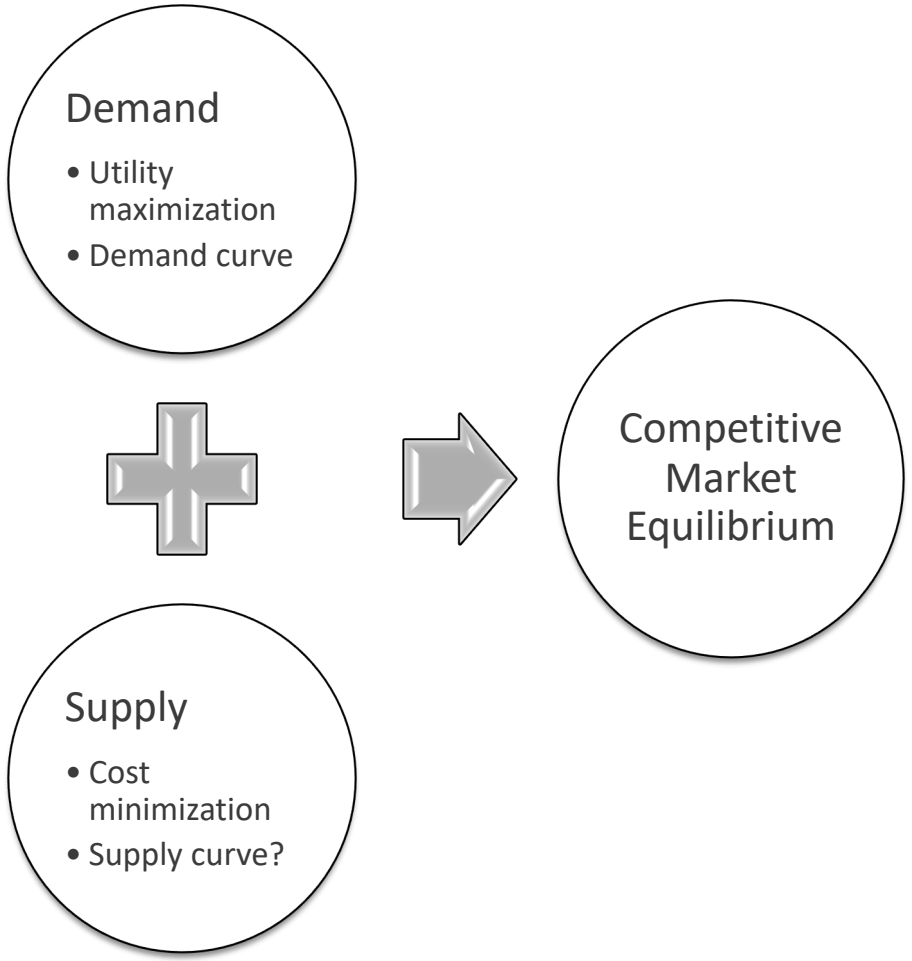
LECTURE 10
PERFECT COMPETITION IN THE SHORT RUN

The Big Picture



Where are we?

- Production function
  - How firms turn *L* and *K* into *Q*
- Cost-minimizing choice of *L* and *K*
  - Cost curves in the short run and long run
- Optimal choice of *Q*
  - At any given price, how much output should the firm produce?
- Firm's supply curve
  - Output *Q* as a function of market price

here we took output Q as given

Part 1

Short-Run Supply Curve

What is a perfectly competitive market?

hard to find a perfectly competitive market in real life

but we have markets that are close to this kind, can be considered as competitive markets, e.g. markets for agricultural goods.

- The industry is fragmented
  - Thus firms and consumers are *price takers*

many small producers and consumers, cannot influence market price on their own, too small to affect the entire market

- The product is homogeneous
  - Products produced by different firms are the same
- Perfect information about prices
  - Thus there will be a single market price
- Equal access to resources
  - Everyone has access to the same technology and inputs
  - Thus the market is characterized by *free entry*

no entry barrier

Example: Catfish Farming Industry in US

- The industry is fragmented
  - There are over 1000 catfish farms
- The product is homogeneous
- Perfect information about prices
- Equal access to resources
  - Production technology is well understood

Short Run vs. Long Run

- In the short run
  - At least one input is fixed
  - Firms choose output to maximize profit
- In the long run
  - All inputs are adjustable
  - Firms choose output to maximize profit
  - Firms decide whether to exit/enter the market

capital fixed

In the SR, the firm can produce, choose how much to produce to max profits. But they CANNOT leave this market. It can choose not to produce (temporarily shut down production), but cannot completely withdraw from the market coz the fixed capital, 1-year contract. They have to wait for the contract to be over to do sth else.

In the SR, cannot leave/enter market, can only choose how much to produce

Profit and Revenue

The profit function & profit maximization problem applies to any firm that wants to max profit, not just a firm in a perfectly competitive market.

- Firm chooses Q to maximize profit
- Profit=total revenue-total cost

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

- Total revenue

$$TR(Q) = P(Q)Q$$

The price the firm sets can be a function of how much the firm produces.

- Definition 10.1 *Marginal revenue*
  - The rate at which total revenue changes with output

$$MR(Q) = \frac{dTR(Q)}{dQ}$$

as u produce a bit more, what is the additional revenue u gonna get?

  - The slope of the total revenue curve

How to maximize profit?

- To maximize profit, we solve

$$\max_{Q} \; TR(Q) - TC(Q)$$

unconstrained maximization problem

we don't even need to use Lagrange method, can just differentiate.

- The first-order condition is

$$MR(Q) - MC(Q) = 0$$

- Rearranging, we have

$$MR(Q) = MC(Q)$$

To maximize profit, u should choose to produce at quantity where MR = MC.
This applies to any firm which wants to max profits, no matter what kind of market the firm is in.

Profit-Maximizing Condition in Perfectly Competitive Market

- Firms take market price *P* as given price taker
- Total revenue is linear in output

$$TR(Q) = PQ$$

P here is not a function of Q
Individual firms are too small to change market price P.

- Marginal revenue = price

$$MR(Q) = P$$

For a firm in a perfectly competitive market, marginal revenue is constant, just the market price.

- To maximize profit

$$P = MC(Q)$$

To max profit, should produce at a quantity where P = MC.

Example: Profit Maximization

- Suppose the total cost curve of a firm is

$$STC(Q) = 25 + Q^2$$

fixed cost: 25
variable cost: Q^2

- Short-run marginal cost is

$$SMC(Q) = 2Q$$

- To maximize profit, we need

$$P = SMC(Q) = 2Q$$

- The profit-maximizing Q given P is

$$Q = \frac{P}{2}$$

this is how u should choose your quantity to max profits

Intuition: Producing Too Little

- Suppose the market price is P=12
- Suppose the firm produces 2 units
- MR=P=12
  - If the firm increases the production level, the total revenue increases at a rate of 12
- SMC=2Q=2*2=4

if the firm produces a little more, total revenue will increase by 12 and total cost will increase by 4.

  - If the firm increases the production level, the total cost increases at a rate of 4

when u produce at a quantity where P > SMC:

- When P>SMC, total revenue increases faster than total cost as production level increases

should produce more to get higher profit.
P>SMC is not maximizing profit.

Intuition: Producing Too Much

- Suppose the firm produces 8 units when the market price is P=12
- MR=P=12
  - If the firm decreases the production level, the total revenue decreases at a rate of 12
- SMC=2Q=2*8=16
  - If the firm decreases the production level, the total cost decreases at a rate of 16
- When $P<SMC$, total revenue decreases slower than total cost as production level decreases should produce less to get higher profits.

So if u are producing at a quantity where P < SMC, u are not maximizing profit.

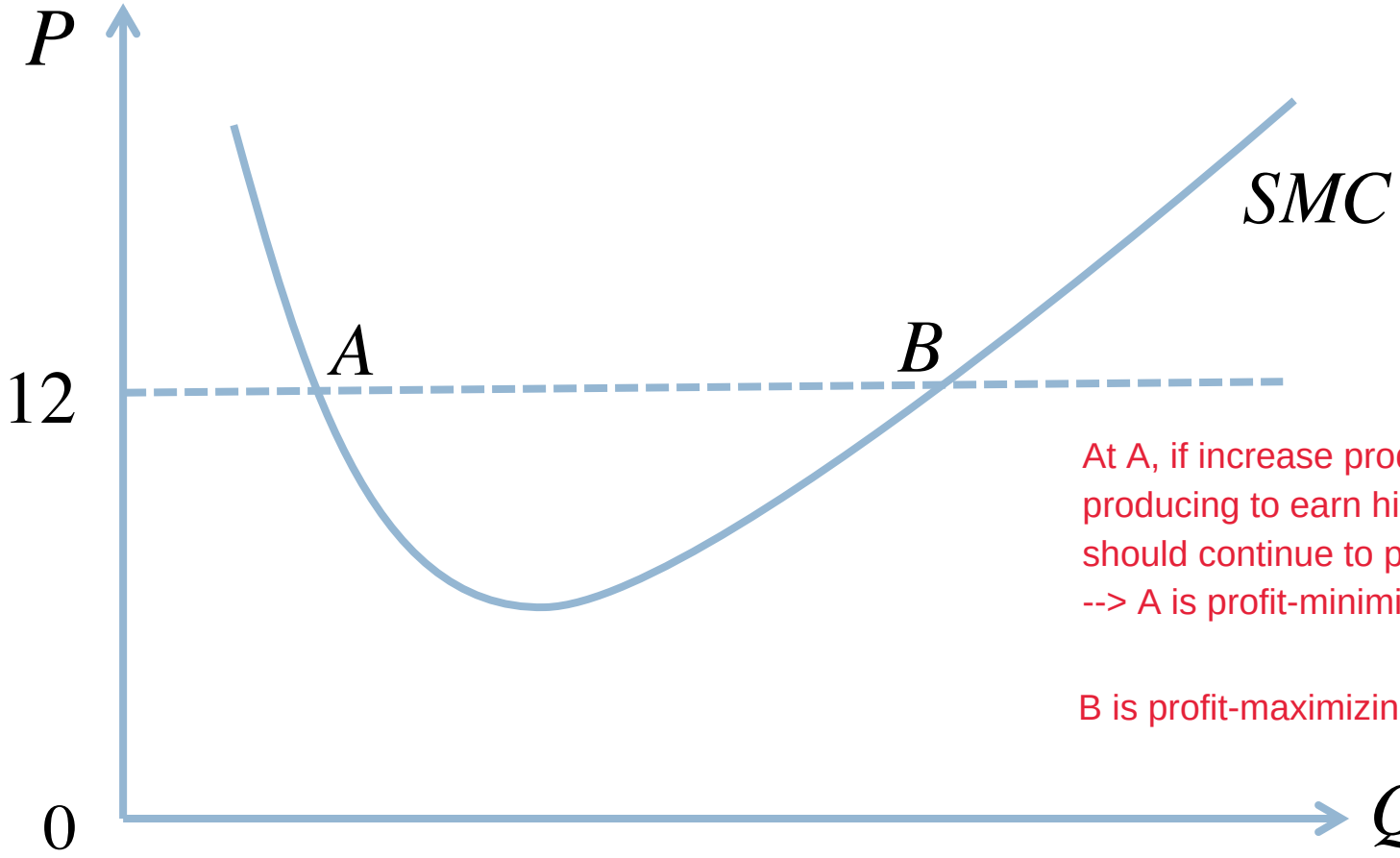
Intuition: Profit-Maximizing Optimal Output Choice

- If the firm can increase the profit by either producing more when *P*>*SMC* or producing less when *P*<*SMC*
- It must be that the firm is maximizing profit when producing an output level such that *P*=*SMC*
- When *P*=12, the optimal output choice is

$$P = SMC \Rightarrow 12 = 2Q \Rightarrow Q = 6$$ profit-maximizing quantity

Caveat: there may be more than one output level at which *P=SMC*

if u have a U-shaped SMC curve, will have 2 points where P=SMC. Are both profit-maximizing?



Point A is the profit-minimizing point

At A, if increase production by a little, MR > MC, means u should continue producing to earn higher profit. If move to the left of A, MC>MR, means should continue to produce less to earn higher profit.
--> A is profit-minimizing point (worst point)

B is profit-maximizing point.

If we just look at first-order condition which gives us P=SMC (from differentiating profit function), this doesn't distinguish profit-minimization and profit-maximization.

Second-Order Condition

if u have more than 1 quantity where P = SMC, should check whether there is a quantity where MC curve is downward sloping.

- To make sure we are maximizing profit, it must be that

$$\pi''(Q) \leq 0$$

need to differentiate profit function twice

- This implies

the first-order derivative gives us MR - MC

$$\frac{dMR(Q)}{dQ} - \frac{dMC(Q)}{dQ} \leq 0$$

- Since $MR(Q)=P$

just a number, doesn't depend on Q

$$\frac{dMC(Q)}{dQ} \geq 0$$

to maximize profit, shouldn't produce at the part of MC curve that is downward sloping.

Non-Sunk Cost vs. Sunk Cost

In the SR, firm cannot exit market, but can produce 0 unit. Is there a scenario where the firm can get higher profit by producing nothing in the SR?

- Fixed cost may or may not be sunk
- Definition 10.2 *Total non-sunk cost* (*TNSC*) is
  - Total variable cost + total non-sunk fixed cost
- Definition 10.3 *Total sunk cost* (*TSC*) is
  - Total sunk fixed cost
- If all fixed cost is non-sunk
  - *TNSC*= STC
- If all fixed cost is sunk
  - *TNSC*= VC

Another way of decomposing total cost. Instead of total cost = variable cost + fixed cost, we can say total cost in the SR = total non-sunk cost + total sunk cost

variable cost is non-sunk coz no need to pay anything when Q=0.

TNSC: no need to pay if u don't produce (can avoid)

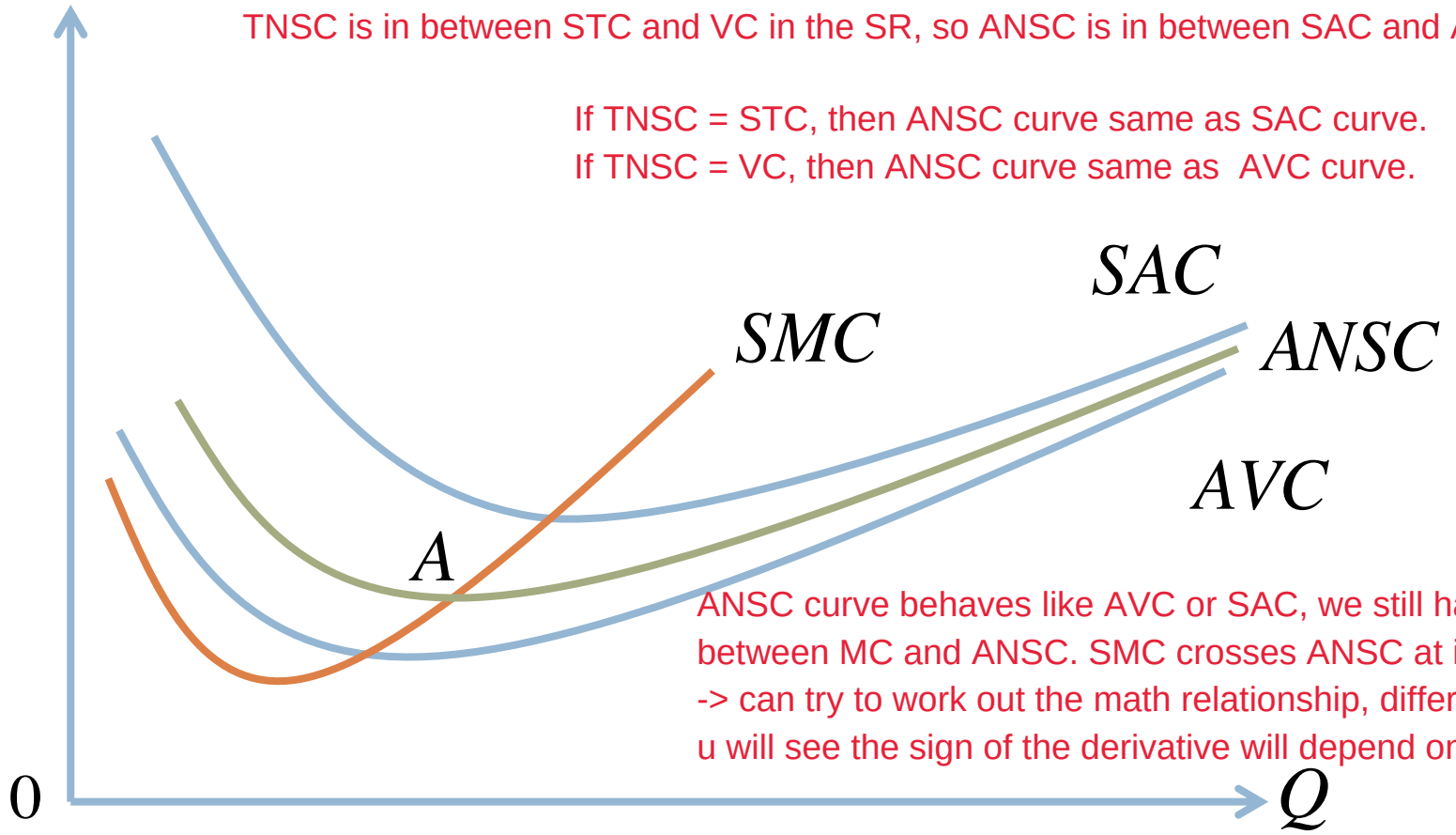
have to pay no matter what

means TNSC in general is in between VC and STC, depending on how much of fixed cost is sunk.

SMC crosses *ANSC* at the minimum point of *ANSC*

TNSC is in between STC and VC in the SR, so ANSC is in between SAC and AVC.

If TNSC = STC, then ANSC curve same as SAC curve.
If TNSC = VC, then ANSC curve same as AVC curve.



ANSC curve behaves like AVC or SAC, we still have the same relationship between MC and ANSC. SMC crosses ANSC at its lowest point A.
-> can try to work out the math relationship, differentiating ANSC wrt Q and u will see the sign of the derivative will depend on SMC & ANSC.

Should the firm produce at all?

Is it possible for a firm to get higher profit by not producing in the SR?

- If the firm does not produce
  - Its profit is -*TSC*

no revenue, no non-sunk cost

- If the firm produces
  - Its profit is *TR*(*Q*)-*TNSC*(*Q*)-*TSC*

produces at the quantity where P = SMC

- Firm only produces when

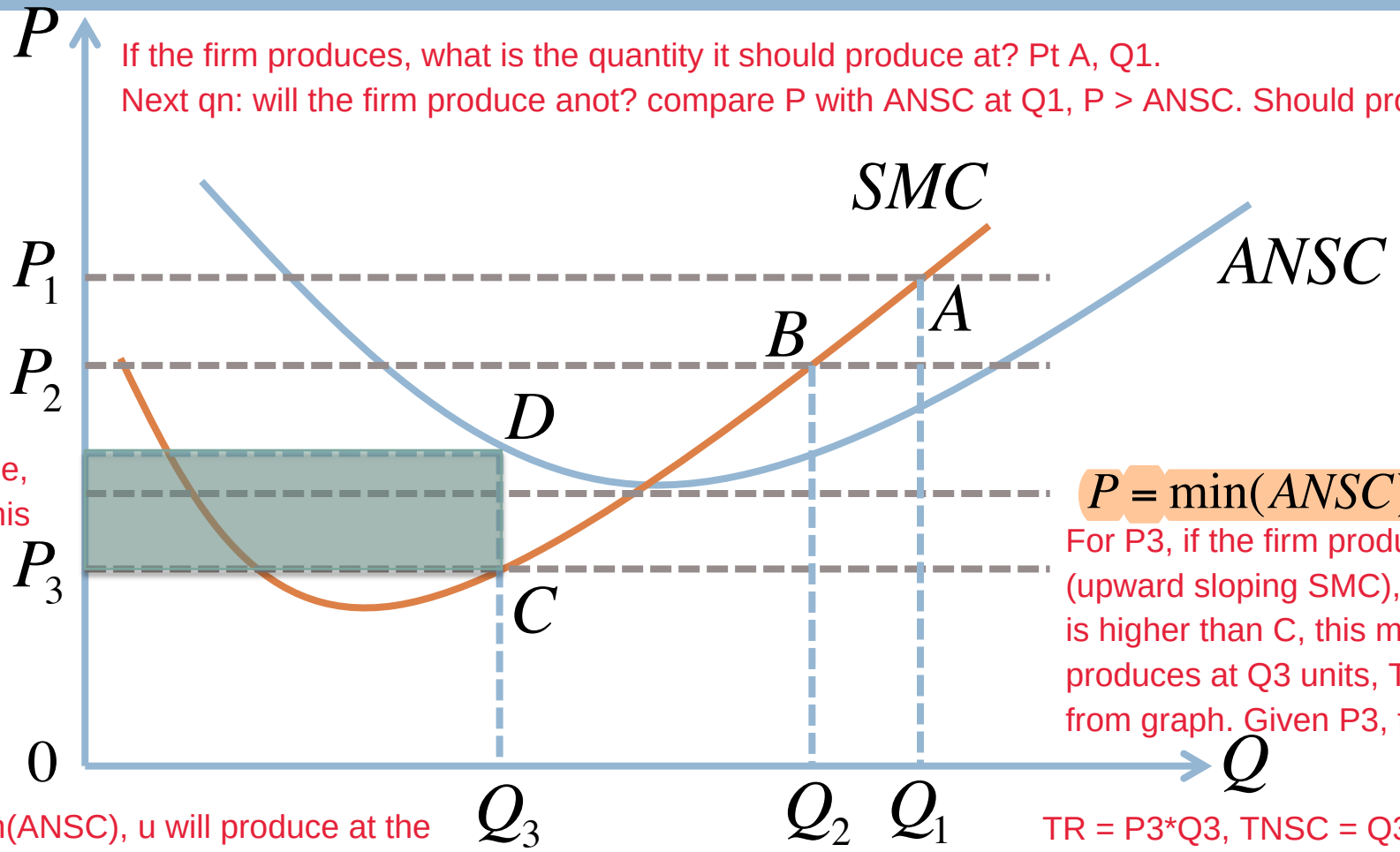
$$TR(Q) \geq TNSC(Q)$$

  - Since

$$TR(Q) = PQ, \quad TNSC(Q) = ANSC(Q) \times Q$$

  - Firm only produces when $P \geq ANSC(Q)$

When should the firm stop producing?



If the firm produces, what is the quantity it should produce at? Pt A, Q1.
Next qn: will the firm produce anot? compare P with ANSC at Q1, P > ANSC. Should produce.

If the firm doesn't produce, it doesn't need to incur this area of loss.

$P = \min(ANSC)$

For P3, if the firm produces, will choose C (upward sloping SMC), which gives us Q3. But D is higher than C, this means when the firm produces at Q3 units, TR < TNSC, can see this from graph. Given P3, firm shouldn't produce.

TR = P3*Q3, TNSC = Q3*ANSC (bigger rectangle)

Conclusion: As long as P > min(ANSC), u will produce at the region where SMC lies above ANSC. To max profit, u will choose a quantity where P = SMC, so if SMC > ANSC, means P > ANSC, so Tr > TNSC. Profit by producing > profit by not producing.

How the firm makes decisions in the SR to max profit

Profit-maximizing conditions in the short run

When P>=min$(ANSC)$, each firm should choose a level of Q such that

- At that output level, $P=SMC$
- SMC is non-decreasing in Q

not the downward sloping part of SMC.

When P<min$(ANSC)$, each firm should set Q=0

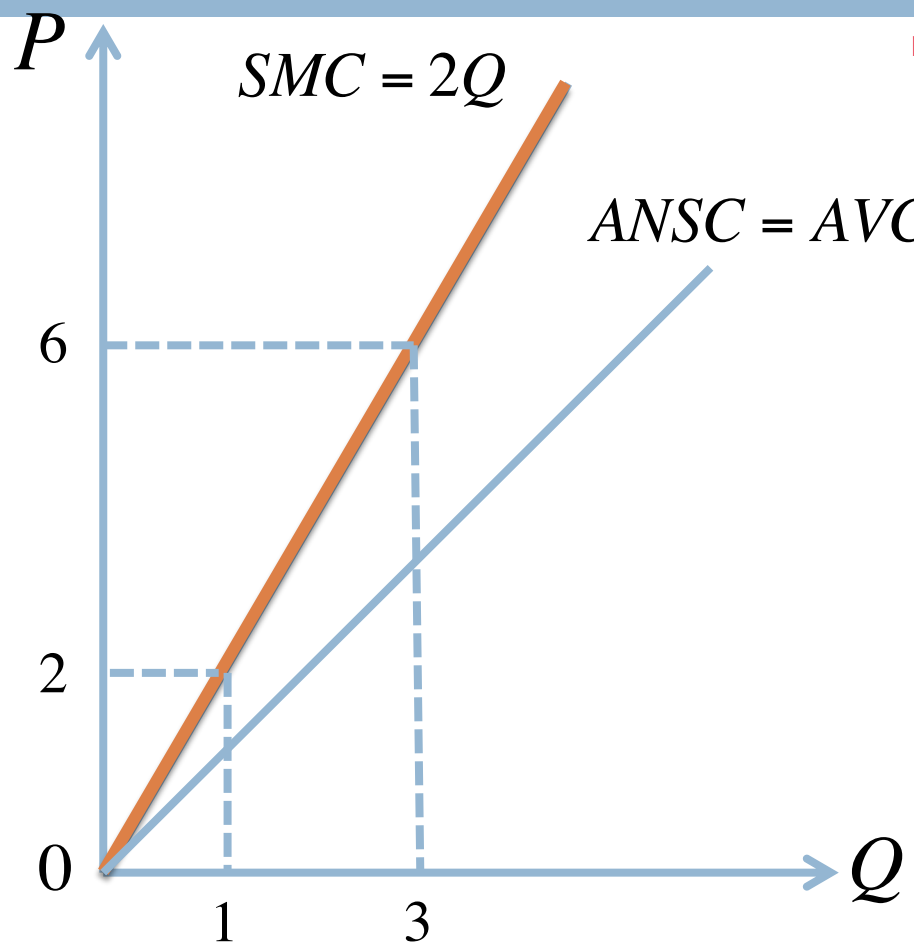
price given to the firm

to max profit

this rule can give us supply curve for firm.

Example: Firm's Supply Curve When All Fixed Cost is Sunk

means TNSC = VC = Q^2



min(ANSC) = 0

means that for this firm to max profit, u are not going to produce anything when P < 0.
This is trivial as P is never going to be -ve, P>=0.
So means the firm is always going to produce.

$$STC(Q) = Q^2 + 25$$

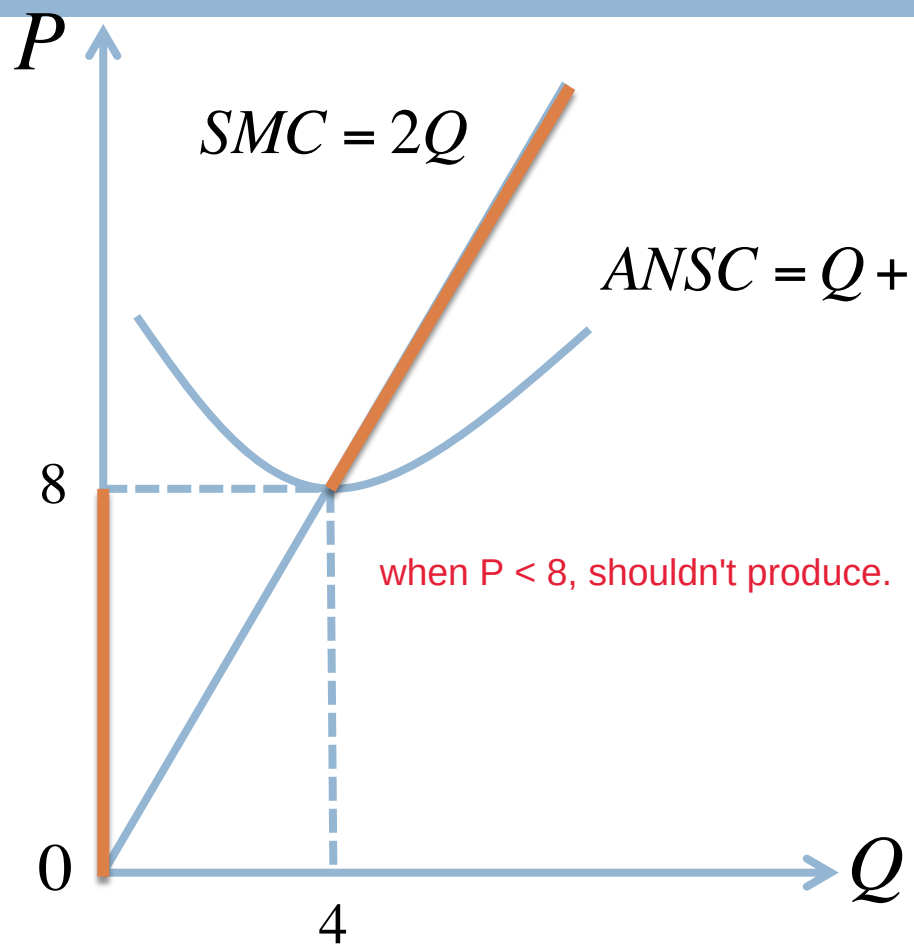
$P=SMC=2Q$

thus the supply curve is

$Q=P/2$

the supply curve is just the SMC curve in this case.
the SMC curve tells u how much u should produce at each price level.

Example: Firm's Supply Curve When Part of the Fixed Cost is Non-Sunk



when P < 8, shouldn't produce.

TNSC = Q^2 + 16

Once have ANSC, find min(ANSC) by differentiate & set derivative to 0. OR equate ANSC with SMC as they cross at the min point.

Suppose the non-sunk fixed cost is 16 out of 25

The supply curve is $Q=P/2$ when $P>=8$ and $Q=0$ when $P<8$

2 parts in the supply curve in this case.

Individual Firm's Supply Curve

generally 2 parts of supply curve

- Definition 10.4 The *short-run supply curve for an individual firm* is the profit-maximizing quantity for the firm as a function of the market price

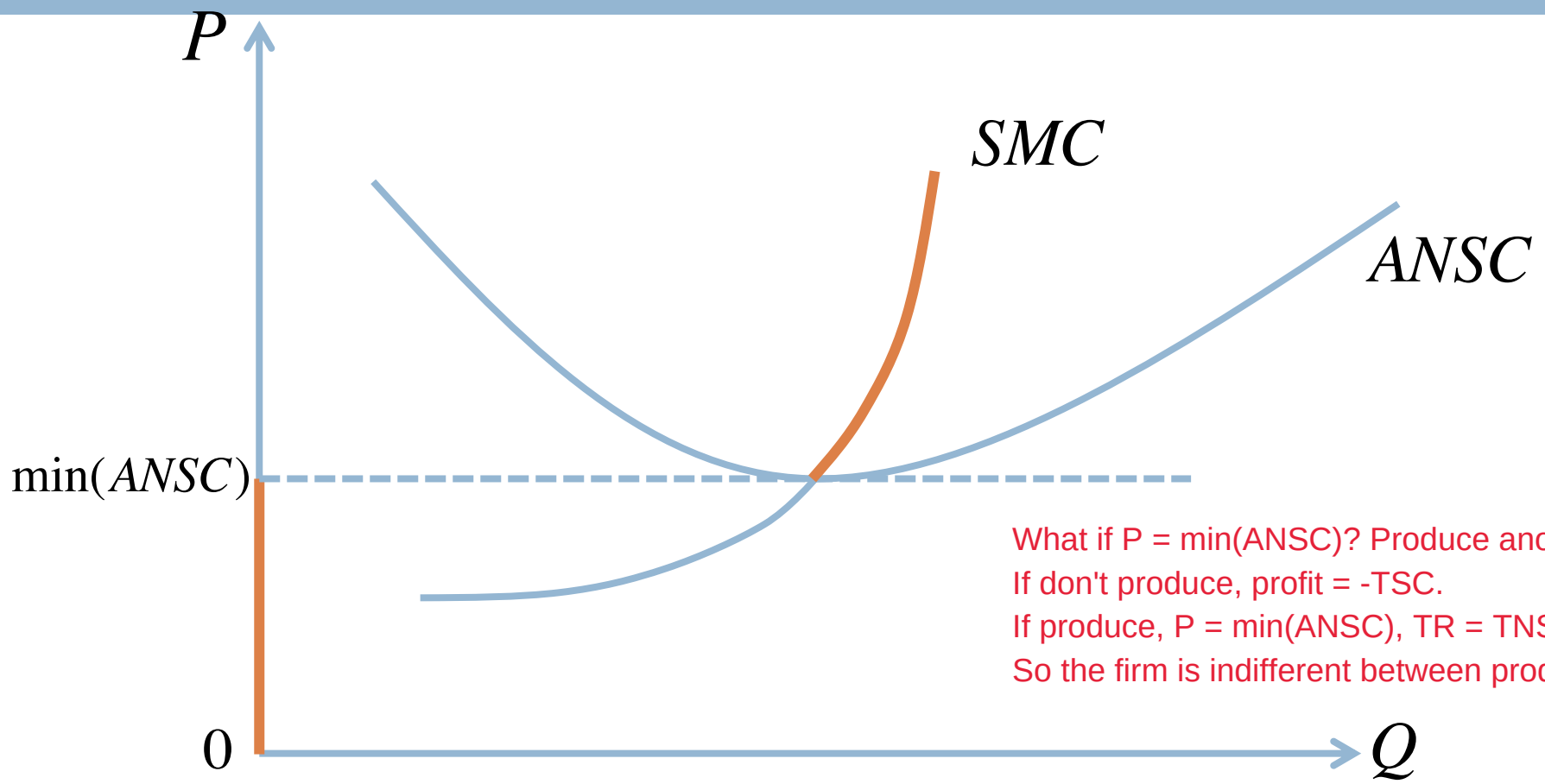
  Given any market price, how much should I produce to max profits.

  Q as a function of P

- If $P<\min(ANSC)$
  - $Q=0$
  - Supply curve is the vertical axis
- If $P>=\min(ANSC)$
  - Firm chooses Q such that $SMC(Q)=P$
  - Supply curve is the marginal cost curve

= sign can be put at either case.

Firm's Short-run Supply Curve in General



What if P = min(ANSC)? Produce anot?
If don't produce, profit = -TSC.
If produce, P = min(ANSC), TR = TNSC, so profit = -TSC.
So the firm is indifferent between producing and not producing.

Short-Run Market Supply Curve

- Definition 10.5 *Short-run market supply curve* is the horizontal sum of all individual firm's supply curve

add up individual firms' supply curve

- Suppose there are 100 identical firms in the market
- Assuming all fixed cost is sunk, each firm has a supply curve

$$Q_f = \frac{P}{2}$$

- The market supply curve is

$$S(P) = 100 \times \frac{P}{2} = 50P$$

convention:
S as a function of P

Market supply curve tells us the total quantity supplied in the market as a function of market price.

Qf: quantity for an individual firm
Qm: total quantity for the entire market

Part 2

Short-Run Market Equilibrium

Short-run Market Equilibrium

For competitive equilibrium, we have the 1st and 3rd condition, no 2nd condition because there is no firm in the exchange economy.

- Definition 10.6 At the *short-run market equilibrium* in a competitive market

  where market demand curve intersects market supply curve

  - Total quantity demanded equals total quantity supplied

    markets clear (no excess demand/ supply)

  - Each firm produces at the profit-maximizing output level given the equilibrium price
  - Each consumer buys the utility-maximizing quantity given the equilibrium price

How do we know the last 2 conditions must hold in equilibrium?
For each firm, the supply curve comes from its profit-maximizing decisions. It tells u how the profit-maximizing quantity depends on price.
Similarly, demand curve comes from each consumer's utility-maximizing problem. It tells u the optimal / utility-maximizing quantity as a function of price.

Example: Short-run Market Equilibrium

hard part is to derive demand and supply curve

- Suppose the demand curve is

$$D(P) = 560 - 20P$$

- Short-run equilibrium price is thus

$$S(P) = D(P) \Rightarrow 50P = 560 - 20P \Rightarrow P = 8$$

- Total quantity produced in the equilibrium is 50*8=400
- Each firm produces 8/2=4 units OR 400 / 100 = 4

slide 27: Qf = P/2 (individual firm's supply curve)

Relationship between Profit and *SAC*

Profit = TR - TC, based on total cost. But usually we don't draw TC curves in graph, we draw AC curves.
So we want to know whether there is a way to represent profit in the graph if we only draw AC curves.

- Suppose the market price is P
- At this price, a firm's optimal output level is Q_f profit-maximizing quantity
- Firm's profit is

$$TR - STC = P \times Q_f - SAC(Q_f) \times Q_f = [P - SAC(Q_f)]Q_f$$

- $P > SAC(Q_f)$
  - Firm's profit is positive at the output level Q_f
- $P < SAC(Q_f)$
  - Firm's profit is negative at the output level Q_f

For each unit the firm produces, the average cost of production is higher than price P. So for every unit I sell, the money I get for that unit is less than average cost I am paying for that unit

P = SAC(Qf)
Firm is making 0 profit.

Profit at Short-Run Market Equilibrium

- What is the profit for each firm?

$$TR - STC = PQ_f - STC(Q_f) = 8 \times 4 - 4 \times 4 - 25 = -9$$

  - The short-run average total cost is

equilibrium price = 8, indeed at profit-maximizing quantity 4, P < SAC(Qf)

$$SAC(Q_f) = \frac{STC(Q_f)}{Q_f} = \frac{25 + Q_f^2}{Q_f} \Rightarrow SAC(4) = \frac{25 + 16}{4} = 10.25$$

- Negative profit is possible in short-run market equilibrium
  - Firms do not take sunk cost into consideration when deciding how much to produce

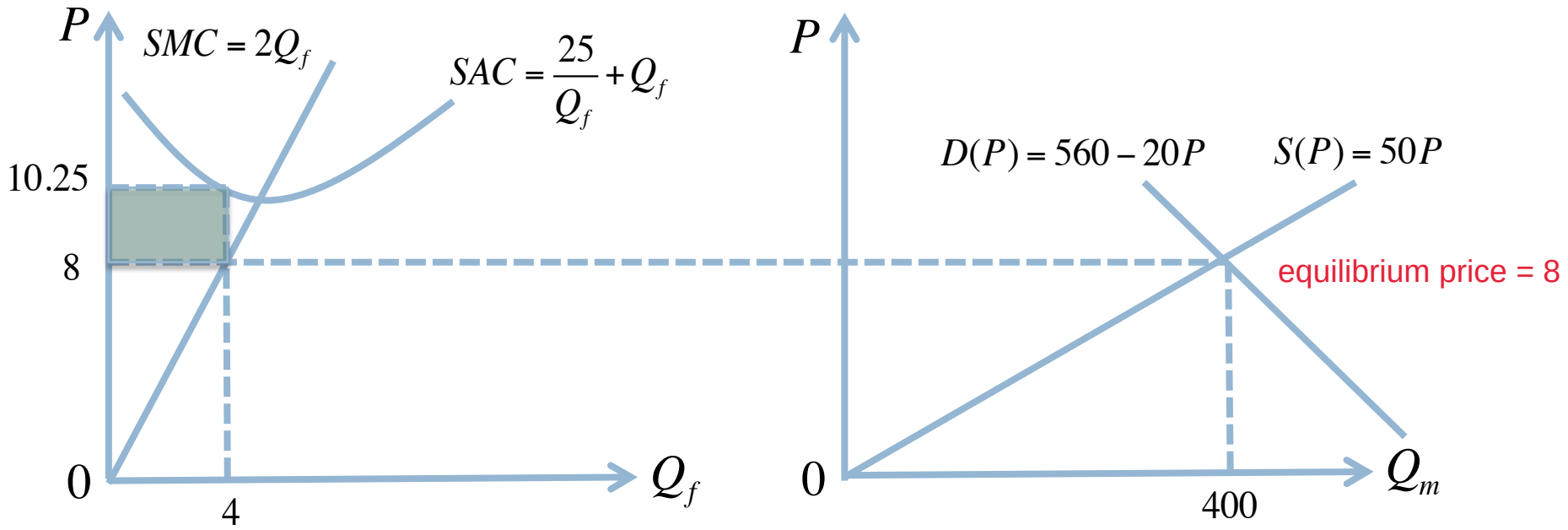
When u decide how much to produce, u don't take sunk cost into consideration. But when calculating total profit, need to include sunk cost. As profit = TR - STC, total cost includes sunk cost and non-sunk cost.

Even if the firm is maximizing profit, no guarantee that the firm's profit will be +ve. Why?
coz we have sunk cost in the short run. If the sunk cost is big enough, even if the firm is max profit, it may still incur -ve profit.

Short-Run Equilibrium in Graph

Typical Firm's Cost and Supply

Market Equilibrium with 100 Identical Firms

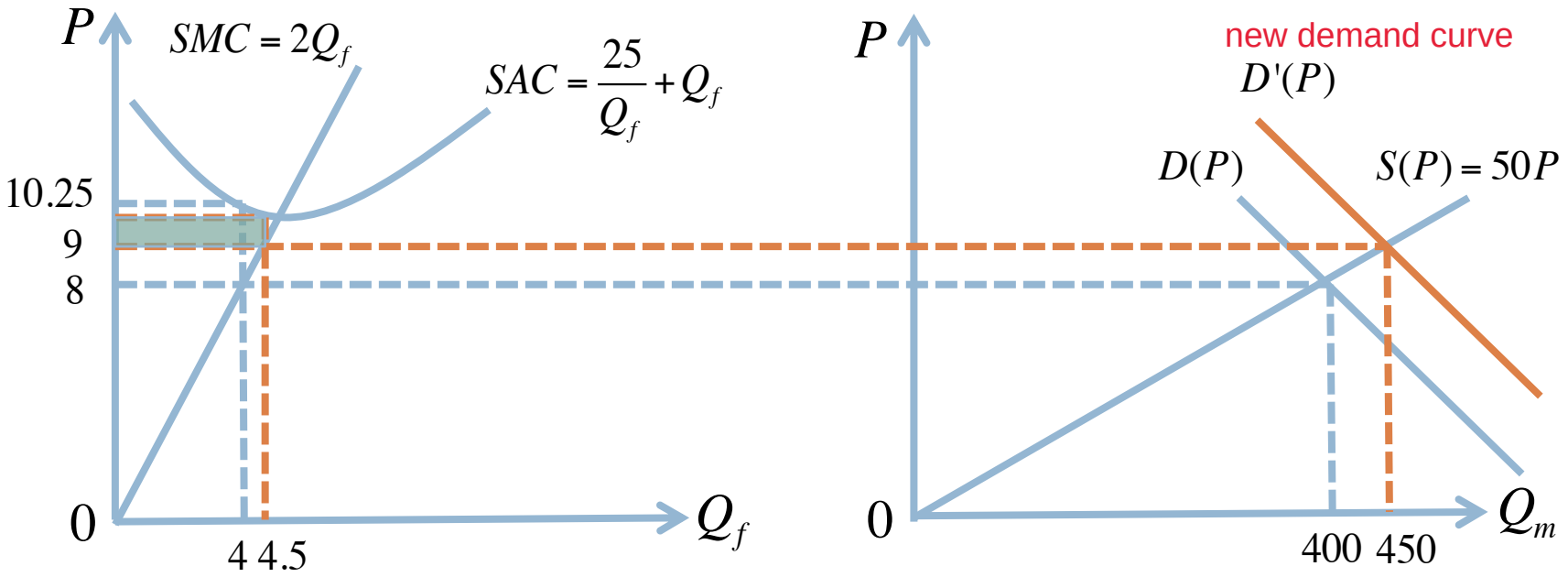


For individual firm, take price 8 as given. Look at supply curve (which is MC curve)
to see how much to produce - 4 units. What's profit? Find SAC when Q = 4. SAC = 10.25.
So profit is the shaded area (-ve profit). TR = 8 * 4 area.

Comparative Statics: What if demand increases?

Typical Firm's Cost and Supply

Market Equilibrium with 100 Identical Firms



shaded area: -ve profit for the firm

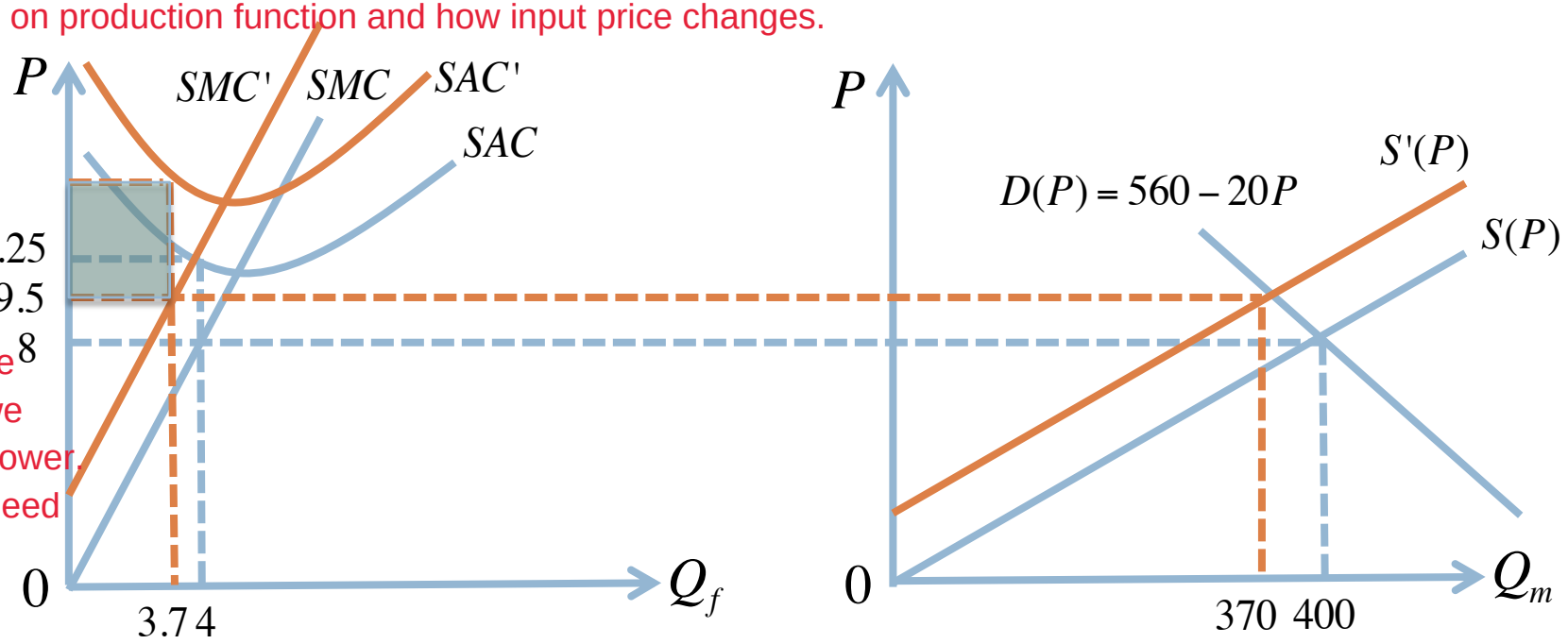
Compare to before demand increase, it is clear that the loss of the firm has reduced. (general conclusion, no need to prove, intuitive)
-> increase in demand is a good thing for firm -> expect profit to grow / loss lower.

Comparative Statics: What if input prices increase?

Typical Firm's Cost and Supply

Market Equilibrium with 100 Identical Firms

From the graph, seems that the shift in cost curves is parallel.
Not necessary. Depends on production function and how input price changes.



shaded area:
-ve profit for firm

when input more ex, more costly to produce Q, so we expect firm's profit to be lower. (general conclusion, no need proof)

Cost curves come from solving the cost-minimization problem for the firm.
-> if input price increases, this gonna increase cost of production in SR. more costly to produce the same Q.
-> cost curves move up.

For each firm, MC curve is the supply curve. Now u have a new SMC curve, means firm has new supply curve, so market supply curve also changes. For each firm, supply curve moves up, so market supply curve moves up too.

Part 3

Producer Surplus in the Short Run

Definition of Producer Surplus

Producer surplus in the market: add up all producer surplus from all the firms.

- Definition 10.7 *Producer surplus* (PS) is the difference between the amount producers actually receive by producing and selling a certain units and the amount producers have to receive to produce a certain units

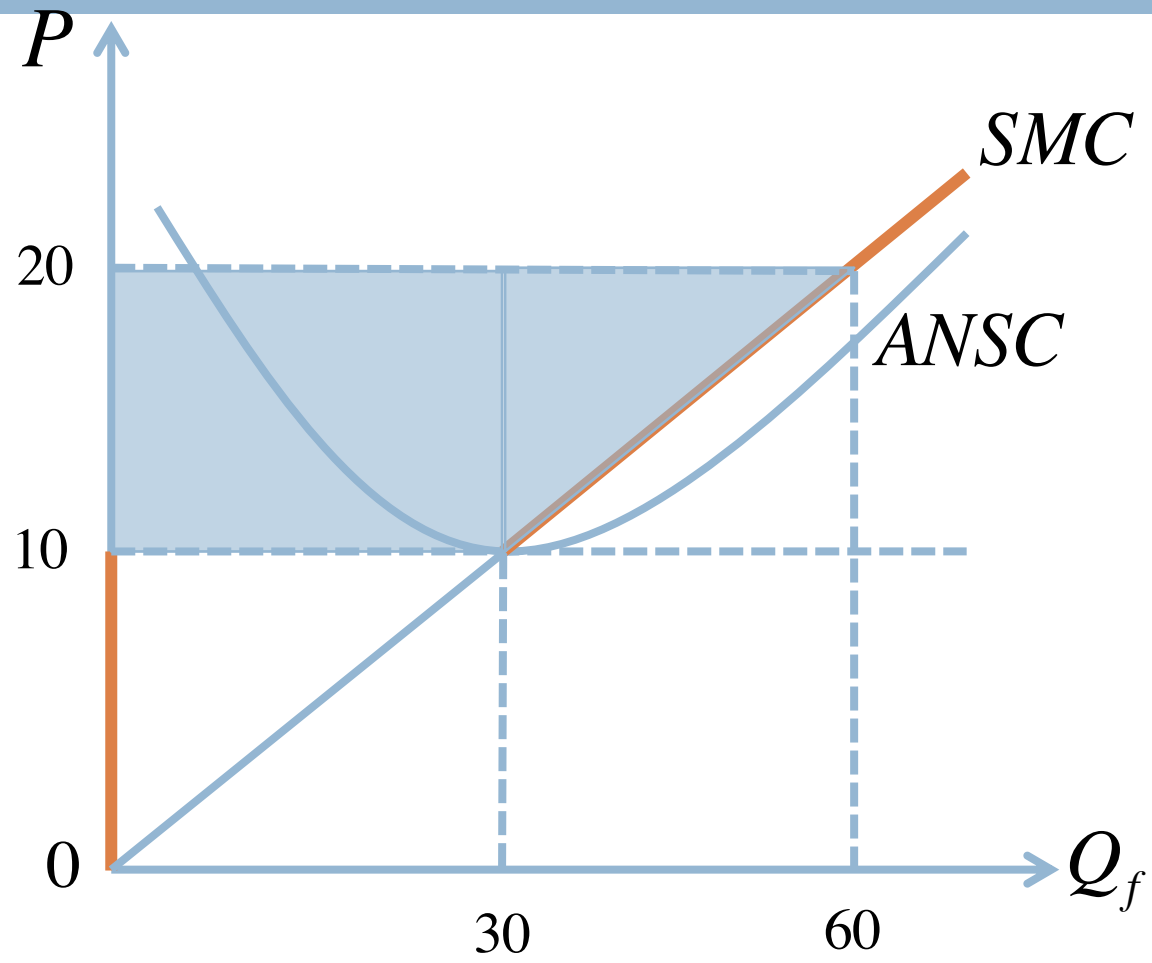
min amount the firm has to receive in order to produce

We covered earlier, in order for the firm to produce, need to ensure total revenue is at least as high as total non-sunk cost.

- PS = total revenue - total non-sunk cost
- PS is the area below the price and above the supply curve

What does PS tell us?
Consumer surplus is a way to measure benefit for consumers when they consume.
Similarly, producer surplus tells us the benefit to the firms when they produce and sell goods.

Producer Surplus in Graph

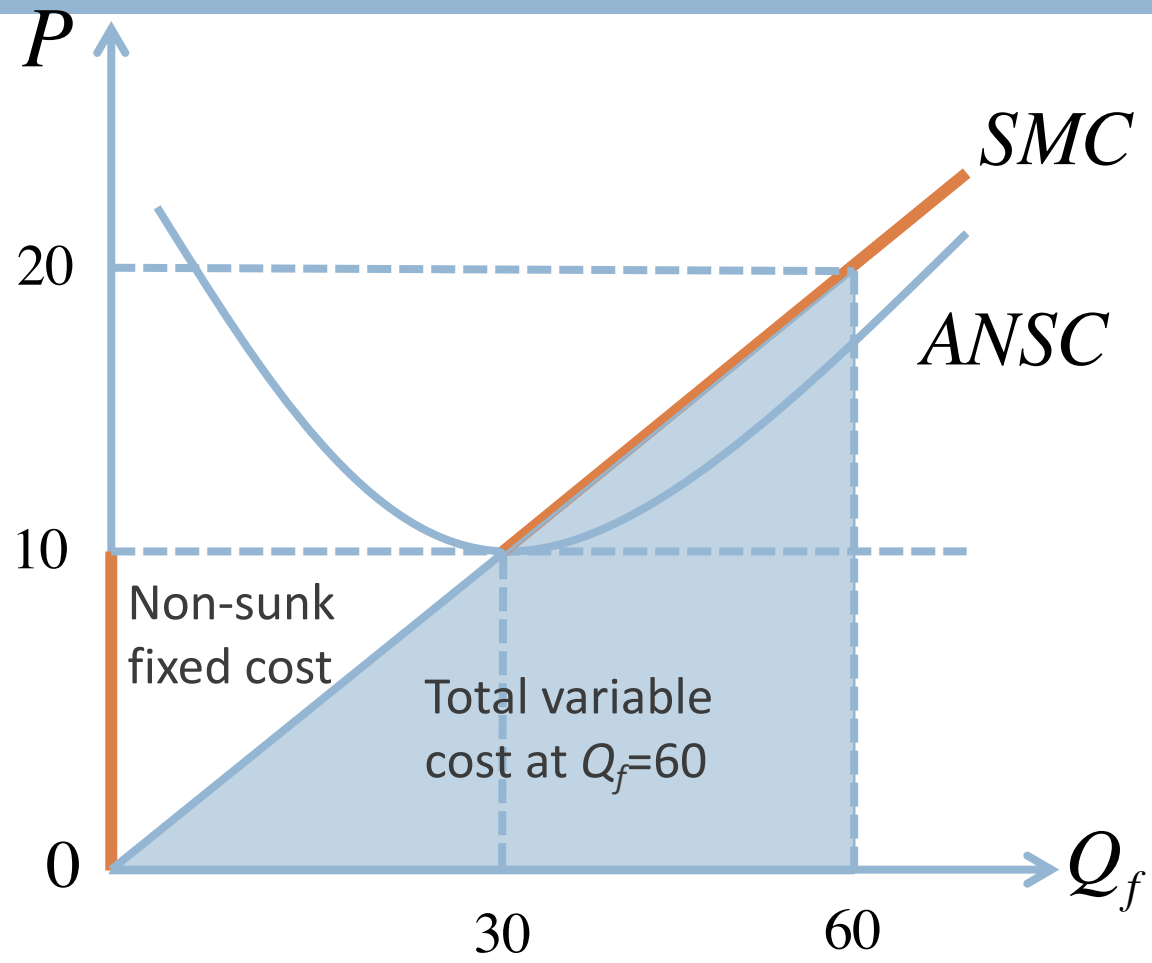


orange line: supply curve

PS=0.5*(30+60)*(20-10)=450

TR = 20 * 60 rectangle (area under price)
TNSC should be the area under supply curve.
Why?

Producer Surplus in Graph Cont'



TNSC = VC + Non-sunk fixed cost

VC: area under SMC curve.
-> MC curve basically tells u how much it costs u to produce 1 additional unit. e.g. For the 30th unit, cost firm $10. For the 60th unit, cost firm $20.
-> another way: SMC = derivative of STC = derivative of VC. If differentiate VC u get MC, so if u integrate MC u get back total VC.

Non-sunk fixed cost: For Q = 30, TNSC = 10 * 30 rectangle. Total VC is the triangle below SMC.

Calculating Producer Surplus from the Graph

- Total revenue
  - 20*60=1200
- Total non-sunk cost
  - *VC* is 0.5*60*20=600
    - The area under the *SMC* curve
  - Non-sunk fixed cost is 150
    - *TNSC* for the first 30 units is *ANSC*(30)*30=10*30=300
    - But *VC* for the first 30 units is 0.5*30*10=150
  - *TNSC*=600+150=750
- PS=1200-750=450
  - The area under the price and above the supply curve