Chapter 16 - Equilibrium

→ Economic models have two important features:

1) optimization

2) Equilibrium

→ Thus far, we've only dealt with the first

→ Now we'll deal with the second, equilibrium

→ What is equilibrium?

→ it is a consistency requirement

- it enforces some consistency between the actions of different parties in the model

e.g. btwn suppliers and demanders of a good

→ a model's equilibrium is a point of "rest" for the model

→ i.e. it's self-reinforcing and a place the model tends towards (generally)

→ As an motivating example, and as an important example to understand for practical purposes, we'll look at market equilibrium.

→ To do this, we need to talk about market supply

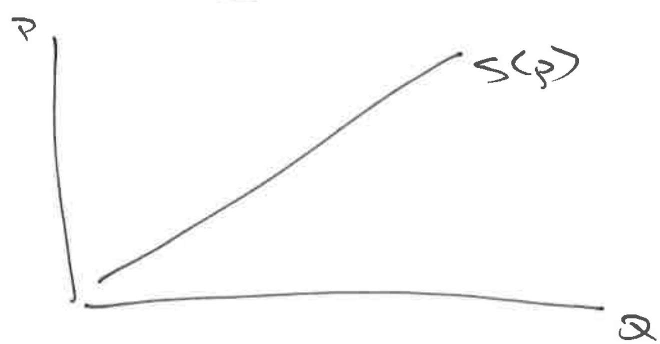
Market Supply

→ The market supply curve relates the quantity of goods the suppliers are willing to sell to the price

→ i.e. for each price, p, the market supply curve ~~[illegible]~~ S(p), tells the quantity sellers are willing to sell at that price

→ Supply curves generally have a positive slope → sellers are willing to sell more of a good at a higher price

e.g. Supply curve



→ like the market demand curve, this market supply curve is simply found by aggregating the supply curves of individual suppliers.

Market Equilibrium

→ For now, we will consider the case of competitive markets

→ a market is competitive if the individual agents, be they buyers or sellers, take prices as given

→ when we say take "price as given", we are referring to the market price.

→ of course any buyer or seller can choose ~~a bid~~ any bid or ask price, but in a competitive market, there are lots of buyers and sellers, so if a seller asks a high price, buyers will go elsewhere.

→ Thus it will end up being the case that there is a single market price charged by all sellers

→ they take this price as given

→ The market price is determined by all the market participants' actions together, but it's out of the control of each one individually

→ This market price is the equilibrium price

→ a market eq'm is determined as the point where the actions of the agents in the models are consistent with one another

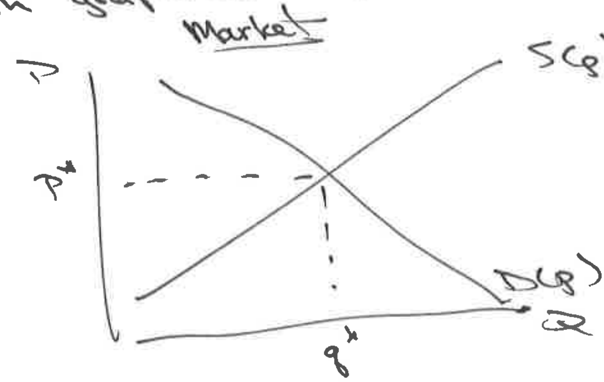
→ The consistency is that the amount demanded equals the amount supplied

→ in equations:

$$\underbrace{D(p^*) = S(p^*)}$$

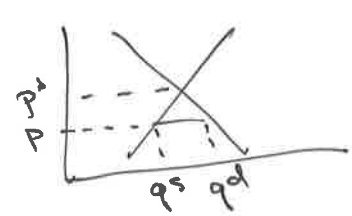
the p^* that solves this is the eq'm price

→ in graphical representation:



→ why is this an eq'm?

→ consider if $p < p^*$

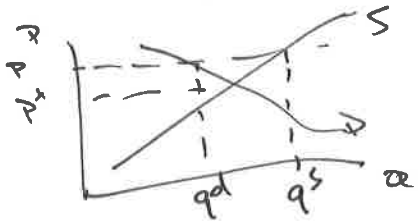


⇒ $q^d > q^s$, a shortage

→ ~~pr~~ sellers could raise prices and still find people to buy their goods

→ all sellers see this and the market price rises

→ consider $p > p^*$



$\Rightarrow q^s > q^d$, a surplus

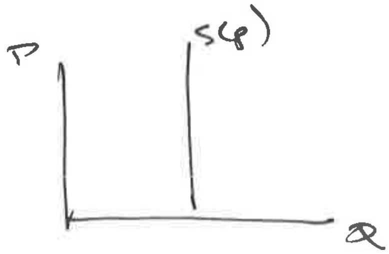
→ sellers lower price to get rid of their excess supply
→ market price is pushed down

→ so mkt price will tend toward the eq'm price

→ Note that the market eq'm is a series of prices (p^*) and quantities $D(p^*) = S(p^*)$

Special cases of market equilibrium

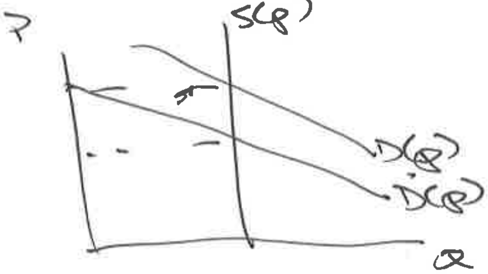
1) Perfectly inelastic supply curve
→ this is where the supply curve is vertical:



→ in this case, the market supply is fixed → it doesn't change as prices change

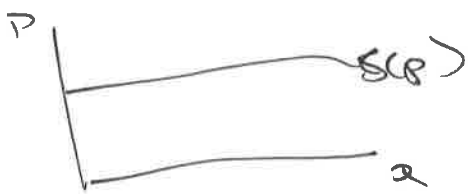
→ so here, market supply determines the eq'm output

→ market price, then, is determined entirely by market demand:



2) Perfectly elastic supply

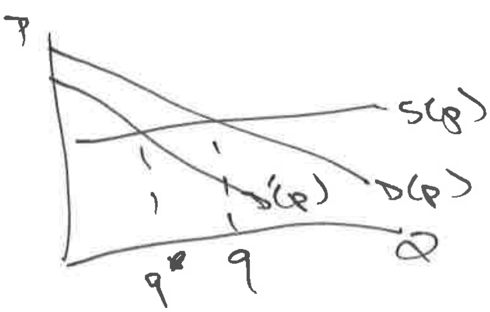
→ this is where the supply curve is horizontal:



→ In this case, the market supplies any quantity at a given price, but zero at all other prices

→ so here, market supply perfectly determines the equilibrium price

→ market demand will determine the eq'm quantity:



Solving for market eq'm

e.g. $D(p) = 100 - 10p$

$S(p) = 10p$

Eq'm condition: $\underbrace{\text{supply} = \text{demand}}_{\text{we call this the "market clearing" condition}}$

$\Rightarrow \underbrace{D(p^*) = S(p^*)}_{\text{solve for } p^*\text{, the eq'm price}}$

$100 - 10p^* = 10p^*$

$100 = 20p^*$

$\frac{100}{20} = p^*$

$\underline{5 = p^*}$

→ to find eq'm quantity, plug p^* into $D(p)$ or $S(p)$

$D(p^*) = 100 - 10p^*$

$= 100 - 10(5)$

$= 100 - 50$

$= 50$

Comparative Statics

→ Δ's in things like income, tastes, or production costs can shift the supply and demand curves

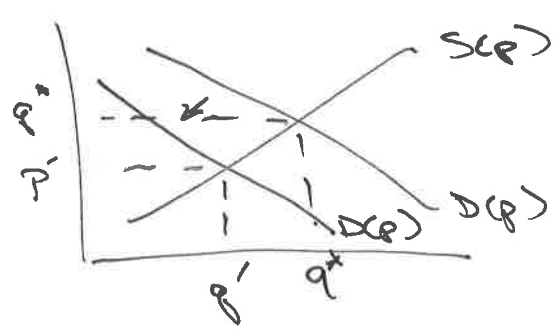
→ <u>comparative</u> statics are how we look at changes in endogenous variables (e.g. price and quantity) as a result of changes in exogenous variables (e.g. changes in income).

→ consider a fall in income for demanders. Now, at any given price, they demand a lower quantity.

e.g. $D(p) = 100 - 10p$

becomes

$D(p) = 50 - 10p$



→ In this case, the eq'm price falls and the eq'm quantity falls

Solving for this analytically, we showed earlier that initial eq'm is: $p^* = 5$, $q^* = 50$

New eq'm is:

$$50 - 10p' = 10p'$$

$$50 = 20p'$$

$$\frac{50}{20} = p'$$

$$2.5 = p'$$

$$\Rightarrow q' = D(p') = 50 - 10p'$$

$$= 50 - 10(2.5)$$

$$= 50 - 25$$

$$= 25$$

Taxes in a Market Eq'm

→ considering taxes in a market eq'm gives us some important insights into how taxes work and market efficiency

→ A tax will act as a wedge between the price a buyer pays and the price the seller recieves

→ consider a quantity tax, such as the federal excise tax on gasoline. The price at the pump includes this tax:

$$P_D = P_S + \text{tax}$$

↑ price per gallon at pump

↖ price per gallon charge by seller

→ similarly, with an ad valorem tax:

$$P_D = (1+\tau) P_S,$$

where τ is the tax rate

→ Consider taxes in a market eq'm.

→ market clearing condition:

$$D(P_D) = S(P_S)$$

$P_S + t = P_D$ → supplier "pays"

→ quantity taxes ⇒ $P_S = P_D - t$

$$\Rightarrow D(P_D) = S(P_D - t)$$

~~Demander pays:~~

→ ~~but taxes also imply~~, $P_D = P_S + t$

$$\Rightarrow D(P_S + t) = S(P_S)$$

→ but this also means $P_D - t = P_S$

$$\Rightarrow \underbrace{D(P_D) = S(P_D - t)}$$

same as above when supplier paid ⇒ no Δ in eq'm for who remits tax

→ another way to see:

→ find inverse demand functions

→ in eq'm w/o taxes:

$$P_D(q^*) = P_S(q^*)$$

→ w/ taxes:

$$P_D(q^*) = \underbrace{P_S(q^*) + t}_{\text{tax "on" suppliers}}$$

$$\rightarrow \underbrace{P_D(q^*) - t}_{\text{tax "on" demanders}} = P_S(q^*)$$

→ the q^* that solves these is the same

→ the "statutory incidence" of the tax is irrelevant for market outcomes.

→ So who "pays" the tax?

→ we need to think about how P_S and P_D change as a result of the tax.

→ Example: linear supply and demand

$D(p) = 100 - 10p$

$S(p) = 10p$

⇒ eq'm w/out tax

$$100 - 10p = 10p$$

$$\Rightarrow p = 5$$

→ eq'm w/ tax:

$D(p_D) = S(p_D - t)$

$D(p_D) = S(p_D - 5)$

⇒ eq'm:

$100 - 10p_D = 10(p_D - 5)$

$100 - 10p_D = -50 + 10p_D$

$150 = 20p_D$

$\frac{150}{20} = p_D$

$\cancel{\Rightarrow P_S = 2.5 + 5 = 7.5}$

$7.5 = P_D$

$\Rightarrow 7.5 - 5 = P_S = 2.5$

⇒

So Price consumers pay went up from 5 to 7.5 → an increase of \$2.5

The price received (after tax) by suppliers went down, from 5 to 2.5 → a decrease of \$2.5

→ so, in this case, they each bear half of the tax

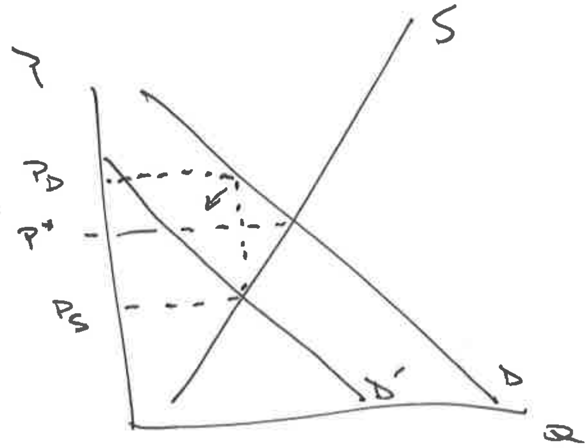
→ true in general?

→ No

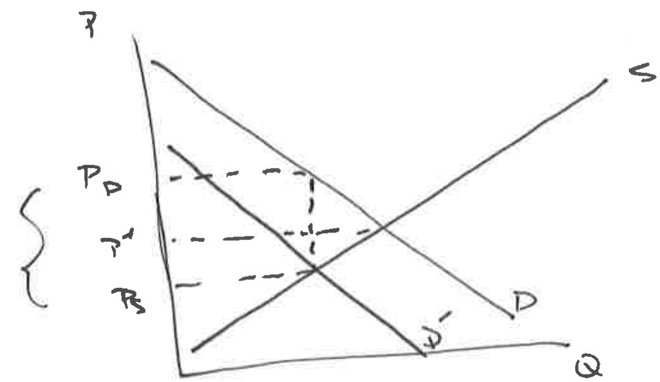
→ depends on relative slopes of demand / supply curves

→ i.e. it depends on elasticities of demand and supply

Consider imposition of a tax, t, w/ 2 diff supply curves:



$P_D - t = P_S$ $\quad t =$



$P_D - P_S = t$

→ w/ steeper S (relative to D), more tax born by sellers

→ w/ flatter S (relative to D), more of tax born by buyers

→ in general, the more elastic parts of the market bear the least of the tax

To see w/ algebra:

consider linear supply and demand:

$$D(p) = a - bp$$
$$S(p) = c + dp$$

in eq'm w/ tax,

$$D(p_D) = S(p_S)$$
$$p_D = p_S + t$$

$$\cancel{D(p_D) = S(p_D -}$$

$$D(p_S + t) = S(p_S)$$

$$a - b(p_S + t) = c + dp_S$$

$$a - c = b(p_S + t) + dp_S$$
$$a - c = (b+d)p_S + bt$$

$$\frac{a-c-bt}{b+d} = p_S$$

$$\Rightarrow p_D = p_S + t$$
$$= \frac{a-c-bt}{b+d} + t$$
$$= \frac{a-c-\cancel{bt}+\cancel{bt}+dt}{b+d}$$

$$p_D = \frac{a-c+dt}{b+d}$$

→ so ~~P_S goes down~~

$$\frac{\partial P_S}{\partial t} = \frac{-b}{b+d}$$

$$\frac{\partial P_D}{\partial t} = \frac{d}{b+d}$$

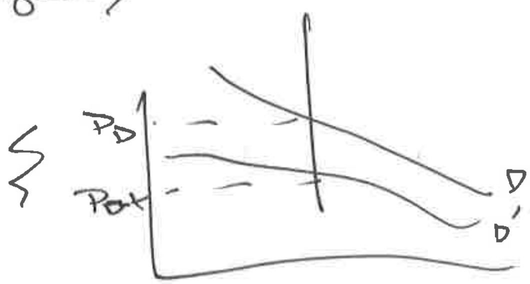
→ if $b > d$, sellers price falls more than buyer's rises

→ if $b < d$, buyers price rises more than seller's falls

→ if $b = d$, then both prices change at the same rate

Special cases

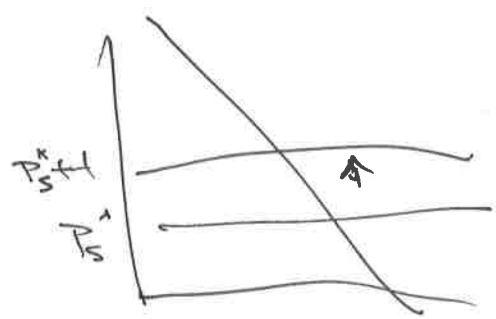
1) Perfectly inelastic supply



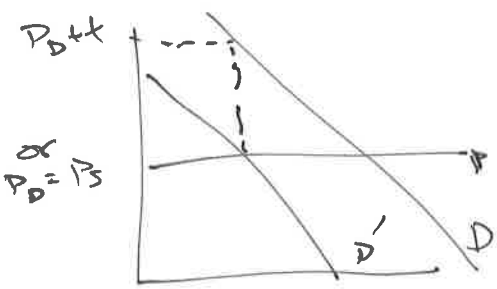
Seller ~~Buyer~~ bears all of tax

→ also note no change in quantity

2) Perfectly ~~in~~elastic supply



or

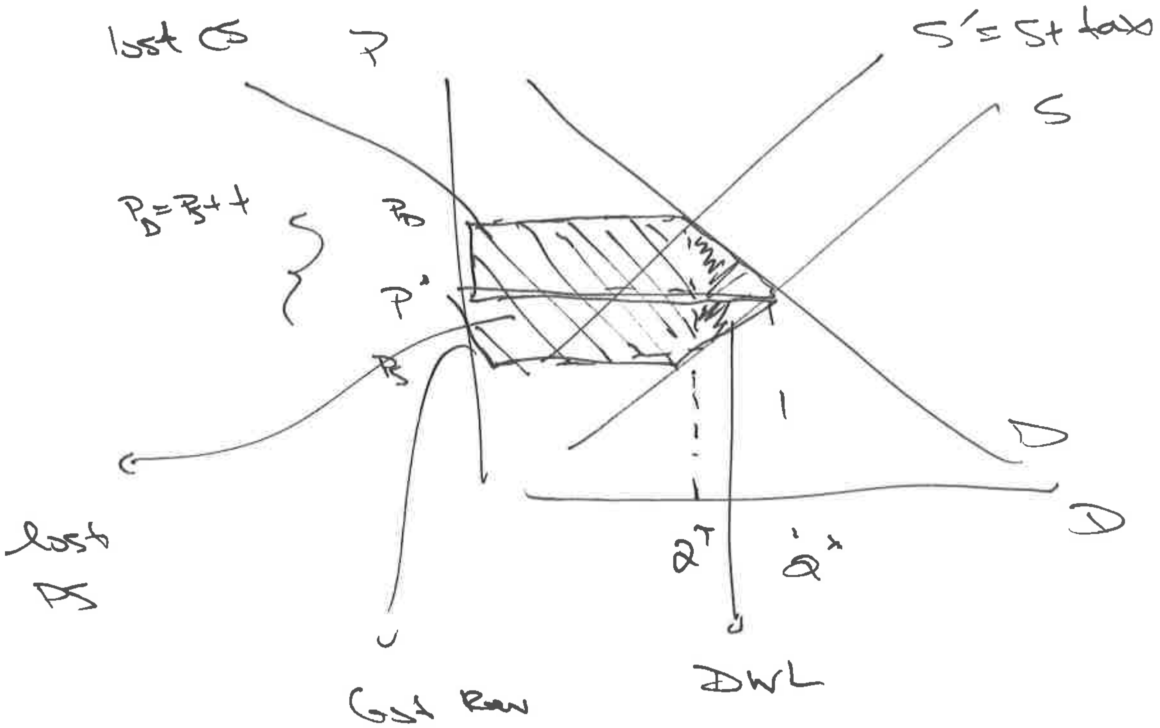


→ tax borne completely by consumers

The Deadweight Loss of a tax

→ Taxes reduce the efficiency in a competitive market

→ See this graphically:

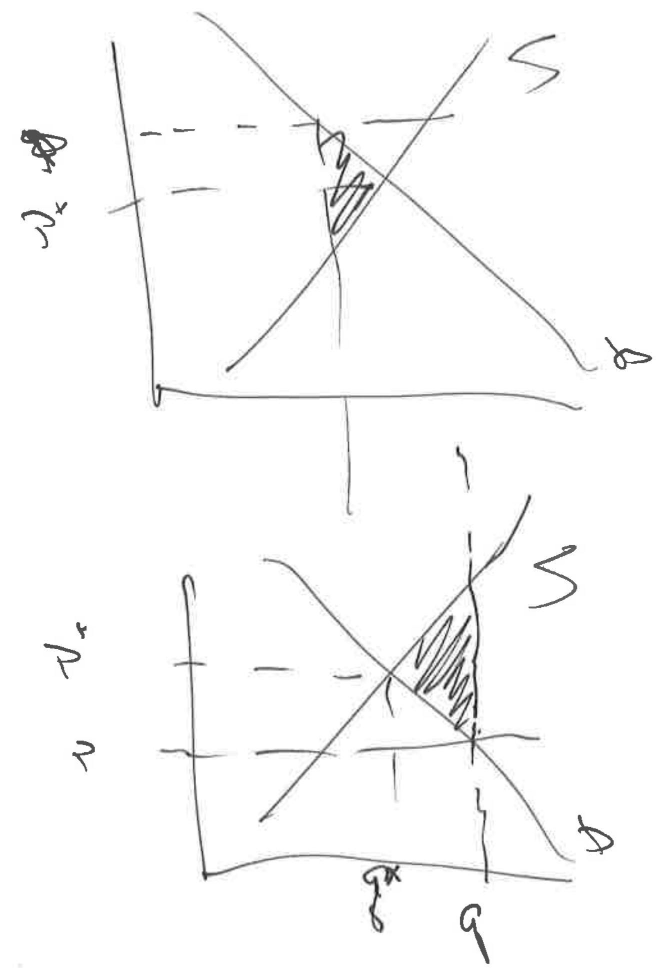


→ DWL also called the excess burden
→ it's the additional burden, above the amount of revenue raised

→ think about why this triangle is a loss
→ it represents transactions that don't happen b/c of the tax, but are transactions where the consumer's willingness to pay exceeds the sellers price they are willing to sell at
→ so we lose out on mutually beneficial transactions

Pareto Efficiency

→ any competitive market outcome is pareto efficient



→ why are prices a good/efficient way to allocate resources?

→ consider the waiting in line example

→ pure DWL b/c no one benefits from time in line