Lecture 9

Production

Firm: an organization that turns input into output

Production Function: $Q = f(input_1, input_2, \dots)$ Indicates how many units of output can be made from combinations of inputs

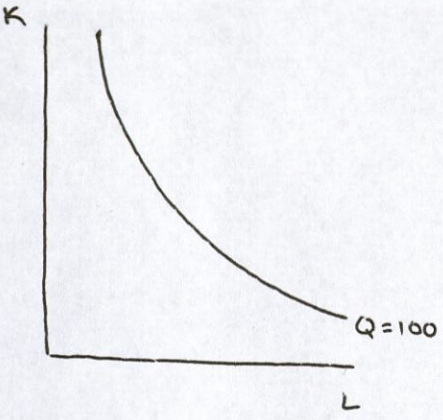
Inputs: - Labor (L)
- Capital (K)

Graphing Production

① Isoquant: a curve that represents all the possible combinations of two inputs that produce the same level of output.

why? - Contractual obligation
- Profit maximizing quantity

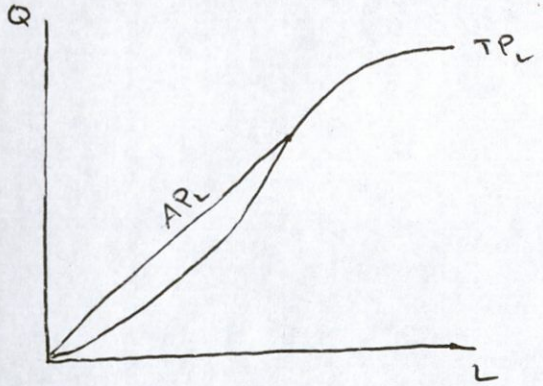
- Quantity increases as you move away from the origin. Not necessarily better, firms want to maximize profit, not quantity.



Marginal Rate of Technical Substitution (MRTS): the number of units of capital the firm can give up for one more unit of labor and still produce the same amount of capital. (Slope of the isoquant)
(between two input combinations or the derivative at one inputs combination)

- MRTS decreases as the firm uses more labor and less capital → diminishing marginal product of labor (and capital)

Total Product (TP) Graph



- Graph represents how total output (TP → Q) is affected by changing labor (L) while holding capital (K) constant

- Marginal Product (MP): the extra amount of output produced by one additional unit of an input
(= slope of the Total Product curve)

$$MP = \frac{\Delta Q}{\Delta L}$$

- Average Product (AP): the amount of output generated by adding one more unit of an input
on average
(= slope of the line from origin to TP point)

$$AP = \frac{Q}{L}$$

- Slope of the TP curve:

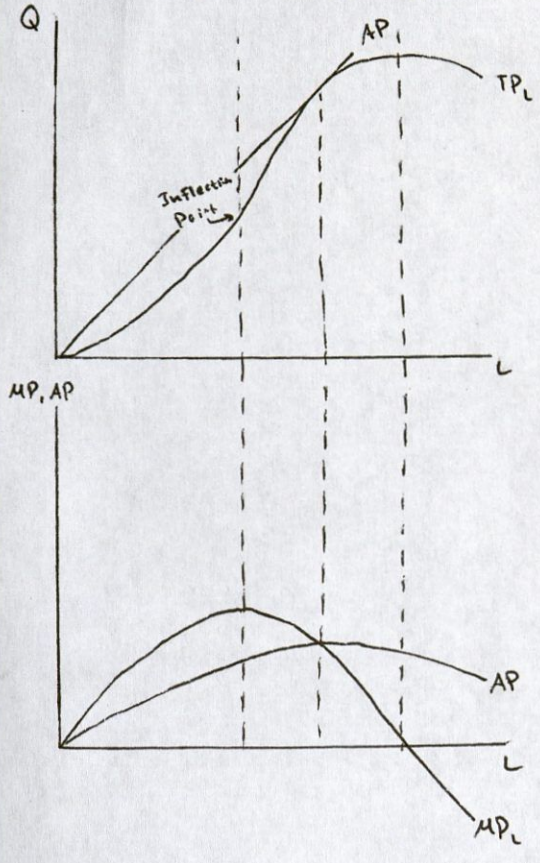
① TP increases at an increasing rate because at low quantities of labor, every extra worker can increase Total Output faster. (Marginal Product → Increasing)
MP (positive, increasing)

② After inflection point, TP increases but MP begins to decrease (stays positive) because additional labor becomes less productive.
MP (positive, decreasing)

③ Eventually, TP plateaus and marginal product actually decreases, becomes negative ("too many cooks")
MP (negative)

• We assume that every worker has the same underlying productivity, so differences are based on when they are hired.

Graphing Marginal and Average Product (MP & AP)



- Marginal Product (MP) is the slope of the Total Product (TP) curve. So, MP curve makes at the inflection point, and then it decreases. Once TP starts to decrease, MP becomes negative.
- Average Product (AP) will always be positive because you can't have negative production.
  AP makes at the point where Marginal Product = Average Product, MP = AP. That is where AP is tangent to ~~AP~~ TP. This is because before that point, additional labor increases average product, and after it, additional labor decreases average product.
- AP follows MP, but more slowly. If MP is rising, so is AP, but it is brought down by the units of labor that were less productive. MP will fall after inflection point, but because those additional units of labor are more productive than some of the firsts. AP continues to rise. After MP = AP, additional units of labor bring AP down... But, AP will now become negative.

Changes to TP, MP, and AP

- If a firm changes their amount of capital, it will affect TP, MP, and AP. With more capital, the firm is more productive, as is each worker. So, TP, MP, and AP all increase. Practice graphing.
- Technology improvement: when technology improves, each quantity of labor will be able to produce more. Thus, isoquants will shift inward, because it takes fewer units of inputs to produce the same quantity of output. Also, you can produce more output with the same combination of inputs. You don't necessarily want to produce more, due to contractual obligations / profit maximization.

Lecture 10

Costs

Types of Costs:

① Opportunity Cost: the value of the next best alternative

② Accounting Costs: the amount paid for resources directly

③ Economic Costs: the amount required to keep something in use, including opportunity and accounting

Firm Goals:

① Cost Minimization: given a desired amount of output, what is the cheapest way to produce it.

② Profit Maximization: given your per-unit input costs, what quantity of output maximizes profit.

Total Cost Formula

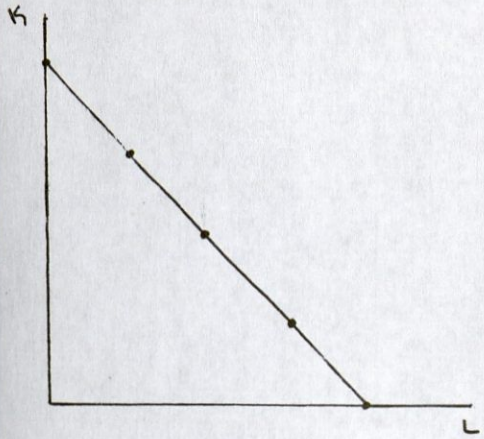
$TC = P_K K + P_L L$

where: P_K: Price of capital
K: capital
P_L: Price of labor
L: labor

* Given a desired output level, a set of combinations, and prices, choose whichever combination would be cheapest by this formula

Isocost Curves

Isocost curves represent sets of combinations of factors of production (inputs) that cost the same.



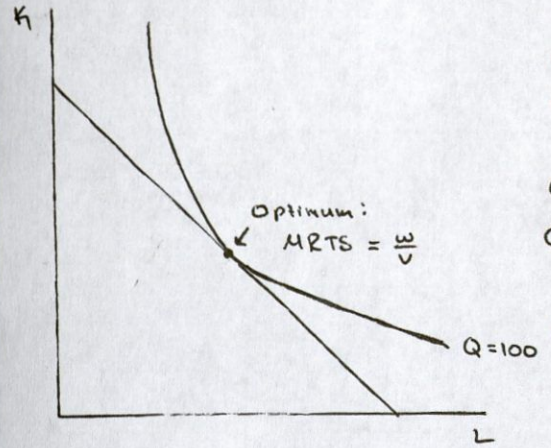
- Slope = Input Price Ratio $\left(-\frac{P_L}{P_K}\right)$

$$\text{Slope} = -\frac{P_L}{P_K}$$

- P_K is also called the "rental rate of capital", v
  P_L is also called the "wage", w
- So, Slope $= -\frac{w}{v}$
- Intercepts: $\frac{TC}{P_K}$ and $\frac{TC}{P_L}$

* The isocost/firm problem entails Q, P_K, and P_L as given, the goal is to minimize TC given these parameters

Cost Minimization



Cost Minimization Problem:

① The output level, Q, and P_K/P_L are given.
So, first draw the isoquant.

② We know the slope of the isocost curve will be $-\frac{w}{v}$

③ Draw isocost curve out from origin with that slope, fix such that it is tangent with isoquant.

④ Here is the optimum, where $MRTS = \frac{w}{v}$ (that is, the firm is able to substitute L for K at the same rate that the market will allow it to.)

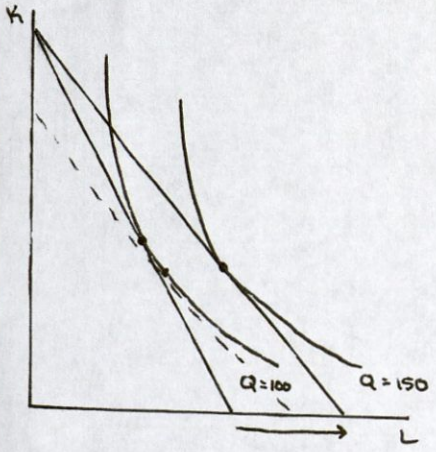
$$MRTS = \frac{P_L}{P_K} = \frac{w}{v}$$

- No other combination of inputs that cost the same will produce as much
- No other combination of inputs that produces that much will cost as little

$$MRTS = \frac{\Delta L}{\Delta K} = \frac{MP_L}{MP_K} = \frac{w}{v}$$

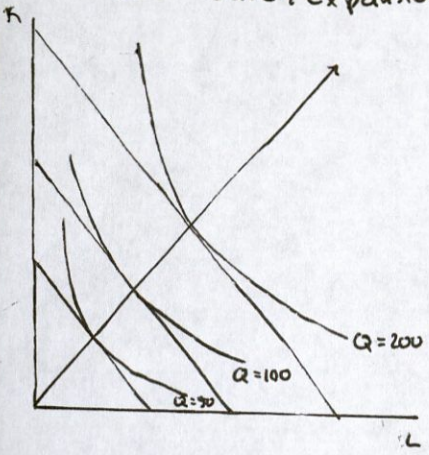
Changes in Input Prices

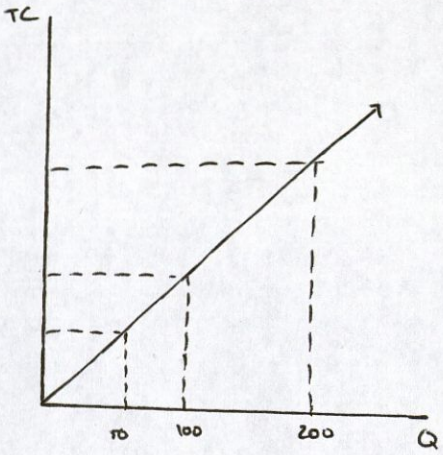
Example: Price of labor decreases, $P_L \downarrow$



- If $P_L \downarrow$, the firm can produce a high quantity of output, Q, for the same total cost, TC.
- If the firm decides to produce the same quantity, it will substitute towards labor because the price has fallen, thus, it has become relatively cheaper.
- To find that point ↗ draw an isocost curve with the slope that represents the new prices / price ratio, and find new optimum

Total Cost Curve / Expansion Path





Lecture 11

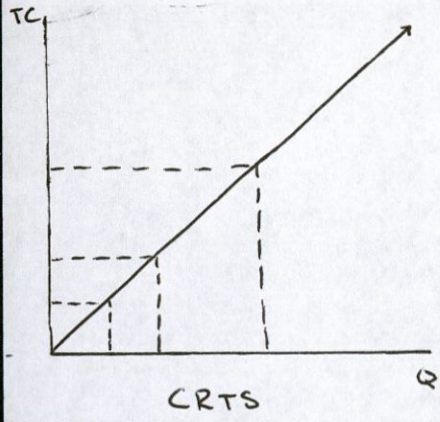
Profit Maximization

Returns to Scale: describes the result of increasing both inputs (labor and capital) proportionally in terms of output

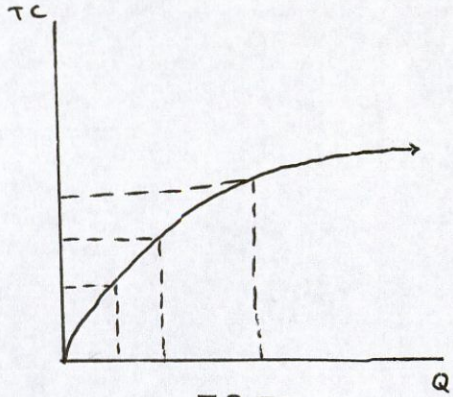
Constant Returns to Scale: the change in output is identically proportional to the change in input.
Double input → double output. (i.e. double costs → double output)
Resulting TC will be a straight line.

Increasing Returns to Scale: the change in output is greater than the change in input.
Doubling input leads to more than doubling output. This can happen if a firm becomes better at producing as it scales.
Resulting TC resembles square root function.

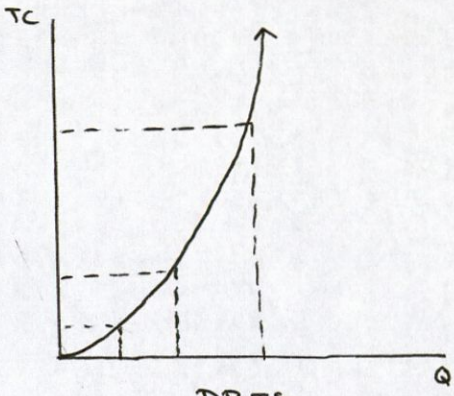
Decreasing Returns to Scale: the change in output is smaller than the change in input.
Doubling input leads to less the double output. This can happen if efficiency is lost as a firm scales.
Resulting TC resembles an exponential function.



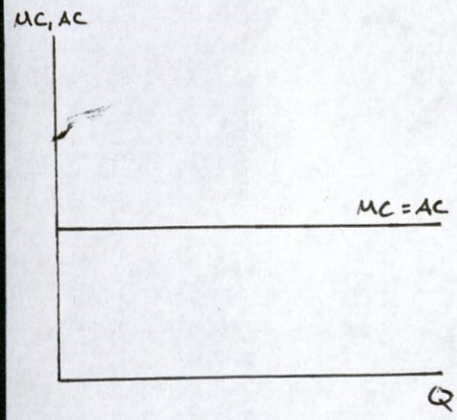
CRTS



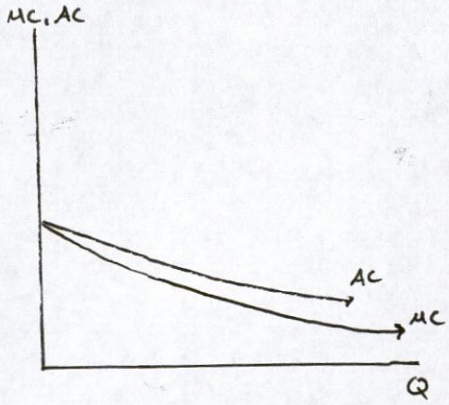
IRTS



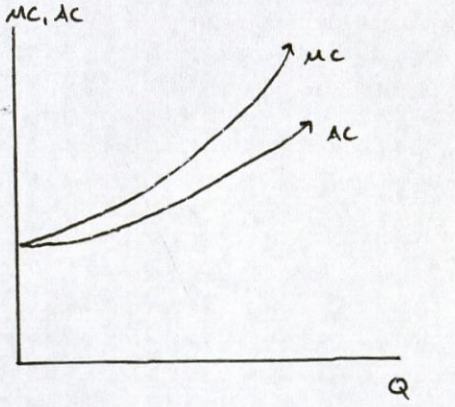
DRTS



- For CRTS, the marginal cost and average cost will be the same because all units cost the same
- So, MC=AC, will be the same, linear, horizontal line

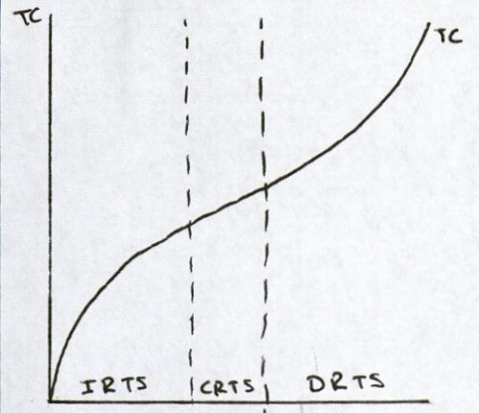


- Because TC diminishes, for IRTS, MC diminishes as each additional unit is less expensive than the previous
- AC also falls, but at a low rate because it accounts for the initial units that were relatively more expensive



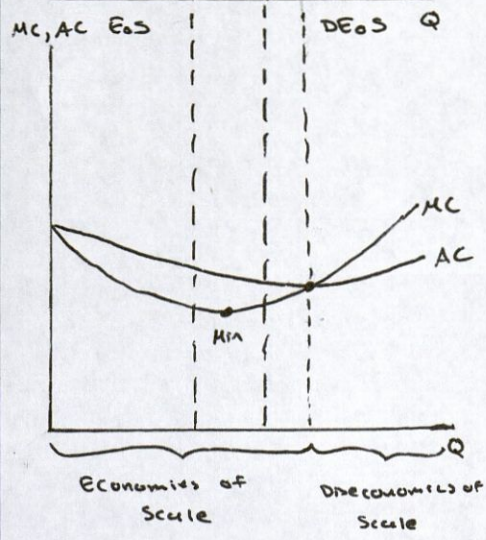
- For DRTS, TC increases at an increasing rate, so MC rises continuously, as each unit is more expensive than the previous
- AC also increases, but at a low rate because it accounts to the initial units that are relatively less expensive

Changing Returns to Scale



What firms actually face is something like this:

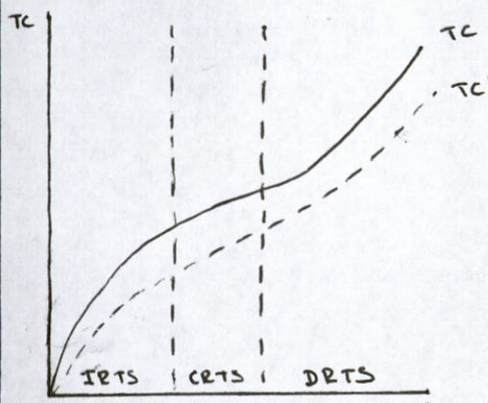
- Increasing returns to scale at low levels of output
- Constant returns to scale over some range (or maybe just an inflection point)
- Decreasing returns to scale at larger levels of output
- Economies of Scale: occur when increasing output lowers average cost
  Diseconomies of Scale: occur when increasing output increases average cost



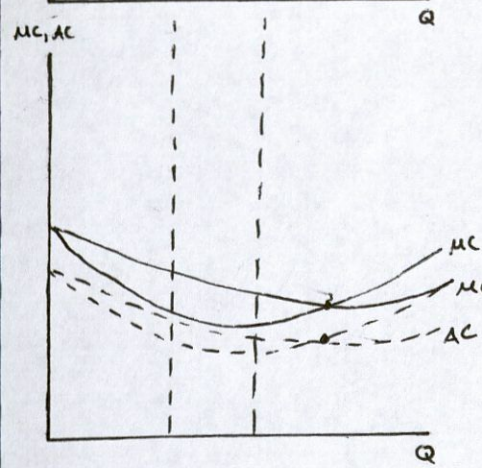
- In the zone of IRTS, MC and AC are falling because production is becoming more efficient
- In CRTS, MC is roughly constant, however, AC is not because
- MC then increases in the zone of DRTS because production is less efficient
  * MC is minimized in the CRTS zone
- Economies of scale occur to the left of the point at which AC is minimized, while
  Diseconomies of scale occur to the right of the point at which AC is minimized
  * Minimum Efficient Scale (MES): the point at which average cost is minimized. This is where average cost, AC and MC intersect.

Changes in Input Price

Example: Price of labor falls (see isocost/isoquant previous example)



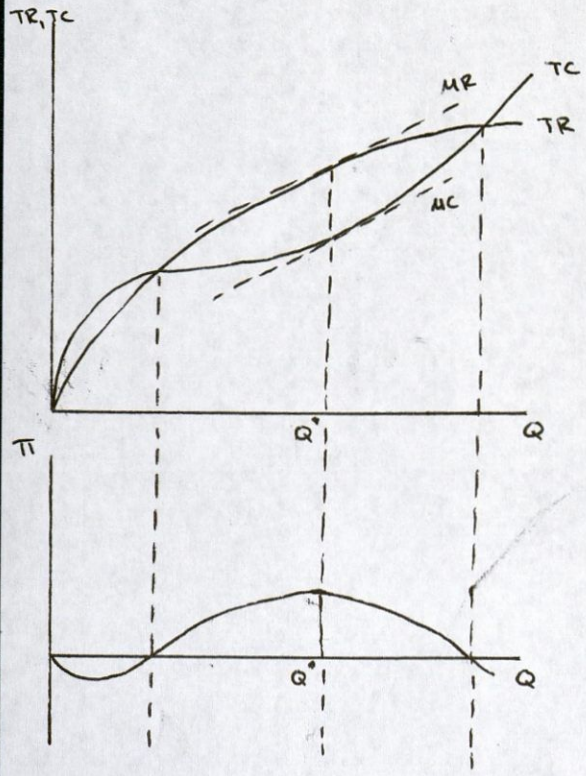
A decrease in the input price of labor lowers TC at all quantities, so the TC curve shifts downwards. MC & AC curves also shift downwards.



Profit

Profit = Total Revenue - Total Cost

$\pi(q_s) = TR(q_s) - TC(q_s)$



- TC exhibits the changing returns to scale curve unit derived
- TR here exhibits diminishing returns, due to market saturation
- $\pi = TR - TC$, so π = distance between the TR and TC curves
- Profit is maximized where MR = MC

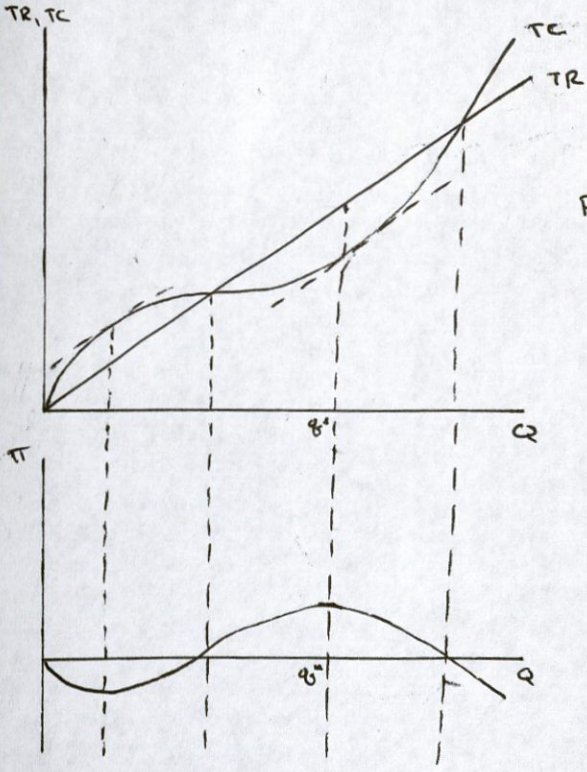
  MR & MC are the slopes (or derivatives) of TR and TC curves. They are parallel where π is maximized, greatest distance between TR and TC curves.

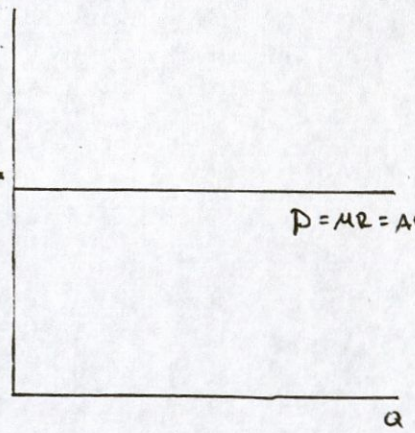
  - If MR > MC, producing the next unit increases profit
  - If MC > MR, producing less output increases profit

* Notice that MR = MC at a point where TC > TR, where profits are negative. This is why profit is maximized!

Price-Taking Firms

We will be working under the assumption that firms are price-taking firms in a perfectly competitive market. Meaning, no firm has the power to affect the market price. As a result, each firm must take the price as given.





Thus, Total Revenue = Pq_s

Marginal Revenue = P

$TR = Pq_s$

$MR = P$

So, firms face a perfectly elastic (horizontal) demand curve at P^*.

Here, TR is a straight line, and MR is on the TC line.

Profit maximization is still where MR = MC

Lecture 12

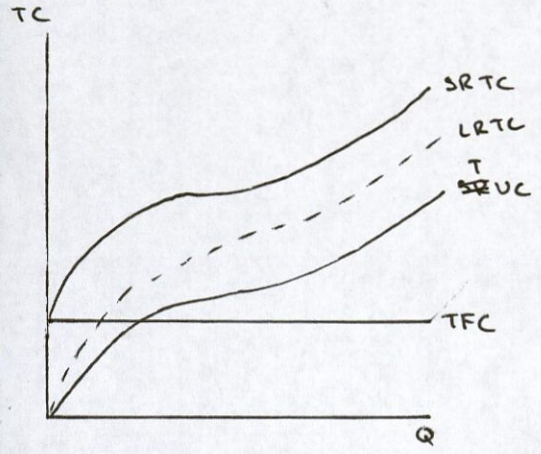
Supply Curves

Short-Run vs. Long-Run

Short-Run will be defined as a period of time during which labor is variable, while capital is fixed.

Long-Run will be defined as a period of time during which all inputs (here, labor and capital) are variable. There are no fixed costs.

Example of Price of Labor, P_L, w decreasing: Because capital, $\bar{K}$, is fixed in the short-run, the input combination wouldn't change if the firm wants to keep the level of production, because it is the only combination with $\bar{K}$ that produces q_0. TC will decrease because of cheaper labor, but because isocost and isoquant are no longer tangent, firm is no longer optimizing.



Short-Run Total Cost: the total cost of producing a given quantity in the short-run

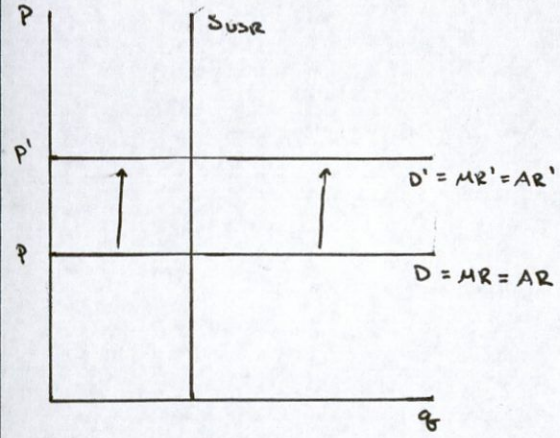
Total Variable Cost: the total costs associated with inputs that are variable in the short-run

Total Fixed Cost: the total costs associated with inputs that are fixed in the short-run

Long Run Total Cost will always be low than short-Run Total Cost at any given quantity because inputs can be optimized due to being variable.

$SRTC = TFC + TVC$

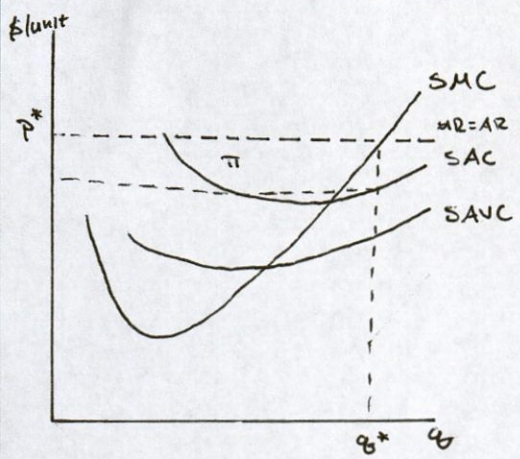
Firm's Supply Curve in the Very-Short-Run (when both K and L are fixed)



In the very-short-run, neither K nor L are variable. So, the supply curve is perfectly inelastic. Meaning, quantity doesn't change in response to price changes.

$P = MR = AR$

Firm's Production in the Short Run



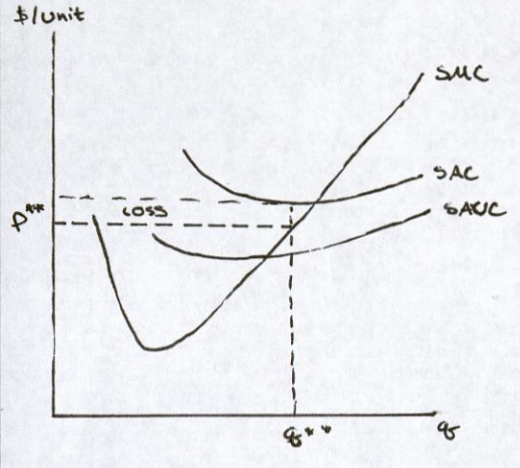
- Market price is p^*
- In the short run, the firm will adjust labor (variable input) in order to produce quantity q^* where $P = MR = MC$
- Finding profit: $\pi(q) = TR - TC$

  $TR = P * q$

  $TC = SAC(q^*) * q^*$
- Difference between SAC and SAVC is the AFC ($TC = TVC + TFC$)

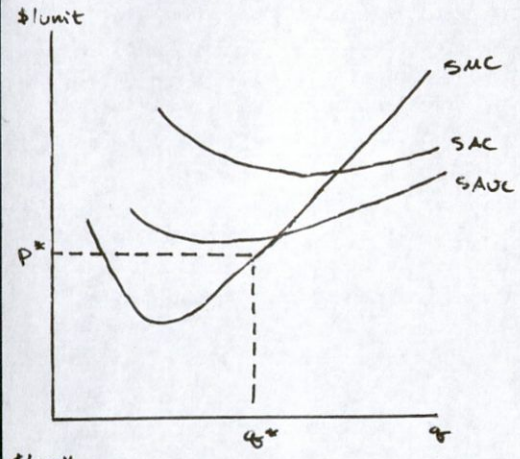
  $AC = AVC + AFC$

  This gets smaller as more quantity is produced because it is fixed but gets spread over more units

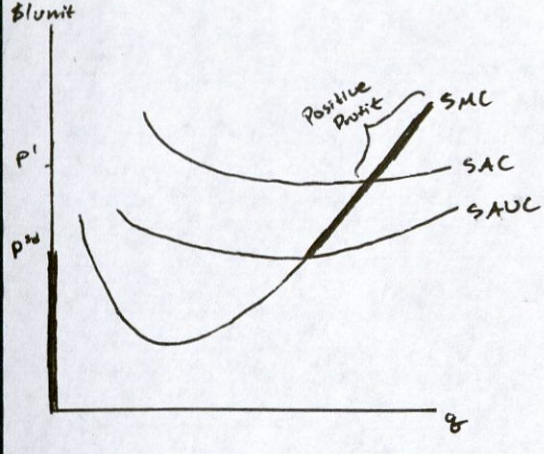


- If price falls to p^{**}, the firm will produce q^{**} where $MR = MC$
- Because $TC > TR$, the firm will make a loss, this is represented graphically by the $P = AR = MC$ line being below the SAC when it intersects with the SMC line (i.e. $SAC(q^{**}) > p^{**}$)
- Despite resulting in a loss, this is still a profit maximizing point where $MR = MC$. The firm would lose money producing more and would be able make more profit if they were producing less
- Acceptable losses: This situation would be considered acceptible losses, because no other quantity > 0 would minimize losses more effectively. Also, revenue exceeds variable costs, so the firm can still pay some of its fixed costs and variable costs. As long as a firm can recoup variable costs, it will produce.

Shutdown

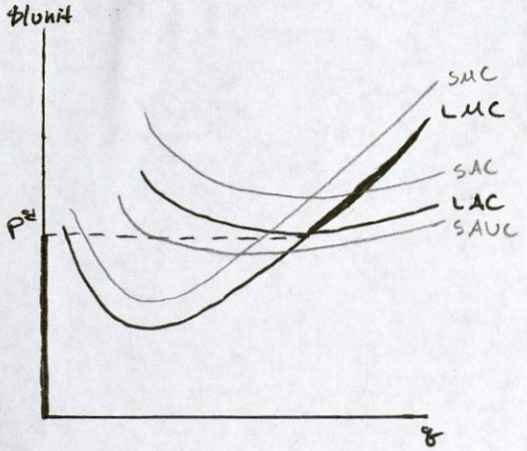


- If p^* falls below SAVC, the firm should shut down because it is better to lose fixed cost alone, rather produce where $MR = MC$, which creates loss on variables costs + fixed costs
- Shutdown Price: the price at which a firm is exactly indifferent between producing nothing ($q = 0$) and producing something (q where $MR = MC$). This is where $MR = AVC$ ($< P$). Here, the firms still makes a loss on fixed costs, and is exactly able to cow variable costs. (written as p^{sd})



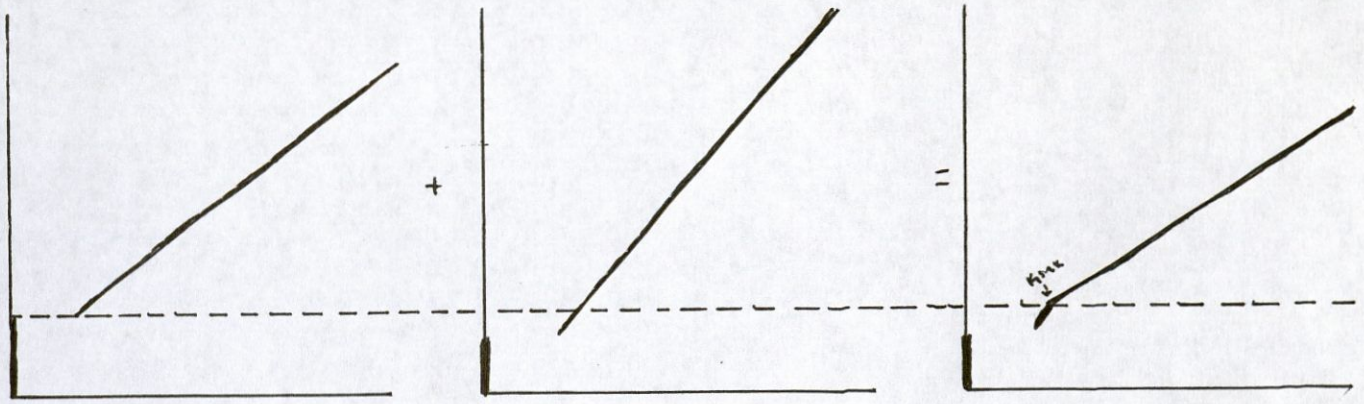
- Dark line represent the firm's short-run supply curve
- If $P > p'$, the firm produces at quantity, q^*, such that $MR = MC$ and will make a positive profit
- If $p^{sd} < P < p'$, the firm produces at quantity, q^*, such that $MR = MC$ but will make a loss
- If $P < p^{sd}$, the firm will shutdown and produce $q = 0$

Firm's LR Supply Curve



- In the long-run, the firm has only one average cost curve, because all inputs are variable (no distinction between variable/fixed costs or curves)
- It will be below SAC because the firm can optimize all factors of input, leading to lower costs. It will be above SAVC because it incorporates fixed costs.
- The firm will not accept monetary losses in the long-run, so the p^{LR} is where LAC is minimized.

Aggregate Market Supply



- Firm in aggregate supply curve results from the fact that the firms have different shutdown prices

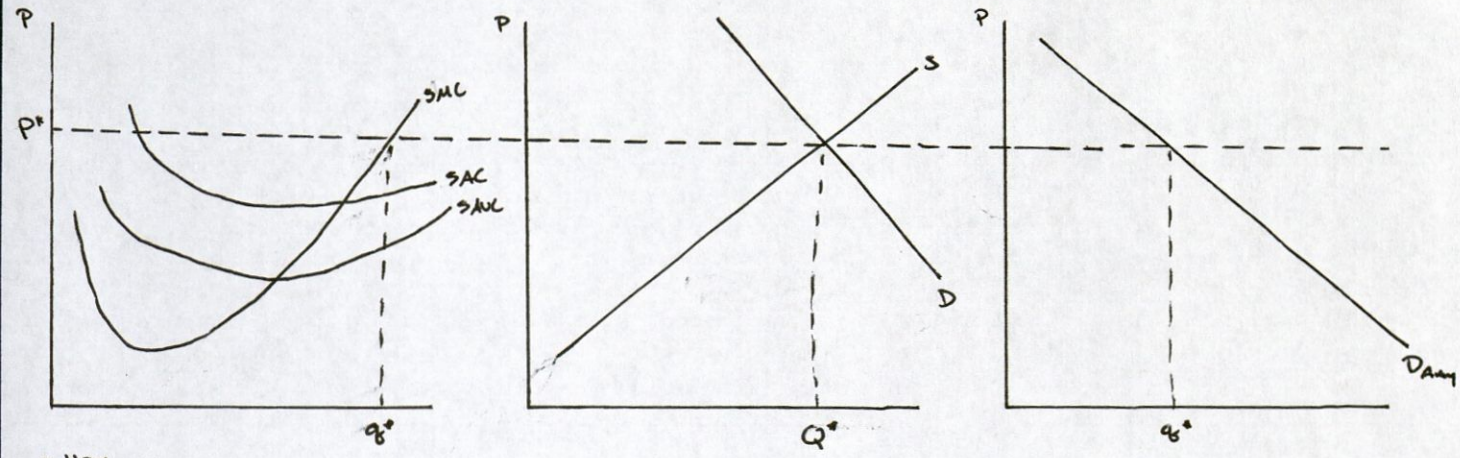
Lecture 13

Competitive Equilibrium

Market Equilibrium: where the amount producers want to sell matches the amount that consumers demand.
At the equilibrium, neither party has incentive to change their behavior.

Equilibrium Price: (P^*) is the price that sets $Q^S = Q^D$

Competitive Equilibrium



- Here, the intersection of market demand and market supply signal produces how much to demand/supply

Shifts in Supply and Demand

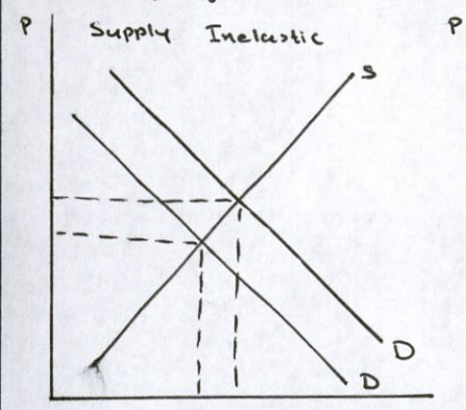
Demand shifts outward due to:
- Income increases
- Price of substitute rises
- Price of complement falls
- Preferences for good increases

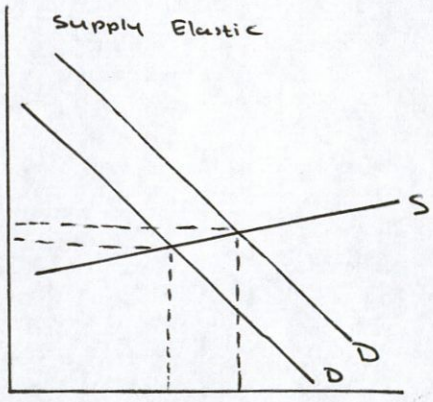
Demand shifts inward because:
- Income falls
- Price of substitute falls
- Price of complement rises
- Preferences for good increases

Supply shifts outward due to:
- Price of input falls
- Technology improves
- New source of inputs discovered

Supply shifts inwards due to:
- Price of input rises
- Technology
- Stock of inputs destroyed

* Unless both S & D shift,
a shift in S means a movement along D, and
a shift in D means a movement along S

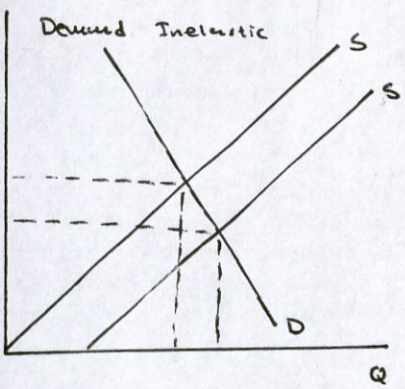


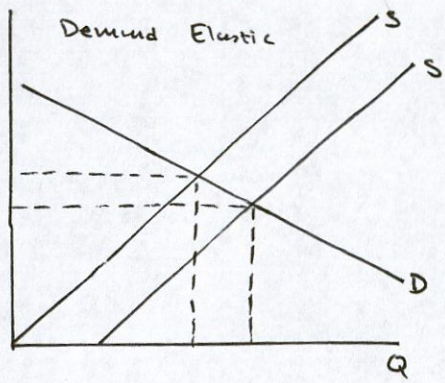


Supply Elasticity:

$$\mathcal{E} = \frac{\Delta Q/Q}{\Delta P/P}$$

- Supply elasticity is usually positive; an increase in price causes firms to supply more





Firm Entry and Exit

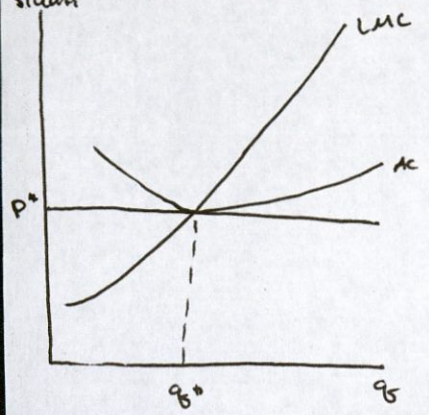
- Firms will enter market as they see other firms profits, and firms will leave market if they make losses
- If we assume that there are no barriers to entry, this will hold true
- This, in the long-run of a perfectly competitive market, Profits = 0

- At long-run competitive equilibrium:

$$P = MR = MC = AC = AR = P$$

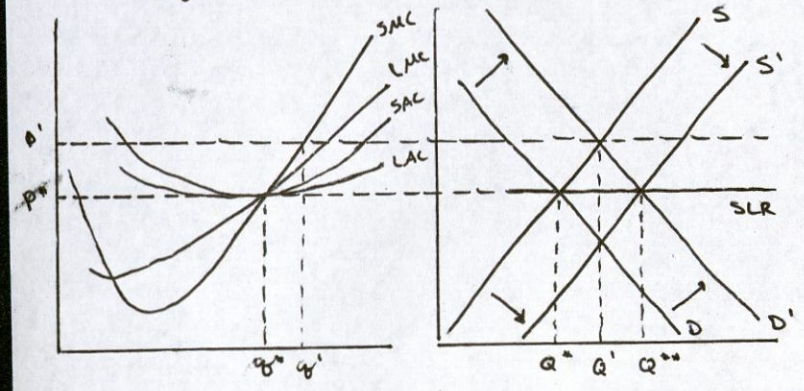
- $P = MR$: firms are price-taker at constant price
- $MR = MC = AC$: optimization; $\pi = TR - TC$, $A\pi = AR - AC$, $\pi = 0$, ...?...
- $AR = P$: price is constant

Long-Run Cost Curve



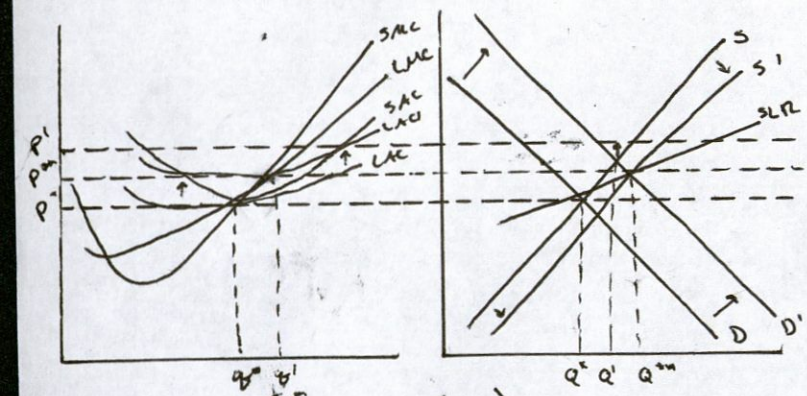
External Price Effects

- When firms enter and exit the market, it changes the supply curve, entrance → shifts out, exit → shifts in
- Firms entry and exiting the market also effect the markets for input goods (capital and labor) When firms enter, it shifts their aggregate demand curve out, and when firms exit, it shifts their aggregate demand curve in.



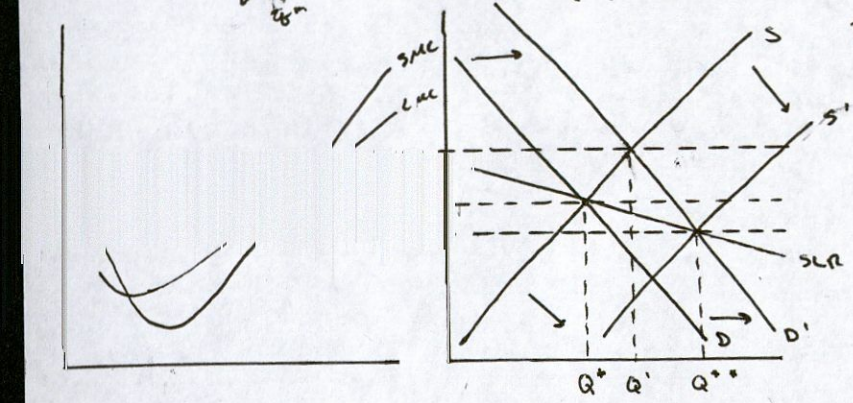
Constant Cost Industry

- Increase in market demand shifts the demand curve out
- Firm this makes some profit
- Entrance of new firms shifts the market supply curve out
- Constant cost industry, so the cost structure stays the same, equilibrium is at the same price as before, and the firm settles back to its original quantity
- SLR is highlighted, and will be at higher quantity



Increasing Cost Industry

- Increase in market demand shifts the demand curve out
- Firm makes profit as the price rises
- Firms enter the market, shifting the supply curve out, but this raises costs, so, LAC raises up, so the new equilibrium point has price P^{**}, which is above P^* and below P'
- Long-Run supply curve is upward sloping, because price is higher and additional firms means quantity



Decreasing Cost Industry

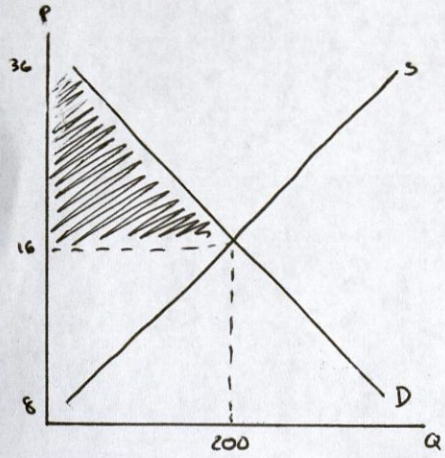
- Increase in market demand pushes the market demand curve out
- Firm makes profit, new firms enter the market, shifting the supply curve out
- Additional firms reduce costs because of network effect so AC lowers
- Long run supply curve is downward sloping because new equilibrium point has a lower price and higher quantity

Lecture 14

Taxes and Welfare Analysis

- We can think of the market supply curve as the "social marginal cost" curve: it tells us the opportunity cost of the resources used to produce one more unit
- Likewise, the market demand curve is the "social marginal benefit" curve: it tells us how the last unit produced is valued by customers
- At the market equilibrium, social welfare is maximized because MB = MC

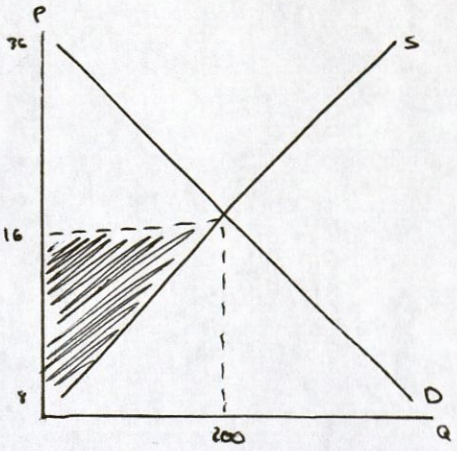
- Competitive Equilibrium: price-quantity combination that yields maximum social benefit, i.e., surplus is as large as possible. There is no DWL.
- DWL → Efficiency loss



Consumer Surplus: the total value of surplus that consumers derive from the market price being less than what they would be willing to pay

$CS = \frac{1}{2}(36-16)(200) =$

$CS = \$2000$



Producer Surplus: the total value of surplus that producers derive from the market price being more than what they would be willing to pay

$PS = \frac{1}{2}(16-8)(200) =$

$PS = \$800$

Supply and Demand shifts

In a linear supply and demand environment, shifts in the supply and demand curve will cause CS & PS to change in proportionally identical (percentage term) amounts

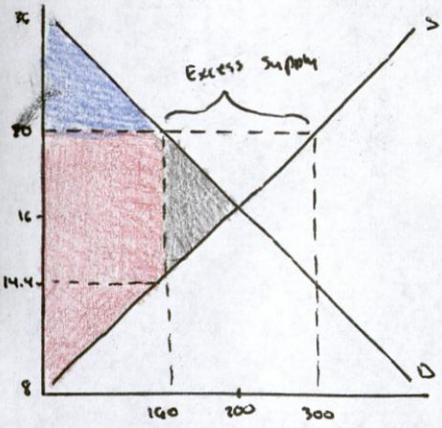
Total Surplus

$TS = CS + PS$

Total surplus measures the welfare of economic actors at any price-quantity combination.

$TS = \$2800$

Price Floors and Excess Supply



- Price floor is a ~~maximum~~ minimum that a price can be
- Here, $P = \$20$
- $Q_D(\$20) = 160$
- $Q_S(\$20) = 300$
- Excess Supply = 140
- Intermediate Price: the price at which suppliers would be willing to supplying 160 units, which is \$14.40

Consumer Surplus:

$CS' = (\frac{1}{2})(36-20)(160) = 1280$

$CS = \$2000 \quad CS' = \$1280$

$TS' = CS' + PS'$

$TS' = 1280 + 1408 = 2688$

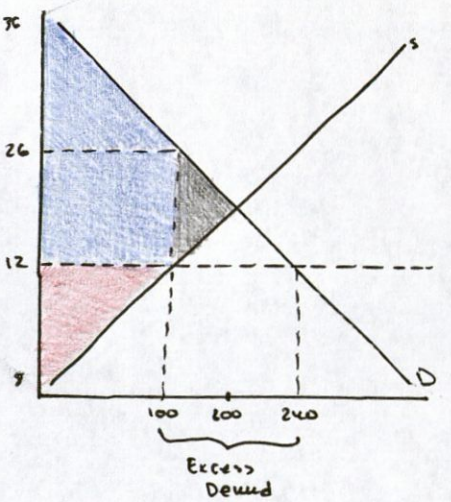
$TS - TS' = \$112 \rightarrow$ DWL

Producer Surplus:

$PS' = (160)(20-14.4) + (\frac{1}{2})(14.4-8)(160) = 1408$

$PS = \$800 \quad PS' = \$1408$

Price Ceilings and Excess Demand



- Price ceilings is a maximum that a price can be
- Here, $P = \$12$
- $Q_D(\$12) = 240$
- $Q_S(\$12) = 100$
- Excess demand = 140
- Intermediate Price: the price at which consumers would be willing to buy 100 units, which is \$26

Consumer Surplus:

$CS' = (\frac{1}{2})(26-26)(100) + (26-12)(100) = \$1400$

$CS = \$2000 \quad CS' = \$1400$

$TS' = 1900 + 200 = \$2100$

$TS - TS' = 2800 - 2100 \quad$ DWL = \$700

Producer Surplus:

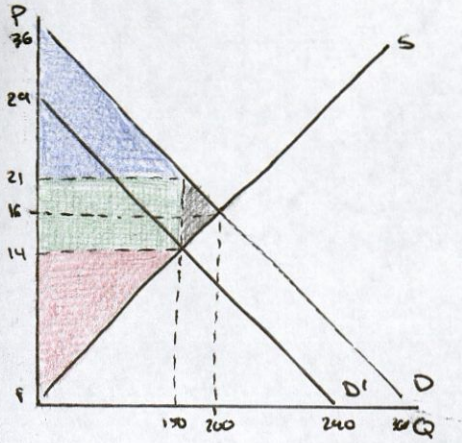
$PS' = (\frac{1}{2})(12-8)(100) = \$200$

$PS = \$800 \quad PS' = \$200$

Taxes

- Remittance: who actually sends the money to the government
- Statutory Burden: who does the government say pays the tax
- Tax Incidence: to what degree does each party see their surplus reduced?

Example: government imposes a tax of $7/unit of a good



- Because of $7 tax,

$P^D = P^S + 7$

So now, $Q_D = 360 - 10P^D$

$Q_D = 360 - 10(P^S + 7)$

$Q_D = 290 - 10P^S$ $\quad P^S = 29 - \frac{Q^D}{10}$

Supply: $Q_S = 25P^S - 200$

New Equilibrium: $Q^S = Q^{D'}$

$25P^S - 200 = 290 - 10P^S$

$P^S = 14$ $\quad P^D = P^S + 7 = 21$

$Q_D = 360 - 10(21) = 150$ $\quad 290 - 10(14)$

$Q^S = 25(14) - 200 = 150$

Consumer Surplus:

$CS = (\frac{1}{2})(36-21)(150) = \$1,125$

Producer Surplus:

$PS = (\frac{1}{2})(14-8)(150) = \$450$

Tax Revenue:

$TR = (21-14)(150) = \$1050$

Total Surplus:

$TS = CS + PS + TR$

$TS = (1,125) + (450) + (1050) = \$2625$

DWL: $TS - TS' = 2800 - 2625 = \$175$

* Taxation causes markets to fail to clear. Causes inefficiencies and DWL. The bigger the tax, the bigger the DWL.

Tax Burden: equal to the lost surplus of each party

CTB = 2000 - 1,125 = $875

PTB = 800 - 450 = $350

CTB → gov't = $(\frac{1}{2})(21-16)(150) = \$750$

→ DWL = 875 - 750 = $125

PTB → gov't = $(\frac{1}{2})(16-14)(150) = \$300$

→ DWL = 350 - 300 = $50

General Rule of Tax Incidence: Tax burden will fall on the party that is more inelastic, when?