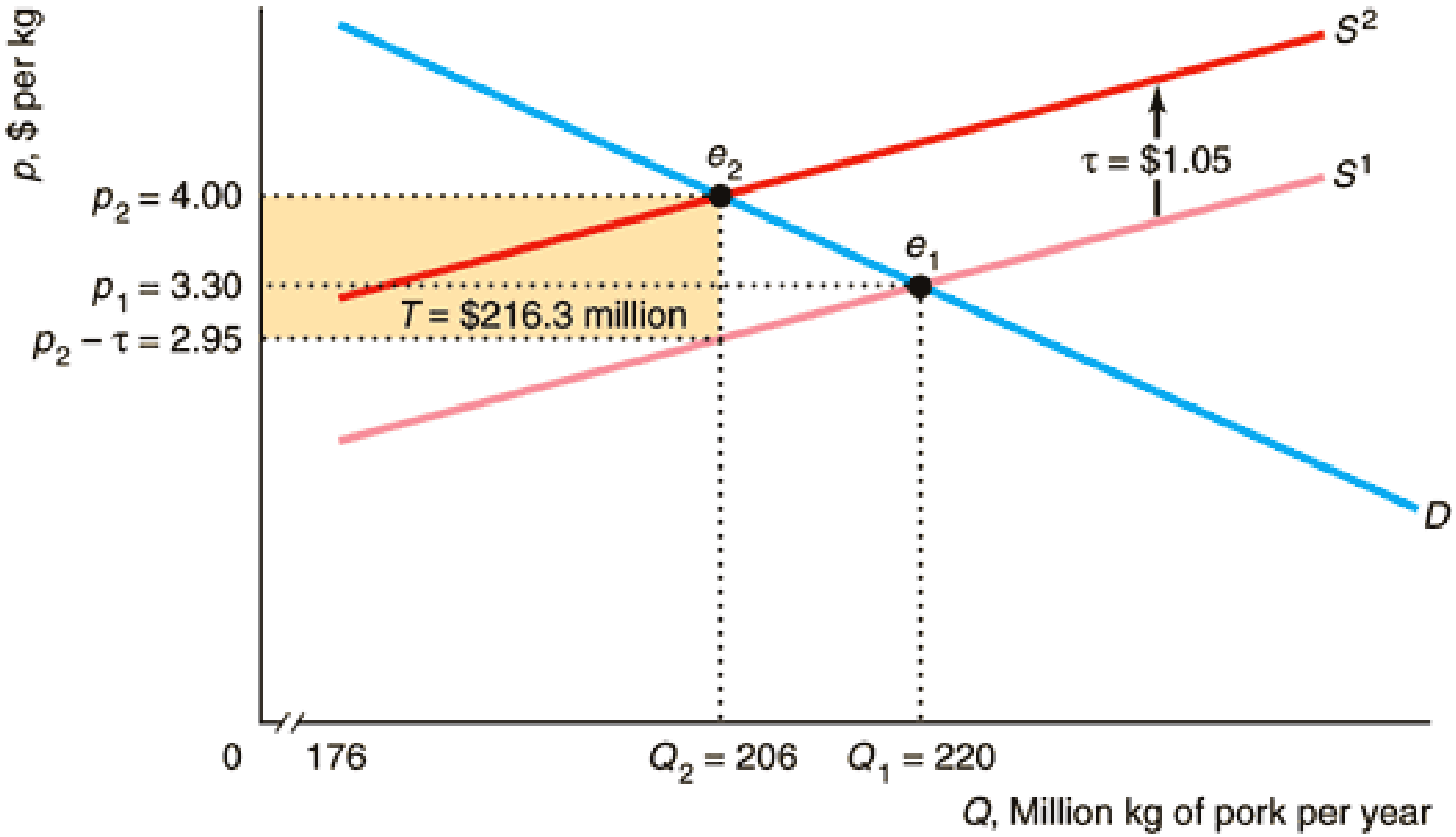
$$46 + 40p^D = 286 - 20p^D$$

- The new price is \$4 and the new quantity is 206 (from plugging back into the demand curve)
- Producers get $\$4 - \$1.05 = \$2.95$

Sales Taxes

- So consumers pay \$.70 more than they did before, and producers receive \$.35 less than before
- The government is getting $Q * \tau = 206 * \$1.05 = \$216.3$ *million*

Sales Taxes


p, $ per kg
$p_2 = 4.00$
$p_1 = 3.30$
$p_2 - \tau = 2.95$
e_2
e_1
$T = \$216.3$ million
$\tau = \$1.05$
S^2
S^1
D
0
176
$Q_2 = 206$
$Q_1 = 220$
Q, Million kg of pork per year

Sales Taxes

- In this example, consumers bear a greater burden of the tax than do producers (they pay twice as much of it)
- The relative elasticities are what determines who is affected the most.

- What is the intuition behind this?

Sales Taxes

- The formula for the relative tax burden (see Perloff for a derivation) is

$$\frac{dp^D}{d\tau} = \frac{\eta}{\eta - \varepsilon}$$

- Where η is the price elasticity of supply and ε is the price elasticity of demand.

Sales Taxes

- In the pork example, $\varepsilon = -.3$ and $\eta = .6$
- The incidence of this tax on consumers is $\frac{2}{3}$ and the incidence of this tax on producers is $\frac{1}{3}$

EXAMPLE

- Suppose quantity demand and quantity supply are

$$\begin{aligned} Q^D &= 10 - \frac{1}{2}p \\ Q^S &= -2 + p \end{aligned}$$

- How much more will consumers pay if the government imposes a \$6 tax on consumers?

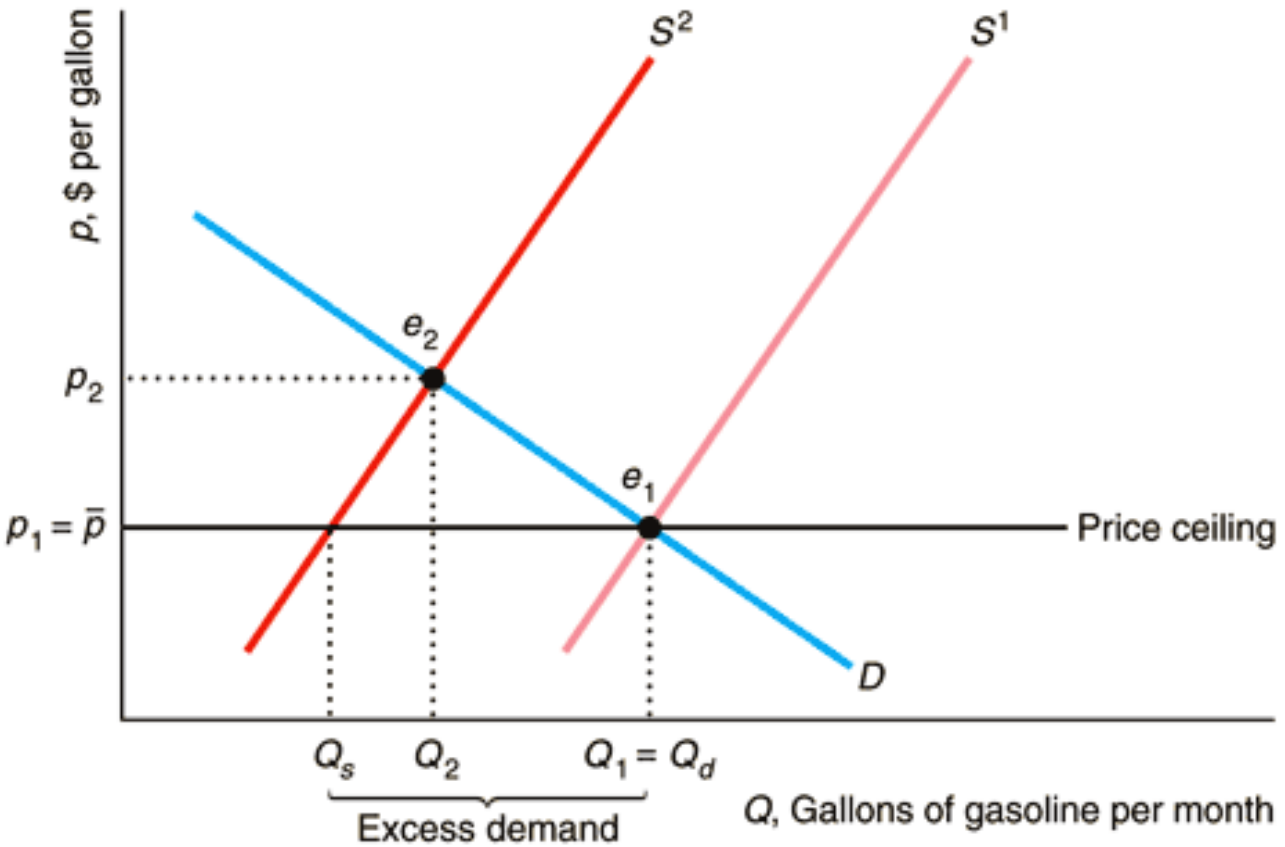
Floors and Ceilings

- Government policy might prevent the market from clearing
- **Price ceilings** are upper bounds on the price
  - Example: Hugo Chavez of Venezuela regularly set price ceilings on food
- **Price floors** are lower bounds on the price
  - Example: Minimum wages

Floors and Ceilings

- When there is a *price ceiling*, the price is kept artificially low.
- Consumers will demand more than producers are willing to supply.
- There is a **shortage** (persistent excess demand)

Floors and Ceilings



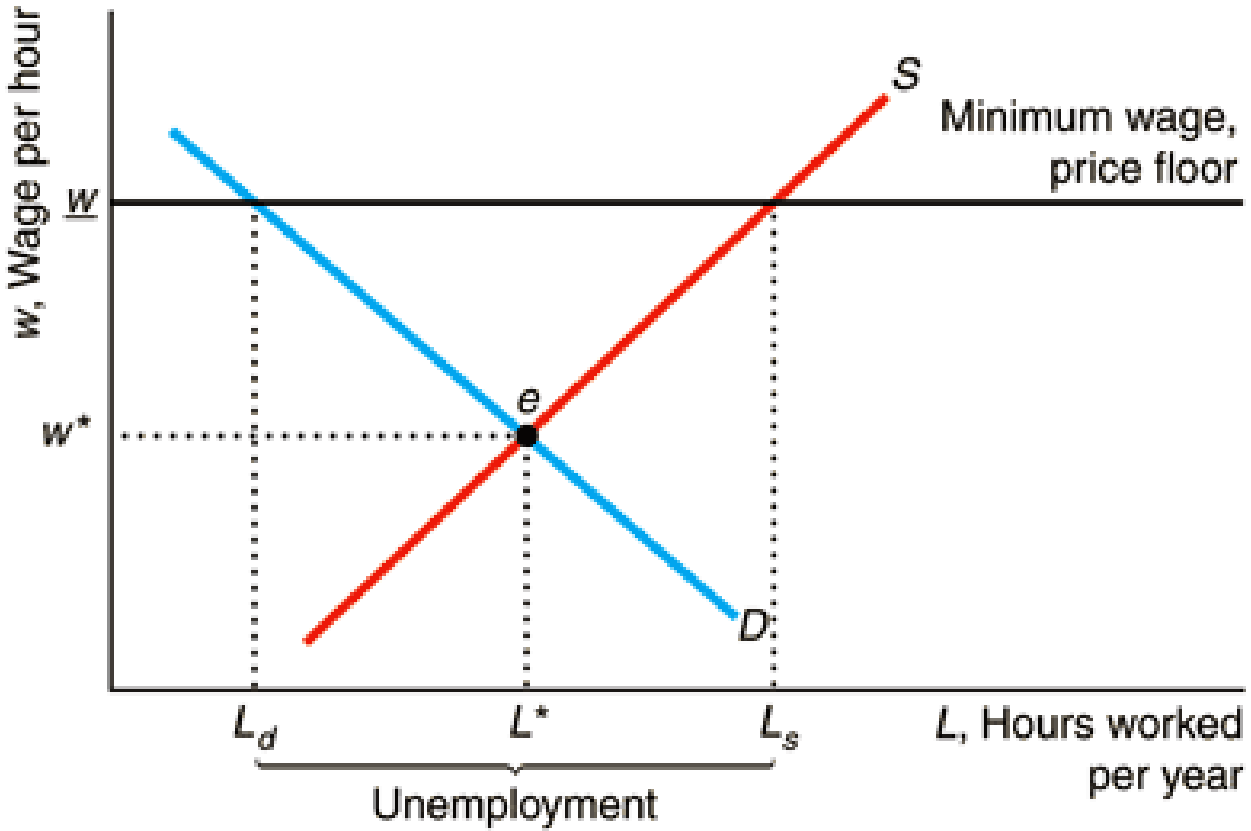
Floors and Ceilings

- When there is a *price floor*, the price is artificially high.
- Producers want to supply more than consumers demand.
- There is a **surplus** (persistent excess supply)

Floors and Ceilings

- Suppose the government institutes a minimum wage above the market clearing wage
- More workers (supply) will wish to supply their labour than firms (demand) wish to hire.
- This results in *unemployment* in the supply and demand model

Floors and Ceilings



Floors and Ceilings

EXAMPLE

$$\begin{aligned} Q^D &= 10 - \frac{1}{2}p \\ Q^S &= -2 + p \end{aligned}$$

- What happens when there is a price floor of 10?
- What happens when there is a price ceiling of 6?

Is This Model Always Relevant?

- We can really only talk about a supply curve in perfectly competitive markets
- We will talk about this in future lectures.
- This model is most applicable in things such as agriculture, finance, labour...
- It is more difficult to apply to industries where firms are engaged in a sort of chess match (Boeing and Airbus for example).

Summary

- What represents a movement along the supply and demand curves?
- What represents a shift in the demand and supply curves?
- How do you find the equilibrium price and quantity?
- If we are not in equilibrium how do we get there?

Summary

- What are comparative statics?
- How do you know who bears the greater burden of a tax?
- How do we get unemployment in the supply and demand model?